Ecology, navigation and sustainable planning in the Danube River Basin

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Ecological framework conditions

Large river systems (LRS) as the Danube are much more than just longitudinal channel networks. Especially in the low-gradient middle, tail water and delta reaches the natural river channel systems together with their wide alluvial floodplains clearly have to be addressed as complex ecological unities. To understand the high complexity of LRS, their relations and exchange processes with the adjoining ecosystems (tributaries, groundwater, alluvial floodplain forests, etc) requires comprehensive observations at the catchment and/or landscape scale. The EU Water Framework Directive (WFD) requires this approach. Modern concepts dealing with river ecology in a holistic way address LRS as multidimensional ecosystems. Natural disturbances (floods, droughts) are key elements that constitute the basis for the highly dynamic nature of riverine landscapes. The complex natural driving forces and exchange processes result in frequently changing connectivity conditions and an especially heterogeneous habitat complex. As the most important consequence of the ever shifting mosaic of habitats and ecotones, natural riverine environments generally feature an outstanding high biodiversity.

Effects of navigation on the riverine environment

Human activities and uses affect the ecological status of large river systems in various ways. From an ecological point of view beside pollution and hydroelectric power plants, river straightening for flood control and/or navigation purposes is a serious pressure. Of crucial importance are river engineering measures that impair the original hydro-morphological situation (e.g. regarding bed-load transport, morpho-dynamic development of the channel network, exchange processes and connectivity conditions river/ floodplains, etc) and/or the natural composition of ecological communities (e.g. through longitudinal migration barriers for migratory fish species or devastation of habitats and spawning places). Navigation needs leading to a stabilized, single thread river channel, create a monotonous aquatic environment that lacks natural in-stream structures with smooth gradients and connectivity conditions towards the adjacent floodplains. Furthermore, in many LRS river bed degradation is a major threat that mostly leads to severe ecological impairment. Locally increased bed load transport and consequently downstream output of bed material caused by channel construction for the improvement of navigation and/or flood control is in many cases additionally intensified by a substantial reduction of the bed load input from the upper catchment (e.g. due to retention by torrent control measures and/or chains of power plants). Since lateral erosion of originally braiding or meandering rivers is limited by channel stabilisation, these processes can not furthermore balance out the natural aggradation of the alluvial floodplains. Therefore, on the one hand river bed stabilization and dredging due to elimination of ecologically important in-stream structures result in a monotonous aquatic environment. On the other hand, river bed degradation may lead to a vertical separation and hydrological decoupling of the river and its floodplain habitats.

A new planning approach

The above examples clearly show that conservation, protection and sustainable use of ecologically intact river-floodplain systems - as required by the EU-WFD - urgently need a new planning philosophy. This is also valid to achieve sufficient results related to navigation pressures. Instead of one-sided measures and uses, multi-usable riverine landscapes must be the goal to achieve WFD requirements. Catchment wide thinking and cross border cooperation are future challenges calling for multi-disciplinary planning and decision processes. The so called "Leitbild" (vision) that uses natural reference conditions as an environmental orientation objective takes an important role in that approach. However, there are still distinct deficits regarding our knowledge of natural processes in LRS as well as of cumulative effects of various pressures and of methodological standards for their adequate evaluation. Therefore, the need and support of further research is essential and should be emphasised.

Philosophy for a joint Danube approach

In order to simultaneously improve Inland Navigation and Environmental Sustainability in the Danube River Basin the development of a common planning philosophy is essential for the success. The ongoing process on a *Joint Statement on Inland Navigation and Environmental Sustainability in the Danube River Basin* aims to define such a common planning approach, which should become operational after an agreement. This paper proposes and outlines the framework for a possible approach.

The prerequisite for future planning approaches for an environmentally sustainable Inland Water Transport (IWT) is a common language across disciplines, necessary to understand the problems of the “other” side and a special communication and discussion culture. In order to guarantee an interdisciplinary approach and broader acceptance of the ongoing and future planning process from the beginning the Ministries of Environment, Water Management and Transport, scientists and experts in river engineering, navigation, ecology, spatial planning and economics as well as representatives of the various stakeholders have to be involved.

As a first step, existing problems and needs for both, navigation and ecology within certain planning regions, river sections and/or of specific existing/future navigation projects need to be clearly identified. Navigation pressures, which can impact river ecology need to be clearly defined. Further, relevant environmental restoration measures, should be proposed, that prevent the deterioration of the ecological status and ensure the achievement of the environmental objective. Both issues on pressures and measures should become a common understanding. This document includes a list of basic navigation needs, measures and pressures as well as environmental measures for discussion (see table 1).

As a follow-up the involved parties should discuss all the issues in more technical detail in the frame of common workshops. This will support the development of the common understanding for the needs of ecology in correspondence with navigation and vice versa. Economic issues need to be taken into account. Thereafter, the concrete planning phase can be initiated. A steering group could be established to coordinate the process.

Main issues to be addressed include e.g. the minimum water depth required for navigation, the extent of river restoration and the procedure of an adequate measure implementation to be either realised along a whole project reach or in an adaptive process.

Planning principles (e.g. aiming for an environmental impact assessment) could include:

- implementation of measures according to given river morphological processes
- integrated design of regulation structures, equally regarding hydraulic, morphological and ecological criteria
- realisation of measures in an adaptive form
- definition of width and depth specifically for the central part of the navigation channel
- optimal use of the potential for river bank restoration and side channel reconnection
- keeping or if possible reducing flood water levels
- river bed stabilisation through e.g. granulometric bed improvement
- improvement of low water depth conditions through e.g. groins

The planning principles should be commonly agreed by stakeholders, politics, navigation and ecology, leading to a river engineering solution that creates a winning situation for ecology and navigation. Only via the accepted planning principles the designing of measures can be continued and will enable modified scenarios, which will be assessed and – if needed – improved. Within the planning and discussion period both, ecology and navigation have to be willing to find a compromise and to agree to a set of measures, aiming for a win-win situation for ecology and navigation. On the way to this success river engineering plays a central role in suggesting and designing suitable and technically sound measures.

Navigation pressures on ecology and integrated measures to improve inland navigation and environmental sustainability in the Danube River Basin

The identification of navigation pressures on the riverine ecology and the design of corresponding integrated measures to simultaneously improve navigation and ecology will support the achievement of required and jointly agreed objectives. Table 1 summarises these issues to be the basis for a workshop discussion and can be supplemented accordingly.

The table outlines navigation needs for current and future projects, which might have an effect (pressure) on the ecological status. Corresponding engineering measures, which need to be undertaken to ensure the technical prerequisites for navigation, are summarised briefly. Further, general effects – caused by the respective engineering measures – are described as well as their specific pressures/effects on the riverine ecology. Environmental measures, which need to be undertaken to achieve and ensure the environmental objectives/sustainability are included. There are two groups of environmental measures. The first group corresponds to navigation measures, aiming to reduce the pressures / impacts (upper part of table 1). The second group are pure ecologically oriented measures, reflecting a compensation for the remaining impacts of navigation measures.

The measures should clearly reflect, that the aims of navigation and ecology are weighted equally. Thus, simultaneously with engineering measures to improve navigation, the full potential for river restoration to improve the ecology should be used.

However, a follow-up mechanism would be useful to develop this list in detail. Needs for ecology and navigation have to be specified for the basin-wide and sectional scale. These issues should be discussed within the workshops of the *Joint Statement on Inland Navigation and Environmental Sustainability in the Danube River Basin.*

Table 1: **List of navigation needs, respective measures, their general effect and specific pressures on ecology. Ecological measures to achieve and ensure the environmental objective/sustainability are included (to be extended).**

Navigation Needs	Navigation Measures	General Effects	Pressures/Effects on Ecology	Ecological Needs	Environmental Measures
Minimum water depth (navigation fairway)	Transformation of the navigation fairway towards outer bank and deep water sections, low water regulation, dredging and refilling of material	Increase of water level at low flows	River channelization due to low water regulation, reduction of morphodynamics	Minimization of river engineering measures	River restoration (esp. river banks and floodplains)
Minimization of lateral flow velocity	Improvements of the flow field at confluences with tributaries and reconnected side channels by river engineering	Low cross sectional flow velocities	Reduced morphodynamics of confluences, less cross sectional flow velocity	No restriction to river bank and side channel dynamics	Side channel reconnection and restoration of tributary confluences
No sudden changes in flow field, flow velocity	Limitation of flow velocity changes (gradual changes) from reaches with e.g. new low water regulation towards not modified downstream and upstream sections	Low spatial variability of boundary conditions for navigation	Modified flow field compared to more natural conditions	Development of flow field and flow velocities towards Leitbild conditions (visions)	Development of river engineering measures to improve flow field variability

Navigation Needs	Navigation Measures	General Effects	Pressures/Effects on Ecology	Ecological Needs	Environmental Measures
Predictable position and geometry of navigation channel	Minimization of sudden sedimentation by use of groins, dredging and refilling	Less interruption / disturbance for navigation	Modified sediment transport and river morphology, habitat alteration	Variable water depths, flow widths, grain sizes, low lateral river bed gradients	Restoration measures leading to high variances of water depth, channel widths, grain sizes, moderate lateral gradients
No extreme trend towards river bed aggradation / degradation of the main channel	E.g. Construction of groins (aggradation), dredging and refilling of material, / river bed widening, granulometric bed improvement (degradation)	Dynamic river bed stability	Also a need for ecology as the pressure is not resulting from the driver navigation	No extreme trend towards river bed aggradation / degradation of the main channel	E.g. Construction of groins (aggradation), dredging and refilling of material, / river bed widening, granulometric bed improvement (degradation)
				Channel morphodynamics	Preservation or improvement of river morphology: no river bed pavement, keeping of morphodynamics, specific groins forms to improve morphodynamics, avoiding of groin fields

Navigation Needs	Navigation Measures	General Effects	Pressures/Effects on Ecology	Ecological Needs	Environmental Measures
				River bank morpho-dynamics	Initiation of more nature-like river banks: river bank restoration, removal of bank protection, side erosion, declinant groins to enhance side erosion
				Lateral connectivity	Floodplain / wetland / sidearm reconnection, more water in the floodplain/alluvial area, improvement of habitats
General needs	**General measures**				
Keeping of flood levels	Improvement of retention areas, river bed widening, no increase of flood risk		,		