Integrated Hydrographical Basin Management. Study Case – Crasna River Basin

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Abstract. Hydrographical basins are important from hydrological, economic and ecological points of view. They receive and channel the runoff from rainfall and snowmelt which, when adequate managed, can provide fresh water necessary for water supply, irrigation, food industry, animal husbandry, hydrotechnical arrangements and recreation. Hydrographical basin planning and management follows the efficient use of available water resources in order to satisfy environmental, economic and social necessities and constraints. This can be facilitated by a decision support system that links hydrological, meteorological, engineering, water quality, agriculture, environmental, and other information in an integrated framework.

In the last few decades different modelling tools for resolving problems regarding water quantity and quality were developed, respectively water resources management. Watershed models have been developed to the understanding of water cycle and pollution dynamics, and used to evaluate the impacts of hydrotechnical arrangements and land use management options on water quantity, quality, mitigation measures and possible global changes. Models have been used for planning monitoring network and to develop plans for intervention in case of hydrological disasters: floods, flash floods, drought and pollution.

MIKE HYDRO Basin is a multi-purpose, map-centric decision support tool for integrated hydrographical basin analysis, planning and management. MIKE HYDRO Basin is designed for analyzing water sharing issues at international, national and local hydrographical basin level. MIKE HYDRO Basin uses a simplified mathematical representation of the hydrographical basin including the configuration of river and reservoir systems, catchment hydrology and existing and potential water user schemes with their various demands including a rigorous irrigation scheme module.

This paper analyzes the importance and principles of integrated hydrographical basin management and develop a case study for Crasna river basin, with the use of MIKE HYDRO Basin advanced hydronformatic tool for integrated hydrographical basin analysis, planning and management.

1. Introduction

Integrated management is a concept with a definition that is interpreted and understood in a different ways. It is widely accepted as recognizing “nonlinear processes and connectivity between problems” in a managerial context.[1] Integrated management has been defined as encompassing the “effective direction of every aspect of an action so that the needs and expectations of all stakeholders are equitably satisfied by the best use of all resources”. [2] Characteristics of the integrated management
are consensus-based decision-making, search for optimal efficiency and the co-existence of both uniformity and diversity within systems.[3]

Integrated hydrographical/river basin management is the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems.[4]

Hydrographical basins are important from hydrological, economic and ecological points of view. They receive and channel the runoff from rainfall and snowmelt which, when adequate managed, can provide fresh water necessary for water supply, irrigation, food industry, animal husbandry, hydrotechnical arrangements and recreation. The need to conserve and manage freshwater ecosystems at the basin scale is increasingly being recognised by governments and NGOs.[5]

Hydrographical basin planning and management follows the efficient use of available water resources in order to satisfy environmental, economic and social necessities and constraints. This can be facilitated by a decision support system that links hydrological, meteorological, engineering, water quality, agriculture, environmental, and other information in an integrated framework.[5]

To achieve integrated management a hydrographical basin requires advanced operational and strategic policy development and planning. For providing information on the existing situation tracking, collection and processing of data systems are used, as well as tools and systems that help in making decisions for alternative future policies and action plans.[6]

Management process involves three stages: documentation – provide the list of problems for each affected resource usage or an explanation of the causes of changes suffered; planning - must provide solutions for each identified problem and intervention - tracking the effects should allow evaluation of results.[6]

The principles of integrated hydrographical basin management are included in many national legislations and international agreements:

1. Watersheds are natural systems that we can work with.
2. Watershed management is continuous and needs a multi-disciplinary approach.
3. A watershed management framework supports partnering, using sound science, taking well-planned actions and achieving results.
4. A flexible approach is always needed,[7].

The benefits resulted from the used principles of integrated hydrographical basin management: it provides a context for integration - using practical, tangible management units that people understand, focusing and coordinating efforts, finding a common ground and meeting multiple needs; it provides a better understanding and appreciation of nature: understanding nature’s interrelated processes, helping to answer the question, “What are we trying to protect?”, linking human activities to the nature’s response, appreciating how nature’s processes can benefit people, identifying ways to work with watershed processes; it yields a better management, by generating ecologically-based, innovative, cost-effective solutions, forging stronger working relationships and supporting consistent, continuous management.[7]

A successful integrated hydrographical basin management is based on following elements:

- a long-term vision for the hydrographical basin, agreed on by all the major stakeholders,
- integration of policies, decisions and costs across sectoral interests,
- strategic decision-making at the hydrographical basin scale, which guides actions at sub-basin or local levels,
- effective timing, taking advantage of opportunities as they arise while working within a strategic framework,
- active participation by all relevant stakeholders in well-informed and transparent planning and decision-making,
- adequate investment by governments, the private sector, and civil society organisations in capacity for hydrographical basin planning and participation processes,
- a solid foundation of knowledge of the hydrographical basin and the natural and socio-economic forces that influence it.\[8\]

In the last few decades different modelling tools for resolving problems regarding water quantity and quality were developed, respectively water resources management. Watershed models have been developed to understand the water cycle and pollution dynamics, and used to evaluate the impacts of hydrotechnical arrangements and land use management options on water quantity, quality, mitigation measures and possible global changes. Models have been used for planning monitoring network and to develop plans for intervention in case of hydrological disasters: floods, flash floods, drought and pollution.

2. MIKE HYDRO Basin

MIKE HYDRO is the common Graphical User Interface framework for Water Resources products of MIKE by DHI. Embedded in one setup editor, MIKE HYDRO offers a state-of-art, map centric user interface for intuitive model build, parameter definition and results presentation for water resources related applications.\[9\]

MIKE HYDRO Release 2014 includes the following modules: Basin module (MIKE HYDRO Basin) and River module (MIKE HYDRO River). MIKE HYDRO Basin is a versatile and highly flexible model framework for a large variety of applications concerning allocation, management and planning aspects of water resources within a river basin. Typical basin module applications: integrated water resources management (IWRM) studies; provision of multi-sector solution alternatives to water allocation and water shortage problems; reservoir and hydropower operation optimisation; exploration of conjunctive use of groundwater and surface water; irrigation scheme performance improvements.\[9\]

MIKE HYDRO Basin is a multi-purpose, map-centric decision support tool for integrated hydrographical basin analysis, planning and management. MIKE HYDRO Basin is designed for analysing water sharing issues at international, national and local river basin level. MIKE HYDRO Basin models generally utilise a river network and sub catchments within the specific river basin as basic model-data; features include: river routing, water users (regular as well as irrigation users), hydropower and reservoirs, hydrology (rainfall-runoff simulations), groundwater, global ranking of water users, reservoir sedimentation and water quality options using ECO Lab.\[9\]

A simplified mathematical representation of the river basin is defined including the configuration of river and reservoir systems, catchment hydrology and existing and potential water user schemes with their various demands including a rigorous irrigation scheme module (figure 1).\[9\]

The benefits to use MIKE HYDRO Basin are: can design model layouts exactly as required, using embedded GIS features and functionalities; creation of a unique overview of the spatial and temporal data in the river basin; development of inspiring workshops for learning, trouble shooting or consensus building discussions with live scenario modelling and creation of the exact maps, graphs and tables need for public presentations.\[10\]
3. Case study

Crasna river basin is located in the North-Vest of Romania (figure 2). Crasna river is a transboundary water course, a subject of Romanian - Hungarian bilateral agreements. Crasna river basin area, to the border with Hungary, is 2120 km², representing 0.9% of the country. The average altitude of the basin is 237 m. The length of the river Crasna is 134 km (from spring to exit the country border), and the average slope of the course is 3 ‰. The slopes decrease from over 10 ‰ in spring area, 0.1 - 0.5 ‰ in the plain zones, approaching zero in the lower areas.
The data necessary for model setup in MIKE Hydro Basin can see in figure 3.

![Figure 3. Input data and simulation scheme](image)

The Crasna river basin was divided into 7 subazins, corresponding to the hydrometrical stations (Table 1).

| River   | Hydrometrical station | Area km² | Hmed m | L spring km |
|---------|-----------------------|----------|--------|-------------|
| Crasna  | Crasna                | 211      | 422    | 22.4        |
| Crasna  | Varsolt Dam           | 327      | 386    | 27.4        |
| Crasna  | Simleu Silvaniei      | 386      | 368    | 41.5        |
| Crasna  | Supuru de Jos         | 1170     | 310    | 76.0        |
| Crasna  | Craidorolt            | 1552     | 274    | 97.5        |
| Crasna  | Domanesti             | 1705     | 261    | 119.0       |
| Crasna  | Berveni               | 2120     | 260    | 134.0       |

The land use is mostly agricultural, without water supply for irrigation from river.

Varsolt reservoir is located on the river Crasna, 1 km upstream from Varsolt and 5 km downstream from Crasna, Salaj County. The execution period was 1977 - 1979. Initially the reservoir was destined for flood control on the river Crasna and providing water for irrigation, later the functionality was changed, currently their main function being water supply and flood control. Reservoir falls into class
of importance II being the only source of drinking water supply of the cities Zalau and Simleu Silvaniei. The intake flow for water supply is 0.201 mc/s.

Another considered water use is the water supply for pisciculture (0.037 mc/s for four months), existing polder near Berveni village is used for fishery.

There were not considered issues related to groundwater.

Hydrological data (discharges, specific runoff etc.) necessary for simulation have been taken from various documentations and studies owned by Romanian National Water Authority “Apele Romane”, Somes-Tisa Basin Administration.

The simulation period is 1 year, time step 1 month.

4. Results and discussions

The obtained results from simulation are:
- For each river node: net flow to node, unallocated water, inflow and outflow, mass balance, water leaving model area (figure 4 and figure 5)
- For each catchment: runoff and mass balance (figure 6)
- For branches: flow, seepage loss, evaporation loss, water depth and mass balance (figure 7)
- For water use: relative deficit, water demand deficit, used water, net flow to node, unallocated water and mass balance (figure 8).

Figure 4. Results for river nodes
Figure 5. Water leaving model area

Figure 6. Results for catchment
The case study was realized on simple river basin, without many water usages, just two, with low flow discharges. On Crasna River there are not major hydrotechnical arrangements, except Varsolt reservoir with 14 m height dam. River Crasna has no major tributaries that significantly modify the regime of the flow. This situation is shown by similar forms presented in the graphs.

The quantity of water leaving model area is important from the point of view of bilateral agreements between Romania and Hungary.
5. Conclusions
The important steps in integrated hydrographical basin management are the policy making, planning and management. These goals must be identified and specified to the basin management problems in order to be resolved and achieve these goals. The identified strategies for problems solve must thank to all the factors involved.

Therefore, we need different management scenarios. The most adequate instruments to find the answer to these scenarios of hydrographical basin are advanced hydrometric tools. Based on comparing the results obtained by its use, it can be made a technical and economic analysis of various management strategies. Finally, the result is the most efficient and convenient management plan that meets sustainable development principles.

References
[1] L. Bizikova, D. Swanson and D. Roy, “Evaluation of Integrated Management Initiatives,” International Institute for Sustainable Development, 2011 (http://www.iisd.org/sites/default/files/publications/evaluation_integrated_management.pdf).
[2] Dalling, “Integrated Management Definition,” Chartered Quality Institute Integrated Management Special Interest Group, Issue 2.1, 2007.
[3] Dalling, “Integrated Management Definition,” Chartered Quality Institute Integrated Management Special Interest Group, Issue 2, 2007.
[4] Global Water Partnership, “Global Water Partnership,” Technical Advisory Committee Background Papers, No. 4, 2000.
[5] http://wwf.panda.org/about_our_earth/about_freshwater/rivers/irbm/river_basin_approach/
[6] http://www.environheal.pub.ro/
[7] https://cfpub.epa.gov/watertrain/pdf/modules/watershed_management.pdf
[8] http://wwf.panda.org/about_our_earth/about_freshwater/rivers/irbm
[9] MIKE by DHI, “MIKE HYDRO User guide,” Horsholm, Denmark, 2014.
[10] http://www.mike-by-dhi.com/mikebydhisoftwarecatalogue2012uk.pdf
[11] www.slideshare.net/mltan4/lecture4hydro