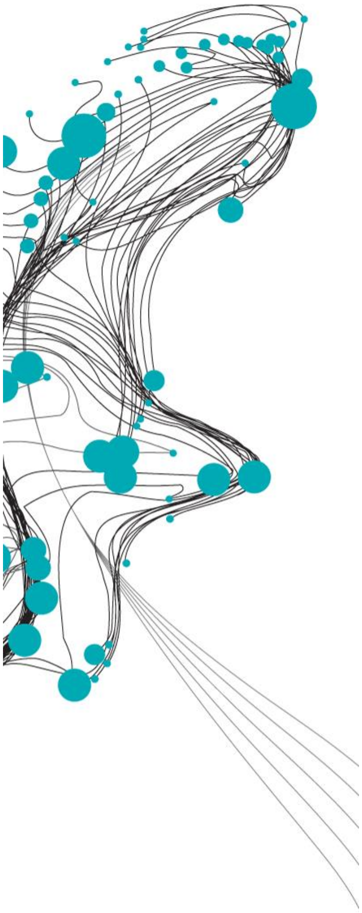

# MINIMIZING WATER SHORTAGES AND OPERATIONAL COSTS OF A WATER SUPPLY SYSTEM BY PROVIDING DECISION SUPPORT

## A CASE STUDY IN LA PAZ, BOLIVIA

The citizens of the La Paz – El Alto metropolis in Bolivia depend on a natural system of catchments for their drinking water. The water supply consists of different source regions which are connected to multiple water treatment plants (WTPs). This natural system is subject to an annual meteorological pattern with a wet season usually occurring from December until April, while the remainder of the year is dry. To provide drinking water during the entire year, reservoirs have been constructed to store water and are connected to the WTPs.

In 2016 La Paz experienced its worst drought in 25 years, which resulted in a water rationing period of two months, affecting over 400.000 of its 1.6 million citizens. The water scarcity problems are mainly caused by a rapid urban expansion. In 2018 two river intakes were built where water can be transported directly from a river to a WTP for additional supply. Using these intakes can mitigate or prevent water shortages but introduce additional operational costs. Furthermore, these intakes make the operational control of the water supply system more complex. This thesis focuses on an optimal real-time control and provides decision support for the river intakes.

Rainfall-runoff models were built to determine the hydrological boundary conditions of the different catchments. Uncertainty in future precipitation was addressed by introducing precipitation scenarios. The combination of a limited intake capacity and a variable potential intake discharge makes it preferable to plan and execute the control on the intakes well in advance. To make such a proactive control possible, the precipitation scenarios need a time horizon of at least one year.

An optimization approach was implemented that can determine the least costly operational control of the water supply system based on a given set of initial conditions and future discharges. The decision about which scenario to use depends on the desired trade-off between water shortage and operational costs, see Figure 1 for this trade-off. The decision maker should consider to what extent water shortages are acceptable and what budget is available for using the intakes. Ultimately the decision is about the balance between the risk of having a water shortage in the future and the costs of lowering this risk. When the decision maker has determined the preferred balance, the decision support on real-time control will provide advice on a strategic level of how much water to take in and how to distribute it over to the different WTPs.

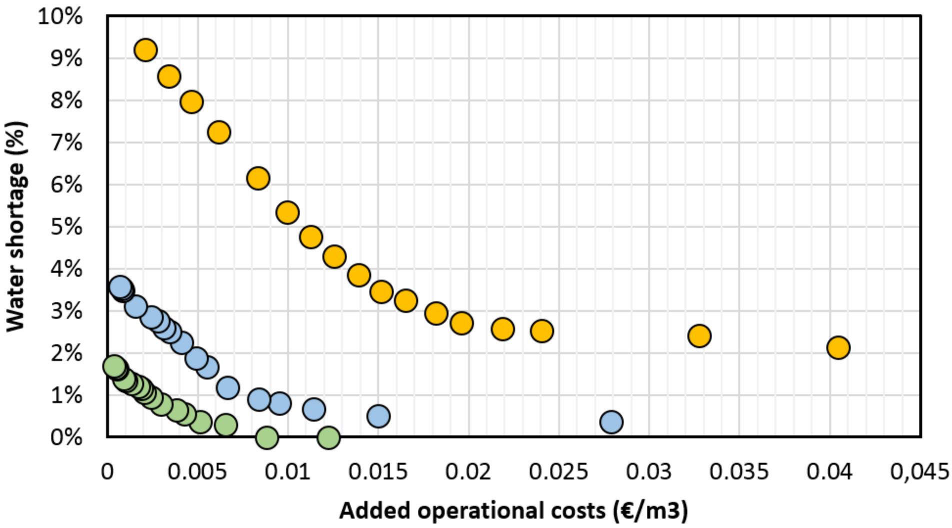


*Figure 1:* Trade-off between water shortage and additional operational costs per $m^3$ of delivered water, green, blue and yellow represent the situations for 2018, 2022 and 2027, respectively.

**Hidde Kats**

**Graduation Date:**
12 June 2019

**Graduation committee:**
*University of Twente*
Dr.ir. M.J. Booij
Dr. M.S. Krol

*Royal HaskoningDHV*
Ir. H.G. Nomden
Ir. R. Huting

UNIVERSITY OF TWENTE.