Assisting integrated planning on waterways by modeling techniques - the Integrated Floodplain Response Model INFORM

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1 Why integrated planning?

Performing construction and maintenance works on German Waterways may cause interference with and impact on the adjacent environment due to functional hydro-ecological interrelations. If there is evidence for significant impact on nature caused by executing waterway training measures, the Waterways- and Shipping Administration (WSV) by law has to arrange for suitable compensation measures (BNatSchG 2009; UVPG 2010).

Nowadays integrated planning which means involving relevant stakeholders in a timely manner and at an early stage considering all impact related pathways is thought to be an appropriate means to realize a calibrated planning of constructional measures. In fact a commonly agreed planning process is likely to result in a project having only little impact on nature and environment. Additionally targets of European legislation like the EU-Water Framework Directive (EC 2000) and the respective National Water Management Plans can obviously be covered by applying such a procedure. As waterborne and riverine habitats hold a high portion of protected European Natura 2000 sites (EEC, 1992) and major parts of German Waterways are nominated as Natura 2000 sites a precautious handling of waterway planning is required. Even in an international perspective an integrated planning approach is supported by the World Association for Waterborne Transport Infrastructure PIANC, promoting its “Working with Nature” position (PIANC 2008).

Though the WSV already goes along with nature related aspects and stakeholders in their projects, especially for considering nature related impact a methodology being able to predict and evaluate ecological impact due to constructional interference is needed to assist effectively integrated planning particularly in early realization stages. In the scope of WSV tasks this allows for re-designing intended measures giving the opportunity to select such a planning alternative having only weak impact on nature, having a mitigating effect on impact or even having a positive effect on floodplain ecology. Because of a political shift in assignment of WSV tasks within the context of national and European nature and water-related legislation (BMVBS 2009) construction or maintenance works on waterways have to take care for ecological aspects in order to dispose both sustainable navigation and intact valuable nature.

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2 Assisting planning by modeling with INFORM

Against this background the German Federal Institute of Hydrology (BfG) developed the software system Integrated Floodplain Response Model INFORM (Fuchs et al. 2003). Its main goal is to support the evaluation and decision process during the planning stage of WSV measures along German waterways. The modeling framework allows predicting the impact on habitats of plants and animals due to natural or anthropogenic interference in riverine hydrology and morphology. Key and innovative components of INFORM are the biotic models (Rosenzweig & Hettrich 2007). These models in principle map and predict the occurrence probability, the distribution or the abundance of riverine organisms or habitats controlled by the specification of environmental predictor variables. At present models for vegetation (MOVER), carabide beetles (MOCAR), molluscs (MOMOR), macro-invertebrates (MOBER) and fish (MOFIR) are included.

INFORM is realized as an ArcGIS™ 9.3-Extension for ArcMap with corresponding toolbar, programmed by C# and Python. In ArcMap the so-called project-tree, a window similar to the table of contents, helps organizing each project with all its contents (Figure 1). The realization of INFORM as ArcGIS™ extension enables to create spatially explicit model results.

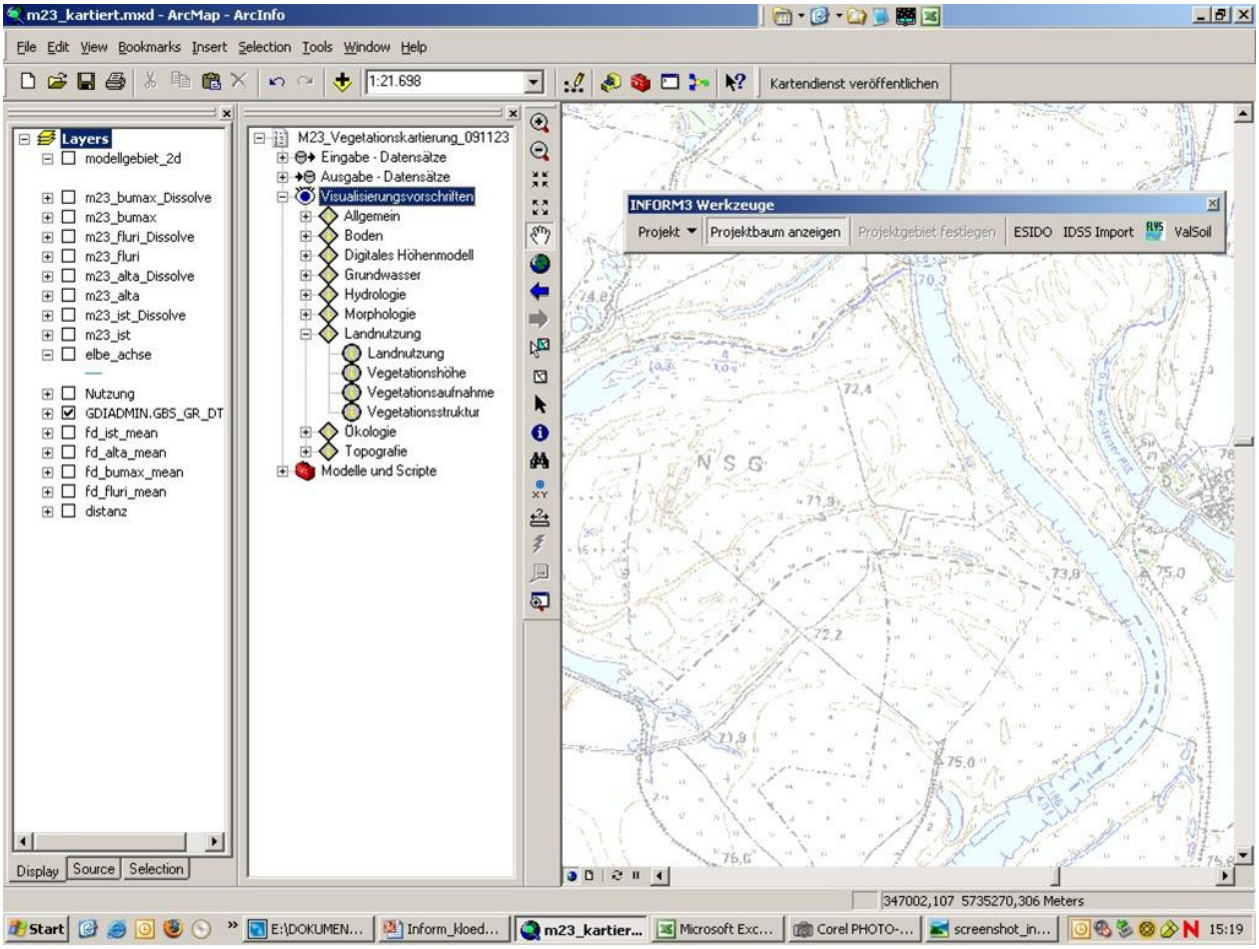

Figure 1. *Graphical user interface of INFORM*

The system architecture of INFORM is set up modular. This allows for joining new components according to various development levels or to clean up not needed or out-dated components. The currently available system components are illustrated in Figure 2.

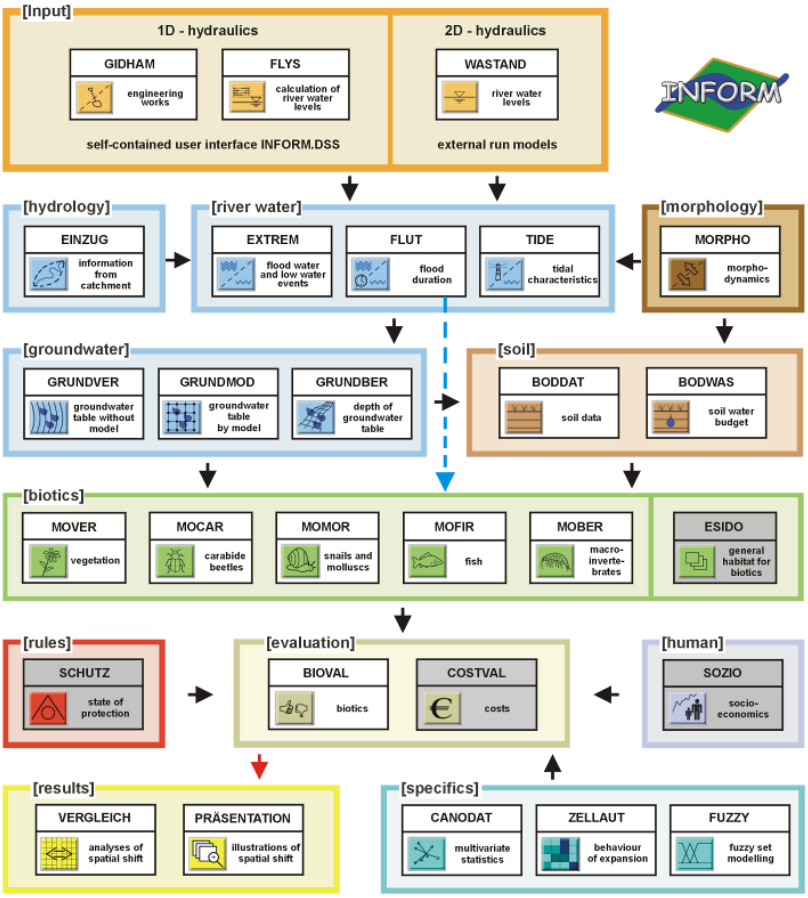

Figure 2. *System components of INFORM*

Implemented habitat models mainly base on empirical knowledge of the main functional interrelations in the floodplain ecosystem. Water of course is the main driver in this system. River water levels, the duration of inundation as well as parameters of the soil and groundwater budget are for example used as predictor variables for riverine vegetation.

A rough automatic evaluation of the predicted habitat situation can be performed. This is done in a formalized way using criteria applied in environmental impact assessment or environmental risk analyses. INFORM additionally offers to communicate to stakeholders and share their expertise and position when evaluating and discussing model results. Implementing their point of view in a multi criteria assessment, at present performed in a verbal argumentative manner, is the last step to come to an agreed decision on an optimum solution for a specific planning alternative.

Using this evaluation process INFORM can help to optimize the planning of measures by selecting designs that are ecologically meaningful and by avoiding expensive compensation measures.

3 Applying INFORM

Along the course of the River Middle Elbe a stretch of about 170 km length (rkm 120-290) is heavily affected by river bed erosion (BfG 2004). The subsequent decline in water levels probably will affect stability of river training constructions, groundwater and soil water budget of the adjacent floodplains, and potentially floodplain ecology. A bundle of optional counteracting solutions to mitigate or even stop the decline in water levels has already been set up (WSV 2009).

Applying INFORM will help the WSV for selecting measures from an ecological perspective. This decision support refers to the modeled impact on riverine plant or fauna habitats calculated by INFORM on the base of pre-computed hydraulic effect of each optional constructional measure (by Federal Waterways Engineering and Research Institute, BAW). Predicted change in vegetation pattern in the floodplain or in habitat quality for different fish species in groyne fields for example will give clear evidence on the ecological measure related alteration.

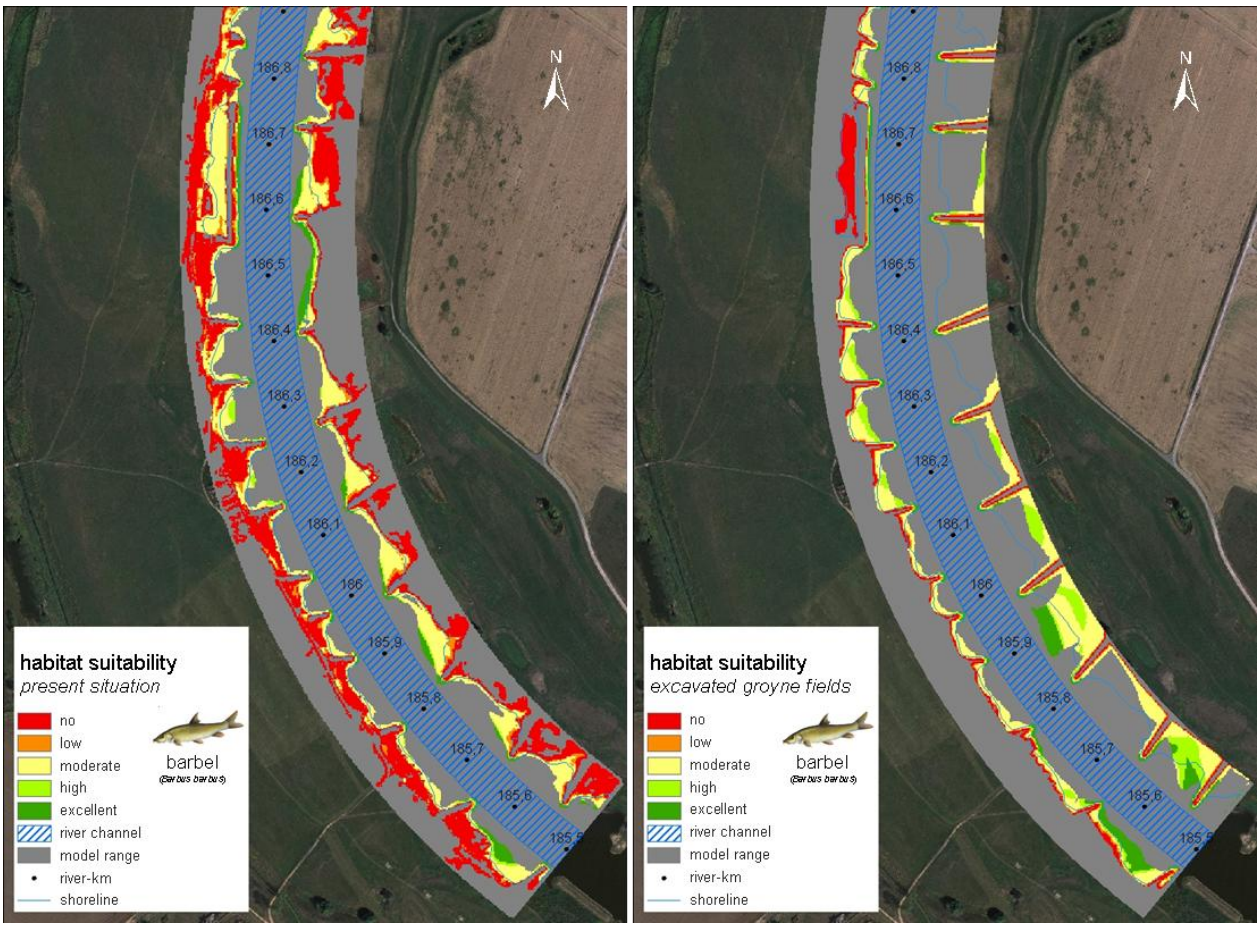

Figure 3. *Detail of pilot area "Klöden" showing the impact on the adult fish species barbel (Barbus barbus) modeled by INFORM (biotic model MOFIR 2) due to excavation of sediment filled groyne fields, on the left: initial state, to the right: future state, both referring to a situation of mean water discharge*

An example of use illustrates the effect of excavating groyne fields on the fish species barbel (*Barbus barbus*) in the pilot area Klöden (Elbe rkm 185-195, Figure 3). At present these groyne fields do not fulfill their initially intended hydraulic effect as they are filled with sediments due to omitted maintenance in the last decades. Sediment excavation aims at restoring the hydraulic effectiveness of groynes leading to

reduced flow velocity within the river channel compared to the present situation. The morpho-hydraulic effect of this measure was modeled by the Federal Waterways Engineering and Research Institute (BAW). The biotic fish habitat model MOFIR 2 of INFORM predicts the habitat suitability for fish species (various fish cohorts) in relation to the predictor variables flow velocity, water depth, substrate of river bed, and the potential to hide.

Side-strips of the river close to the bank offer only poor living conditions for the barbel in the present situation. Excavation of groyne fields upgrades this situation by creating habitats of moderate to good quality for the adult barbel. This is of interest for the Middle Elbe region as the barbel plays a significant role for nature quality and fishery.

Evaluating the measure related effects on habitat alteration will result in advice for selecting or refusing a measure from an ecological point of view. In addition to the desired effect on hydraulics the selection of appropriate measures for mitigating river bed erosion at the mid-reaches of the River Elbe will include the effects on nature predicted by ecological modeling techniques. Obviously this process of well-considered and comprehensive pre-planning will finally result in a well-founded planning accepted and agreed by involved stakeholders and decision makers.

4 Conclusion

Applying the hydro-ecological software INFORM enables to assist the planner and decision maker in the Waterways and Shipping Administration in an early planning stage in taking optimum decisions targeting at only weak river training related interference with nature or even promoting nature. This option based on innovative modeling techniques will contribute to an integrated planning process where all relevant stakeholders are included in discussing measure related impacts by means of a transparent and comprehensible way.

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