Multipurpose optimization of water resources management in a complex semi-arid catchment area

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The overarching goal of the *African Dams Project: Adapt planning and operation of large dams to social needs and environmental constraints (*ADAPT) is to strengthen the interdisciplinary science of integrated water resource management (IWRM). New models for real-time control and multi-objective optimization of large hydraulic structures will be created and data resources and conceptual frameworks which drives and integrates these models will be enhanced.

The study will focus on the Zambezi River Basin (ZRB), located in the East part of the African continent (Figure 1). From its headwaters in Angola to the delta in Mozambique, the Zambezi River runs over 2600 km and connects eight African nations that share different portions of its 1.4 Mio km^2 large drainage basin: Angola (18.3%), Namibia (1.2%), Botswana (2.8%), Zambia (40.7%), Zimbabwe (15.9%), Malawi (7.7%), Tanzania (2.0%) and Mozambique (11.4%). The average annual rainfall in the basin is about 1000 mm yr^{-1} but only ~7% (70 mm yr^{-1}) discharges to the Indian Ocean (compared to ~50% runoff in Switzerland). Current water use is mainly limited to hydropower production through a series of impoundments: Kariba Dam between Zambia and Zimbabwe, Kafue Hydropower scheme consisting of the Kafue Reservoir and the Itezhi-Tezhi Reservoir, 450 km upstream of the Kafue Dam, and Cabora Bassa Reservoir in Mozambique. The upper Zambezi has a natural flow regime. About 40 new hydropower plants with a total installation capacity of more than 13,000 MW have been proposed in the basin.

Figure 1 : Geographical position of the Zambezi river basin

The research project aims to develop a generally applicable methodology, which allows the multipurpose optimisation of water resources management in a complex semi-arid catchment area. Environmental aspects, hydraulic concerns and energy and economical issues have to be considered. The following objectives will be achieved during the thesis:

- In **step A,** a hydrologic-hydraulic model of the whole catchment area will be set up including all relevant elements such as hydraulic structures, wetlands, flood plains, groundwater exchanges, runoff, etc. It will be derived from the code *Routing System,* used for flood management in the Upper Rhone River. The hydrological part of the models will be calibrated and validated and the operation rules of the power plants will be defined based on the available data.
- In **step B**, scenarios will be developed based on the economic evolution of the basin evaluated in a parallel PhD thesis. They will include the new dams and hydropower schemes planned. A climate change scenario will be elaborated with collaboration of external specialized laboratories. The impact of the scenarios will be quantified in term of flood and drought cycles.
- In **step C,** a progressive optimisation and decision support tool, integrated in the hydrological model, will be developed in order to determine the optimal water management scheme. It will be based on fuzzy logic approach.

A literature review on hydrologic-hydraulic modelling of large semi-arid catchment has been conducted. It underlined the problem of data scarcity and the necessity to use novel data sources. Consequently, the initial problematic assessed in this PhD thesis was the development of a database used as input and validation sets for the hydrologic-hydraulic model. Since measured data are scare in this region, satellite derived data have been analysed and compared to the few available meteorological stations. The research plan has been accepted in October 2009. The planning of the different steps is presented in the Table 1.

Table 1 : Planning of the research project

Activity	2010		2011		2012	
Step A: Hydraulic-hydrological model						
Step B: Scenario development and implementation						
Step C: Optimisation of water resources management						

Keywords: **hydrological-hydraulic modelling, satellite-derived data, water resources management, optimization.**