logical measures employed in the course of the project (Habersack et al. 2008).

Another study on the Hungarian Danube deals with the application of the 3D SSIIM-model to simulate the flow and sediment transport processes in a 6 km long river section with several groynes downstream of Mohács where a sequence of an over-widened and a shallow channel section causes frequent navigational difficulties (Rákóczi et al. 2008).

Outlook and conclusions

The examples given above may point towards the future direction of modeling river bed morphology to support an integrated planning process. The models used in these studies allowed to capture flow and transport phenomena such as secondary currents, non-uniform sediment transport, and sorting and armouring processes. They were applied to study dune and bar movements, the exchange processes between the river channel and groyne fields, and the impact of structures on river morphology, features that may be of paramount importance when the morphological situation of the bottleneck sections of the Lower Danube shall be analysed and modeled.

References

Behr O, Gutknecht D, Modev S, Bondar C, Prohaska S (2000): Danube river morphology: a common initiative was taken. Danube Watch 1/2000, 6–8

Bloesch J (2007): Editorial Danube News 15, 1

DonauConsult Zottl & Erber (2004): Flussbauliches Gesamtprojekt östlich von Wien. Variantenvergleich: Furtendynamik – Zusammenfassende Darstellung. Erstellt im Auftrag von Wasserstraßendirektion. Juni 2004

Fischer-Antze T (2005): Assessing river bed changes by morphological and numerical analysis. Ph.D. Thesis, Vienna Univ. Technology, 179 pp

Habersack H, Hauer C, Liedermann M, Tritthart M (2008): Modelling and monitoring aid management of the Austrian Danube. Water21, Dec. 2008, 29–31

Hohensinner S, Herrnegger M, Blaschke A P, Habereder C, Haidvogl G, Hein T, Jungwirth M, Weiß M (2008): Type-specific reference conditions of fluvial landscapes: A search in the past by 3D-reconstruction. Catena 75, 200–215

Kutzenberger H, Nichersu I (2007): Towards an integrated planning approach in the Danubs River Basin. Danube News 16, 2-4

Minh Duc B, Bernhart HH, Kleemeier H (2005): Morphological numerical simulation of flood situations in the Danube River. Int J River Basin Management 3 No.4, 283–293

Modev S (2005): Bottlenecks in the Lower Danube River. In: Bloesch J, Gutknecht D, Iordache V (eds), Hydrology and Limnology – Another Boundary in the Danube River Basin, IHP-VI Technical Documents in Hydrology No. 75, 65–74

Olsen NRB (2002): A three-dimensional numerical model for simulation of sediment movements in water intakes with moving option. User`s Manual, Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology, Trondheim, Norway

Phare (2000): Morphological changes and abatement of their negative effects on a selected part of the Danube river. Phare Project OSS 98-5303.00. Final report, September 2000

Rákóczi L, Baranya S, Jósza J (2008): Improving the navigability on a sand-bed section of the Hungarian Danube reach. In: Altinakar, Kokpinar, Gogus, Tayfur, Kumcu, Yildirim (eds), River Flow 2008, 1497–1503

Schabuss M, Schiemer F (2007): Key threats to the Danube in the IAD perspective. No.1, Navigation: Is there a potential for compromising the contradictory stakeholder interests? Danube News 15, 2–4

Tritthart M (2005): Three-dimensional numerical modelling of turbulent river flow using polyhedral finite volumes. Wiener Mitteilungen Wasser-Abwasser-Gewässer 193, 1-179, www.tuwien.ac.at/publications/downloads

Tritthart M, Liedermann M, Habersack H (2009): Modelling spatio-temporal flow characteristics in groyne fields. River. Res. Applic. 25, 62–81

An integrated model approach for sustainable floodplain management: the case study of the urban floodplain Lobau

Thomas Hein, Gabriele Weigelhofer: University of Natural Resources and Applied Life Sciences, Institute of Hydrobiology and Aquatic Ecosystem Management, Department of Water, Atmosphere and Environment, Vienna, Austria & Wasser Cluster Lunz – Interuniversity Center for Aquatic Ecosystem Research, Lunz am See, Austria, e-mails: thomas.hein@boku.ac.at; Gabriele.Weigelhofer@wkl.ac.at
Alfred Paul Blaschke: Institute for Hydraulic and Water Resources Engineering, Technical University of Vienna, Karlsplatz 13, 1040 Vienna, Austria, e-mail: blaschke@hydro.tuwien.ac.at
Walter Reckendorfer: University of Vienna, Faculty of Life Sciences, Department of Limnology and Hydrobotany, Vienna, Austria, e-mail: walter.reckendorfer@univie.ac.at
Karl Reiter: Dep. of Conservation Biology, Vegetation and Landscape Ecology, University of Vienna, Althanstraße 14, 1090 Vienna, Austria, e-mail: karl.reiter@univie.ac.at
Bernd Schuh: ÖIR - Austrian Institute for Regional Studies and Spatial Planning, Franz-Josefs-Kai 27, 1010 Vienna, Austria, e-mail: schuh@oir.at

Introduction

Floodplains are highly endangered ecosystems as shown for the Danube River Basin, where about 80% of the pristine floodplain areas are lost (WWF 1999). The remaining areas show a distinct decline of ecosystem functions and services. In face of the increasing ecological and socio-economic constraints on river floodplain systems, sustainable management strategies are urgently needed. However, conflicts among the various societal demands and utilizations tighten the potential for good solutions. An additional challenge is the often limited understanding of these complex systems, especially as regards the interaction between different natural and anthropogenic driving forces. With respect to a sustainable development of the ecosystem, management approaches must be based on predictive geomorphological, hydrological and ecological models as well as on the comparison with reference conditions or guiding images which give an insight into the complex interactions of the different compartments. Especially in urban areas, ecological objectives have to integrate the many-fold, often conflicting social and economic demands and involve local and regional stakeholders in a participatory process to raise public support for the proposed strategies (Hargrove et al. 2005).

From a methodological point of view, the integration of the various ecological and socio-economic aspects of urban floodplain management often confronts managers and scientists with the problem of the incomparability of quantitative and qualitative data. Together with contradicting objectives

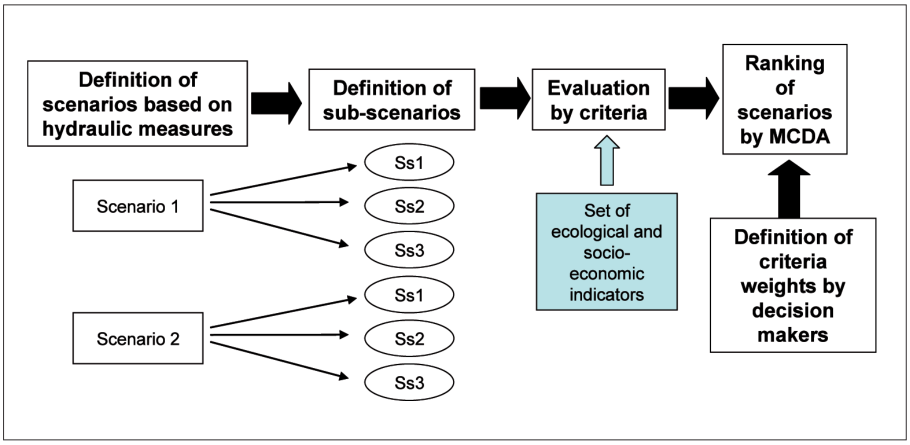


Figure 2. Work flow scheme, showing the interdisciplinary co-operation in the Lobau Project. Ss 1–3 = Sub-scenarios 1–3 (modified after Weigelhofer et al. 2006)

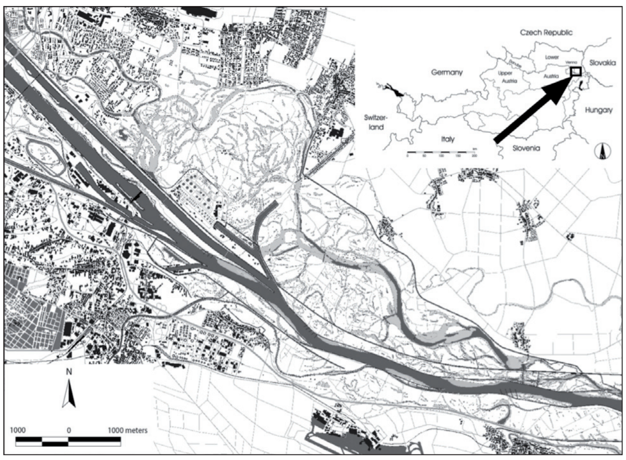
this may hamper the comparison and evaluation of different management strategies. A sustainable management approach for urban floodplains, hence, needs an evaluation method which has the power to overcome these problems (Faucheux et al. 1998).

Here we present the outcomes of an interdisciplinary approach for identifying potential solutions for the sustainable management of an urban floodplain in the frame of the project "Optima Lobau". Because of the multi-objective nature of floodplain management, we used an integrated model framework and a Decision Support System (DSS) based on a multi-criteria decision aid (MCDA) method. This approach is mainly based on the comprehension of the physical and biological processes and on the identification of drivers and factors for degradation.

Case study: urban floodplain Lobau

The Lobau is situated along the left bank of the Danube River at the eastern border of the city of Vienna *(Figure 1).* During the major regulation of the Danube in the 19th century, this former dynamic floodplain was disconnected from the main channel by the construction of a flood protection dam (Hein et al. 2006). Today, the Lobau represents a groundwater-fed and back-flooded lake system where sedimentation and terrestrialisation processes prevail. River engineering has not only led to a reduction of most of the basic ecosystem functions, but also to a drastic shift in the structure and composition of habitat types and vegetation cover. The reduced hydrological dynamics favors the establishment of rare but atypical species of dry meadows. Nevertheless, due to a still existing complex mosaic of aquatic, semi-aquatic and terrestrial habitats, the Lobau features an extraordinary high biodiversity. The floodplain has been designated as UNESCO Men and Biosphere Reserve, Ramsar site and Natura2000 area and constitutes a part of the Alluvial Zone National Park.

Figure 1. Project area Lobau at the eastern border of Vienna, Austria (after Hein et al. 2008)



Because of its proximity to Vienna, societal demands, including flood protection, drinking water supply (5 groundwater wells) and recreation (more than 600,000 visitors per year) play a considerable role in floodplain management. Land- and water-use like forestry, agriculture and sports fishery are currently regulated by the National Park Authority, but still need to be considered and harmonised in future management schemes.

Scientific approach and results

The MCDA approach in this project is based on the creation of scenarios and changed hydrological exchange conditions which describe possible future conditions of the floodplain as hydrological responses to different hydraulic measures (Weigelhofer et al. 2006). Main scenarios were differentiated into sub-scenarios as to the effects of the maximum development of one dominating ecological and socio-economic demand *(Figure 2).* In a participative, transdisciplinary process, the following driving forces were identified for the Lobau: fishery, eco-farming, recreation, drinking water supply, and the maximum potential for ecosystem development (rehabilitation of functional processes and conservation of habitats). Restrictions due to laws and legal regulations as well as the ecological potential of the landscape for various utilizations determined the framework of the different sub-scenarios. For the assessment of the sub-scenarios, various ecological and socio-economic indicators were developed by linking hydrological, ecological and socio-economic models.

To assess the effects of the potential changes, 75 indicators were selected from the following fields: aquatic ecosystem quality, terrestrial ecosystem quality, drinking water use, potential for recreation, potential for sport fishing and potential for organic farming. The details for the set up of the models and the data used can be found in Hein et al. (2006) and in the final report. The results for each indicator and each scenario were integrated in the MCDA using the PROMETHEE outranking technique. The basic matrix for the MCDA was a 31 scenarios x 75 indicators table. The calculation of the MCDA was performed for the unweighted indicator matrix as well as for several weighted matrices based on preferences from the different stakeholder groups.

Summarizing the results of the MCDA, the comparison of the different rankings clearly showed that the status-quo is not the preferred status for most of the involved stakeholders. The hydro-ecological and social modelling yielded measures involving a partial reconnection of the area that have the power to improve ecosystem conditions and equilibrate different ecological and socio-economic demands by keeping gains and losses in a balance. By contrast, a full reintegration of the area into the riverine flow regime will lead to a decrease of all human orientated utilizations, like e.g. recreation or the drinking water supply, while the impacts on endangered species in secondary developed lentic habitats remain unclear. Thus, a partial and controlled re-connection of the floodplain with the river constitutes the “best compromise solution”, which also lies within the preferences of all involved stakeholders.

Future aspects and strategies for urban floodplain management

The developed approach linked research tasks with management strategies in a more explicit way and provided a scientific sound basis for further planning steps in the management of the Lobau area. So far, the potential directions for future strategies have been identified and the trade-offs between social and ecological demands, like e.g. requirements of increased ecosystem quality vs. the security of the drinking water supply, are presented.

The Lobau project covers the analysis of the status quo, including information gaps for further research (e.g. the need of a more advanced sedimentation model), a detailed description of drivers and demands in the area, and a historic analysis of potential reference conditions (compare to Hohensinner et al. 2005). The presented research, thus, constitutes the basis for a proposed planning process and provides a scientific sound background for the next steps in design and implementation of measures *(Figure 3).* The MCDA turned out to be an useful tool to assess operational guiding images, reveal trade-offs among different indicator fields which may constrain the latitude of solutions, and offer compromise solutions with a high potential for an integrated sustainable development of this urban floodplain ecosystem. Based on these results, potential measures for floodplain restoration are developed in a cooperative process of stakeholders and scientists.

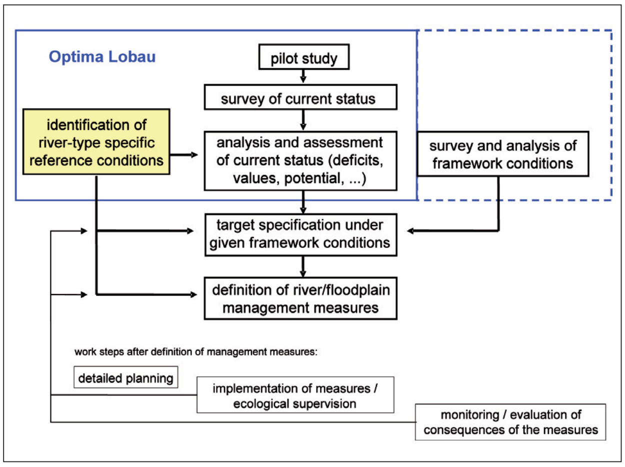


Figure 3. Scheme showing the role of the research project Optima Lobau in a planning process (modified after Muhar et al. 2003)

Acknowledgement

The study was conducted in line with the proVision-project “Optimized management strategies for the Floodplain Lobau, Austria – based on a multi criteria decision support system”. We are thankful for the great teamwork of Iris Baart, Christine Habereder, Gertrud Haidvogl, Severin Hohensinner, Stefan Preiner and Gregori Stanzer. This work was partly funded by the Austrian Ministry of Science (ProVision 133-113), the Federal Ministry of Agriculture, Forestry, Environment and Water Management, the Federal Ministry of Transport, Innovation and Technology, Municipal Authorities of Vienna, the provincial government of Lower Austria and the Nationalpark Authority.

References

Faucheux S, Froger G, Munda G (1998): Multicriteria Decision Aid and the “Sustainability Tree”. In: Faucheux G & O’Connor M (eds) Valuation for Sustainable Development – Methods and Policy Indicators. Edward Elgar, Cheltenham, Northampton

Hargrove WL, Wilsom RM, Snethen DD (2005): Developing and implementing locally led watershed restoration and protection strategies. River Basin Manag. III. Transactions on Ecology and the Environment 83, 97–109

Hein T, Blaschke AP, Haidvogl G, Hohensinner S, Kucera-Hirzinger V, Preiner S, Reiter K, Schuh B, Weigelhofer G & Zsuffa I (2006): Optimised management strategies for the Biosphere reserve Lobau, Austria – based on a multi criteria decision support system. Ecohydrology and Hydrobiology 6, 25–36

Hein T, Baart I, Blaschke AP, Habereder C, Haidvogl G, Hohensinner S, Preiner S, Reckendorfer W, Reiter K, Schuh B, Stanzer G, Weigelhofer G (2008): Optima Lobau: Future scenarios for a sustainable management perspective of an urban floodplain. In: 4th ECRR Conference on River Restoration, Proceedings

Hohensinner S, Jungwirth M, Muhar S, Habersack H (2005): Historical analyses: a foundation for developing and evaluating river-type specific restoration programs. Internat. J. River Basin Manag. 3(2), 87–96

Muhar S, Poppe M, Schmutz S, Egger G, Melcher A (2003): Analyse und Ausweisung naturräumlicher Flusstypen Österreichs. Österreichische Wasser- und Abfallwirtschaft 7–8, 113–121

WWF (1999): Evaluation of wetlands and floodplains areas in the Danube river basin. Final report of the Danube Pollution Reduction Programme, 85 pp

Weigelhofer G, Blaschke AP, Haidvogl G, Hohensinner S, Reckendorfer W, Reiter K, Schuh B, Hein T (2006): Optima Lobau: An interdisciplinary scientific approach evaluating future scenarios in an urban floodplain. Proceedings 36th International Conference of IAD, Austrian Committee Danube Research / IAD, Vienna