Use Case C2: The impact of climate change on the reliability of building a reservoir (NTUA)

1. Short description of the case

Even though Pili subbasin was initially suggested as the Use Case B area, a discussion with people from the Thessalia local authorities directed the OpenMI application to a different Pinios subbasin. Use Case B focuses on the operation and reliability of the Smokovo reservoir located on the northwest part of the Thessaly Water District, Greece. The reservoir is situated on the confluence of two smaller streams. A total area of approximately 376km^2 contributes flow to the reservoir. There are many points of unregulated groundwater pumping in the greater area, which have significantly lowered the water table. In that manner, no major groundwater resources are estimated to contribute to the reservoir. The reservoir has to satisfy the following water uses:

- Adequate flow to support the ecosystem along downstream, along Sofaditis river
- Water to support the local municipalities (~55000 permanent residents)
- Sufficient water for the required energy production at Leontari hydroelectric station
- And most importantly, enough water volume for the increasing irrigation needs. More specifically, the Smokovo reservoir aims to supply 25000 ha of agricultural land, through a pressured pipe network, thus limiting the extensive use of boreholes. Today, small part of the network, 1800 ha, is finished and other 3700 ha are irrigated through small barrages.

2. Identification of the management / policy issue

There are various concerns related to the optimum operation of the Smokovo reservoir. Future climatic changes may place under stress the operation of the reservoir and its design specifications. The objective of the study is to evaluate how the effects of climate change may affect the effort to maintain reliable yields for all different water uses and suggest solutions for optimum water allocations. Since many different parties benefit and request different reservoir water allocations, investigating an optimum solution accepted from everyone is not an easy task. An integrated modelling approach will allow taking into account all essential water balance components and decision dependent water abstractions at runtime and improve the understanding of water availability and demand in the area. The OpenMI standard allows for the linking of a commercial model (MIKE11) to an in-house reservoir management model (RMM-NTUA) to support the objectives of the analysis.

3. Solution to these management / policy issues

A hydrologic model and a reservoir management model will be linked to analyse the study area. Since the compliant version of MIKE-SHE was not available at the beginning of the OpenMI-Life project, MIKE-11 was chosen to discharge input through the NAM module. The RMM-NTUA will be migrated in OpenMI and the end-users will set up the scenarios, identify the links, populate and link the models. Evaluating the linked system during extreme events will provide input to the Competent Authorities about the optimum use of the reservoir.

4. Setting the objectives

The present study objectives are the following:

Specific use case objectives

Use the OpenMI standard to achieve the following:

- Examine the reliability of the reservoir during the selected calibration and validation period of three years, according to present and future demands
- Evaluate how different rainfall scenarios may impact the reliability of the reservoir operation
- Assess the impact various water allocation scenarios relatively to the different rainfall events
- Focus on specific sectors separately and investigate the possible impact of extreme events on them
- Improve regional decision making and existing policies implementations
- Prioritise and optimise possible actions taken and their expenses to secure the reliable reservoir operation
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Wider perspective objectives

Take advantage of the OpenMI standard ability to link models in runtime and achieve the following:

- Connect models created from different developers, in different languages, with different control specifications.
- Acquire better understanding and improve the representation and the way different processes interact in the basin
- Evaluate whether the simulation results have improved or not by using the OpenMI standard and under which scenarios
- Test the behaviour of a hypothetical scenario involving a system of 2 reservoirs in the area using bi-directional links

5. Defining the actions

5.1 Preconditions for linking models

In order to start linking the models, the following actions should be completed:

First, the modeller should decide on the selection of the necessary models to perform the analysis:

- The present study will link a hydrologic module of MIKE11 to an in-house reservoir management system, RMM-NTUA. RMM is built in Delphi by the ITIA research group in NTUA. MIKE11 is already OpenMI compliant while RMM-NTUA should migrate in OpenMI to communicate with MIKE-11
- Thus, as a next step, OpenMI, Visual C#, NUnit, and language compilers should be installed on the computer. Also, the model codes should be available to the people that will work on the migration process.

Finally, the selected models must be set up for the study area. Five years of precipitation and stage data (2002 to 2007) will be used to calibrate and validate the models. The calibration will be furthermore supported by field surveys and data from the Ministry of Environment and Public Power Corporation.

5.2 Actions for the definition phase

5.2.1 Define the hardware environment

The present study will use personal PCs for modelling purposes.

5.2.2 Define the interactions to be modelled

The node where information is exchanged between MIKE-11 and RMM-NTUA is the confluence of the 2 streams downstream the Smokovo reservoir. The study will include two more nodes at areas where there are geometric characteristic changes and there is a need to assess the parameters.

5.2.3 **Define the links**

One-direction links will initially be used in the study. The NAM module accepts the time dependent input of rainfall and provides flow rate (m^3/sec) from two subbasins. Depending on the various scenarios run and the operational rules, the reservoir accepts the estimated discharge and returns an output flow rate (m^3/sec) to the river. The hydrologic and the reservoir model will initially share the same time step, for simplicity reasons. In the future (when a system of two reservoir models will be used as an hypothetical scenario) the links will change to bi-directional

5.2.4 **Define and correct the gaps**

It is not sufficient to relate inputs to outputs to have a proper model but to represent adequately the variation of parameters within the catchment. For that reason, if required, the models will run on different time steps. Instabilities due to the boundary conditions imposed to MIKE-11 will also be examined.

5.2 Actions for the iterative phase

- Perform the model migration steps as described in the training
    - Convert engine to .dll
    - Create two .Net assemblies, one for the Wrapper and one for the Testing classes
    - Test the migration using the NUnit Framework
    - Load the compliant component into the OpenMI Editor, connect with trigger and Simple River and test the compliance

To perform runs with the models not yet linked

- Run simulations and compare the simulated to the available observed values to verify that the models are correctly set up and the data are of good quality
- Test the models separately to extreme conditions and examine their stability
- Check the physical meaning of the results

To link models and to perform tests of linked runs

- Link the models and compute similar runs to the ones mentioned above

- Evaluate the differences (if any) between the results of the respective scenarios

To solve the problems, encountered during the tests

- Re-examine the quality of the input data
- Check whether the shared variables are correctly linked in time and space
- Check the units
- Repeat the tests to see whether the issues are resolved

5.4 Actions for the demonstration phase

- Run a representative scenario for the area, where are observed values to compare results
- Run a couple of scenarios that will provide input to decision makers, forecast, or suggest solutions to the pollution issues

5.5 Actions for the evaluation phase

- Examine whether using the OpenMI interface provides an added value to the analysis or which scenarios may benefit more from using OpenMI
- Evaluate the effort needed from potential End-Users to employ the OpenMI technology and simulate their case studies
- Examine whether added value is provided from the implementation of OpenMI when a second reservoir downstream of Smokovo contributes also to the area.

6. Milestones, deliverables, success scenarios

The first results of successful model linking in this case study are expected by the end of February 2007. The milestones are divided, as suggested, into two categories:

6.1 Technical Milestones

- The hydrologic and reservoir models are OpenMI compliant
  - o Test new model migration using the NUnit Framework
  - o Check whether the models can communicate in OpenMI
- Models are successfully linked
  - o Run scenarios with and without the OpenMI linking and produce reasonable (and comparable) results

- Input is provided to the OpenMI technical group related to the learning process and the implementation process of the OpenMI interface

6.2 Use Case Specific Milestones

- Different scenarios of reservoir operation are examined
    - Different rainfall conditions are considered and the reliability of the reservoir is tested
    - Scenarios examining different water allocations are created
    - The impact of extreme events to different parties water demand is evaluated
    - Conclusions are drawn and input is given to all interested parties
- The Competent Authorities get trained as OpenMI End Users and employ the OpenMI compliant models of the present study to create and evaluate their own scenarios