7th International Conference on Hydroinformatics
HIC 2006, Nice, FRANCE

AIMS AND FUNCTIONS OF THE NOFDP IDSS

CHRISTOPH HÜBNER
Institute of Hydraulic and Water Resources Engineering
Darmstadt University of Technology, Petersenstrasse 13, 64287 Darmstadt, Germany

AXEL WINTERSCHEID
Institute of Hydraulic and Water Resources Engineering
Darmstadt University of Technology, Petersenstrasse 13, 64287 Darmstadt, Germany

The August 2005 flood in the Alpine Region was just one of a series of severe flood events in recent times. However, it caused damage amounting to several hundreds of million Euros and casualties. Again the public demanded for better future flood protection supported by technical solutions. At the same time, politicians realised again the difficulties and existing conflicts in finding appropriate and effective solutions. The nofdp (**n**ature-**o**riented **f**lood **d**amage **p**revention, www.nofdp.net) project is embedded in the Interreg III B programme, an initiative of the European Commission aiming at the promotion of interregional cooperation within Europe. The project has the ambitious target to harmonise and balance the various conflicts of interests in flood management. One of the projects objectives is to develop a modular and integrative **I**nformation and **D**ecision-**S**upport **S**ystem (IDSS). The IDSS aims to support water managers in developing regional flood damage prevention strategies by means of a progressive decision making process. This technique ensures to achieve a balanced view in the planning procedure. The methodology of a priori and progressive decision-making and the resulting IDSS concept is presented.

SCOPE OF THE IDSS

The acronym IDSS stands for Information and Decision Support System. The IDSS is designed to assist water managers in developing flood risk management strategies, which keep track with a balanced view on the often conflicting issues of spatial planning, water management and ecological development. The IDSS is specially designed for the use in small and medium scale river basins. The overall objective is to develop a system that is modularly structured, open source and free of charge for the user [1]. In that way, this decision support software intends to be a strong foundation for further development and enhancement by the later user community.

The process of scanning and evaluating the advantages as well as disadvantages of a multitude of possible flood damage prevention measures and locations is a prerequisite for the development of strategies or conceptual plannings. We define this phase as the pre-planning procedure. The IDSS is designed for this particular purpose and not to support an expert's opinion aiming at the dimensioning of measures and execution planning. To support water manager and decision makers the IDSS provides the following functionalities:

– a comprehensive catalogue including different types of measures to be tested,
– an impact/effect assessment for each measure,
– an evaluation of each variant to be tested, where a variant refers to a number of coordinated measures,
– communication of the results by means of reports and maps and
– A Priori and Progressive Preferences Articulation to support the decision-making procedures

New technology like the Open Modelling Interface & Environment (OpenMI) [2] allows to connect the IDSS to modelling systems, which are also equipped with the OpenMi interface. The IDSS does not introduce new modelling systems to replace existing and well-validated models. By implementing the OpenMI standard it is possible to use the synergies of already modelled results and information gained.

Planning is an iterative process. Plans and strategies under development have to be discussed, evaluated and communicated in order to receive feedback and information for improved planning proposals. The IDSS supports this iterative process, by means of a priory preference articulation process, which is expandable to A Progressive Preferences Articulation in order to seek improvements for previously discarded solutions.

PROGRESSIVE DECISION MAKING

The Decision Maker (DM) is confronted with a set of solutions that must be considered as a compromise between multiple objectives and choices determined by the available alternatives. Thus, the decision outcome results from both solution search and decision processes. The decision process always includes the DM's preference articulation. In Decision Support Systems this preference articulation is mostly represented with a vector function, which assigns a weight to each objective and constitutes the multipliers for the value functions.

Even though some authors define finer grades most authors [3-5] define three grades of the decision process. The final decision results from the DM's articulation of preferences, which is known either *before*, *during*, or *after* the solution search process. This is more formally declared as follows:

A Priori Preference Articulation. *(Decide ⇒ Search)*
DM combines the differing objectives into a vector function.

Progressive Preference Articulation. *(Search ⇔ Decide)*
DM and solution search are intertwined. Partial preference information is provided upon which solution search occurs providing an "updated" set of solutions for the decision maker to consider.

A Posteriori Preference Articulation. *(Search ⇒ Decide)*
DM is presented with a set of candidate solutions and chooses from that set.

By the A Priori Preference Articulation the DM has to define the vector function. In this case the multi-criteria decision problem is transformed into a single-objective search problem. The principle process is shown in Figure 1, derived from [3].

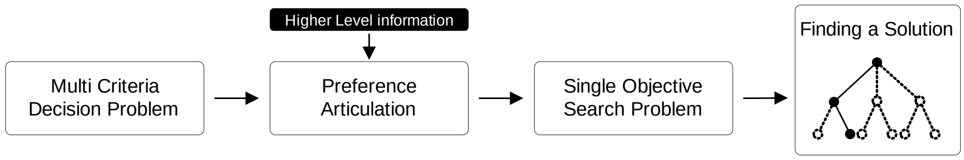

Figure 1: A Priori Preference Articulation.

The intertwined search and decision process by the Progressive Preference Articulation can be realised in manifold ways. In the case of the IDSS the Progressive Preference Articulation is an enhancement of the previously described A Priori Preference Articulation. The decision process is considered as an iterative process and in each cycle preferences can be modified and criteria can be added based on the experiences and feedback reactions gathered in the previous cycle. The principle process is depicted in Figure 2.

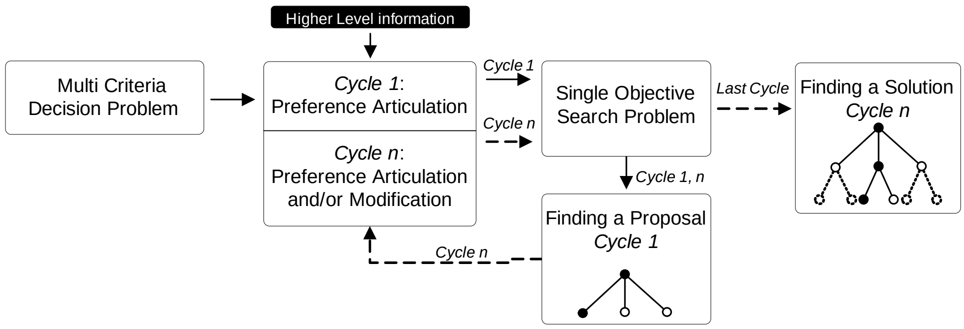

Figure 2: Progressive Preference Articulation

Decision making by means of A Posteriori Preference Articulation presupposes that the whole decision space is explored and all optimum solutions are found. Due to the small changes of the starting parameters a multitude of evaluation cycles are required. Therefore, the value assessment has to be fully automated. In this case criteria value assignment cannot be done manually. The principle process is depicted in Figure 3, derived from [3].

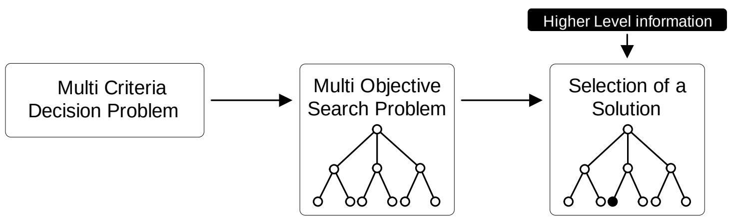

Figure 3: A Posteriori Preference Articulation

Multi-criteria optimisation algorithms, for instance Multi-Criteria Evolution Strategy [5] or Multi Objective Genetic Algorithms [6], are suitable for finding a set of best solutions for multi-criteria problems.

WORKFLOW OF THE IDSS

In a first step the user must setup a project and add basic information like project location, project duration and partners involved. The setup process includes operations like uploading and establishing links to data and information. The IDSS will mainly be GIS-based due to the spatial characteristics of most data and information.

Subsequent to the project setup the user primarily selects a certain type of measure from the catalogue and then implements the measure at any desired location within the project area. An assistant will guide the user through the steps needed for a rough dimensioning of the measure. An optional number of measures can be realised in a project.

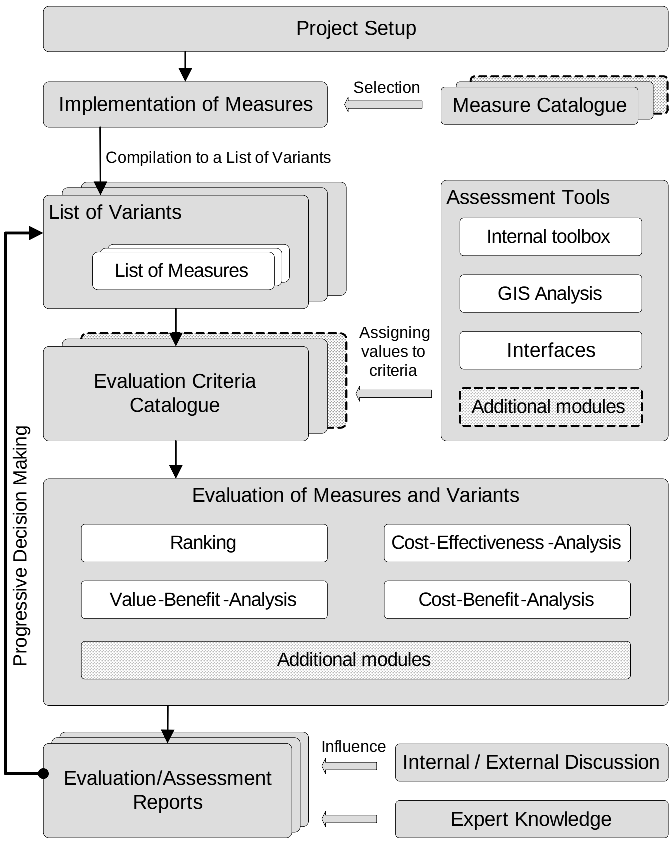

Figure 4. Workflow and software components of the nofdp IDSS.

After this the user groups optional selections of measures to variants. The IDSS will provide catalogue of standard criteria to continue with the evaluation procedure. Additional criteria can be added by the user taking into account the particularities of the project area. Before starting the evaluation procedure values must be assigned to the criteria. For this purpose the IDSS provides functionality that facilitates an automated value assessment. If the database is limited not all evaluation criteria can be allocated with values. In such a case values have to be estimated and can be added manually. This guarantees that knowledge can be gathered from all different kind of sources.

The criteria and the vector functions are input to four possible evaluation procedures, where complexity and data requirements increase from 1) to 4):

1. Ranking Analysis
2. Value-Benefit-Analysis
3. Cost-Effectiveness-Analysis
4. Cost-Benefit-Analysis

It will be possible to add other methods like dynamic-cost-comparison-analysis.

The IDSS workflow supports the Progressive Preference Articulation depicted in Figure 2. Result of the analysis is an evaluated set of solutions, which serves as information input for subsequent debate. Presuming that one of the solutions constitutes a compromise accepted by all parties involved the decision process is considered to be finished. In the case that none of the solutions are satisfying the decision making path will be restarted. But now knowledge and experience from the previous cycle is available.

AUTOMATED VALUE ASSESSMENT

The IDSS will provide respective tools that will supporting an easy handling of the GIS functionality, in particular to improve the handling of the IDSS for users with little GIS and modelling experience. Interfaces like OpenMI and others are also classified as assessment “tools” because they deliver information and data from existing models and systems.

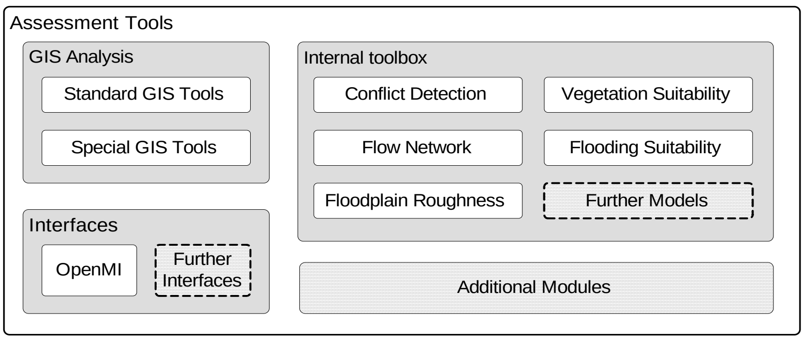

Figure 5: The primary delivered assessment tools.

GIS Analysis

A number of sequential GIS operations will be summarised for an easier assessment of evaluation criteria including spatial information. It is assumed that these functionalities are not generally provided by a GIS like simple layer overlay function.

Internal Toolbox

The IDSS will include a simple and fast but robust toolbox to provide a prognosis of effects / impacts on hydraulic, ecological values and changes spatial patterns.

Table 1: Overview of modules included in the internal toolbox

Name of the module	Functionality
Conflict detection	This module is designed to consider the needs related to spatial planning on a regional scale by means of an overlay of flood risk maps or inundation maps with zoning plans. Using the information included in deficit maps of physical river quality, this module provides functionality for conflict detection on a local level along the river.
Flow network	A simple GIS-based model will provide functionality to test measures with respect to hydraulic effects (discharge and water levels). Flood routing will be described by the empirical Kalinin-Miljukov equation in a node-channel flow network. The module will be equipped with an OpenMI interface.
Floodplain Roughness	Based on a known vegetation pattern (= map) this module uses knowledge tables to determine roughness values as input factors for the flow network module or an external hydraulic model.
Vegetation Suitability	This module is based on the MOVER model [7]. Based on a knowledge table (if-then relation) with flooding frequency and type of land use as main input parameters a new layer with predicted potential vegetation distribution will be created. Application of the existing knowledge table is so far limited to low-land rivers located in the Netherlands and Belgium as well as the north-western part of Germany.
Flooding Suitability	This module analyses the suitability of an area for water retention. Attributes (land cover layer, inundation map, inundation duration, recurrence interval and season of flooding) are linked to a knowledge table (based on the STOWA method [8]). Application of the STOWA knowledge table is limited to lowland rivers located in the Netherlands and Belgium as well as the north-western part of Germany.

Interfaces

The above mentioned tools provide information in an easy way of handling. The target group consists of water manager and not of modelling specialists. The choice of system for these users is likely to be a GIS or a Decision Support System (DSS) [9]. The IDSS combines GIS and DSS technology and enhances the potential of those systems by using the OpenMI Interface. This interface enables an easy coupling with externally operated models (e.g. water quality model or advanced hydraulic models) presuming those are also equipped with OpenMI. The ability to automatically generate integrated modelling runs increase the power and usefulness of DSS.

MODULARITY

Due to the multitude of particularities of a case there is no holistic catalogue of criteria as well as no automated value assessment of criteria. Assessing knowledge like ecological effects and demand for future spatial planning are in most cases subjected to qualitative or so-called soft data and information.

Therefore, the IDSS will be designed as an open and modular system. The modularity will be realised by means of an implemented "extension interface", which allows adding other assessment tools, evaluation methods, interfaces, evaluation criteria, types of measures to the primarily delivered system. In Figure 4 and Figure 5 positions for additional modules and interfaces are depicted as dotted boxes.

CONCLUSION

At present many Decision Support Systems for catchment management are developed, but in most cases they are not transferable to other catchments. The used data und functionality are mostly determined by the particularities of one catchment. This contribution presents an Information and Decision Support System that is transferable to other catchments. The modular structure provides the flexibility to enhance the system according to the needs pre-determined by the characteristics of the catchment characteristics. Existing and therefore validated models can be incorporated into the iterative decision process making use of the OpenMI interface and the possibility to add alternative interfaces. Supporting A Priori and Progressive Preference Articulation the IDSS supports the reintegration of unsorted feedback and other information back into the next cycle of the preplanning procedure. The IDSS architecture is a step forward to holistic Decision Support Systems.

ACKNOWLEDGMENT

The here presented IDSS concept is a joint product of the nofdp project. Special thanks

goes to Stephan Rosenzweig, Peter Horchler (both German Federal Institute of Hydrology), Piet van Iersel (Water Board Brabantse Delta) and Jac Slikker (Provincie Noord Brabant) for their fruitful and fundamental contributions to the overall IDSS concept.
This project has received European Regional Development Funding through the INTERREG III B Community Initiative.

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