In-class exercise #1: Framing the problem is the problem itself

The goal of this exercise is to give you intuition on setting up model-based decision support for water management and planning given conflicting interests and uncertainties. We will inspect the Nile case as it embodies typical challenges of large transboundary river basins.

Nile River Basin context:

The Nile is the largest river in northeast Africa spreading over 10 countries. The Nile's basin supplies riparian countries with water for hydro-power generation, municipal, industrial and agricultural consumption, with more than a dozen reservoirs scattered in Egypt, Sudan and Ethiopia. The rights over the water resources in the Nile have been contested for years. Egypt, the most downstream country with respect to its riparian position, has historically drawn the largest benefits from the Nile water resources. However, Egypt's claimed historical right over the Nile's resources has been challenged by Ethiopia with the unilateral decision to build the Grand Ethiopian Renaissance Dam (GERD) in 2011, intensifying political tensions in the eastern part of the Nile Basin. Ethiopia's ambition with the GERD is to exploit unfulfilled hydro-power potential of Ethiopian highlands and contribute to poverty alleviation, and claim that completely blocking the flow of water will be of no interest to them. Nonetheless, downstream countries Sudan and Egypt view the project as a threat to their water security and independence.

The GERD will be among the world's largest dams with its projected total storage capacity of 74 billion cubic meters (BCM). Particular concern of the downstream water users is the filling period of GERD's large reservoir. Although negotiations to reach a consensus over a filling scenario remain in a state of deadlock with increased tension between parties. Further, the Nile system is vulnerable to hydroclimatic extremes, such as droughts and floods, as well as demographic challenges produced by a fast-developing economy, political instability and armed conflicts. Please refer to references [2] and [3] to learn more about the system.

Your role as an analyst is to provide decision support in the Blue Nile Basin by finding filling strategies and the water allocation policy after the filling of the newly built GERD, that are able to balance conflicting interests and water uses between the involved parties, *i.e.* across Sudan, Ethiopia and Egypt. Further, you will need to provide the insights about the expected system's vulnerabilities to hydroclimatic extremes (*e.g.* floods and droughts) and demographic uncertainties (*e.g.* population growth, and water uses).

Step 1. High level conceptualization of the problem. The main deliverable of this exercise is an XLRM diagram (Figure 1) of the Nile case.

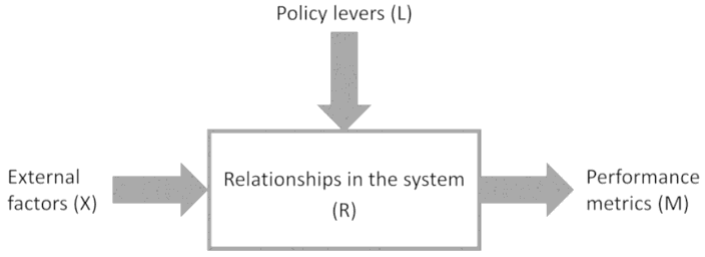

Figure 1. Diagram of the XLRM framework.

The XLRM framework [1] is meant to guide policymakers when dealing with deep uncertainty, *i.e.* when the likelihood of different future scenarios is under debate. In the XLRM framework; variable X refers to exogenous factors, L are the policy levers or decisions, R are the relationships between decisions (L) and the system performance, while M represent performance metrics to evaluate the suitability of alternative decisions.

Answer the following questions to help you brainstorm during the construction of your XLRM diagram.

1) Who are the actors involved?
2) What are the actor's interests?
3) How can the goals of each actor be conceptualized?
4) How can the goals of each actor be assessed?
5) What water infrastructure components are relevant for our model?
6) What natural phenomena do we need to understand in order to evaluate the impacts of filling strategies and of reservoir operations?
7) What are the decision variables, *i.e.* the aspects of the system which we can control?
8) What are the relevant decision and management scales? e.g. how often do we need to make decisions?
9) What are the system boundaries? *e.g.* the relevant spatial scales for our modeling exercise?
10) What are the relationships that we need to understand?
11) Are the relationships well understood?
12) What data would you need to understand those relationships?
13) What are potential uncertainties in the system, *i.e.* exogenous variables that we cannot control?
14) Are there any constraints in the system?
15) What data do you need to understand the impacts of different planning and management alternatives in a system?

Step 2. Prepare your XLRM diagram, it does not have to be perfect, but try to capture the problem from as many perspectives as possible, and justify why the components of the XLRM are important to perform the analysis.

References

[1] R. Lempert, S. Popper, and S. Bankes. Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis. RAND Corporation, 2003. ISBN 9780-8330-3275-1. doi: 10.7249/MR1626.

[2] Wheeler, K.G., Jeuland, M., Hall, J.W. *et al.* Understanding and managing new risks on the Nile with the Grand Ethiopian Renaissance Dam. *Nat Commun* **11**, 5222 (2020). doi: 10.1038/s41467-020-19089-x

[3] S. G. Yalew, J. Kwakkel, and N. Doorn. Distributive Justice and Sustainability Goals in Transboundary Rivers: Case of the Nile Basin. Frontiers in Environmental Science, 8, Feb. 2021. doi: 10.3389/fenvs.2020.590954.