Interactions and feedbacks between water availability and domestic consumption in São Paulo Metropolitan Area

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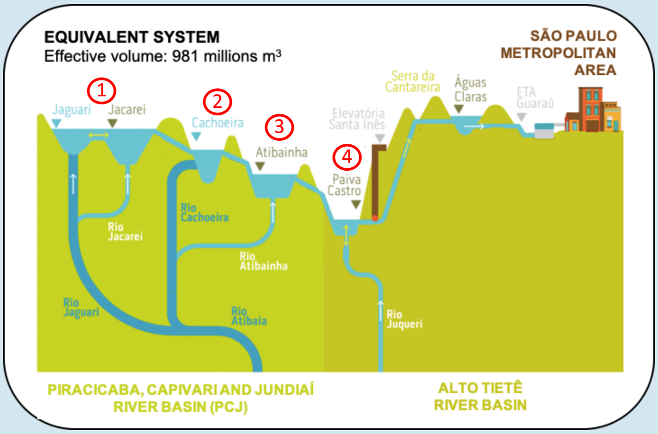


Figure 1 – Graphic representation of the Cantareira System. Adapted from ANA (2017)

Introduction

Water supply in large cities has challenged governments and water authorities because of the complexity involved in meeting water demands. The traditional challenges stem from the seasonality of precipitation and population growth.

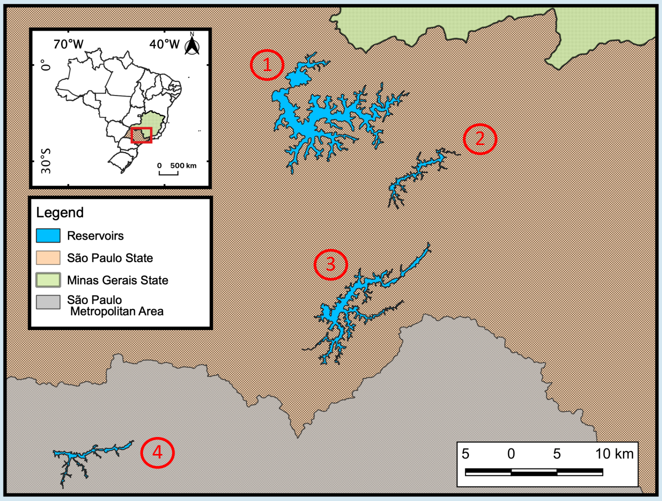


Figure 2 – Location of reservoirs

Although water resources management strategies assume potential scenarios for water demand growth to design water infrastructure, unexpected changes in the hydrological cycle may cause shocks to urban water supply systems and generate unanticipated patterns of consumption, such as occurred during the water crisis experienced by the São Paulo Metropolitan Area (SPMA) from 2014 to 2016.

Satellite imagery of reservoir 3

09/Feb/2012 **01/Jan/2015**

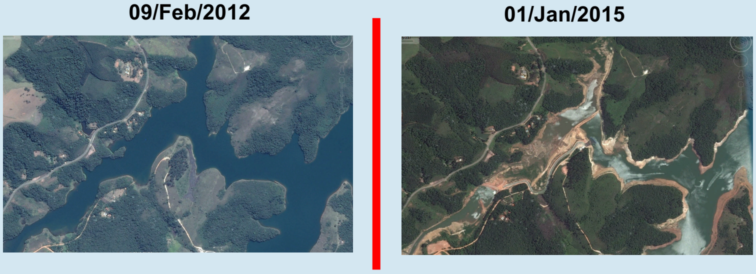


Figure 3 – 23°12'S; 46°23'W. (Google Earth, 2019)

This work explores the coevolution of the coupled human-water system variables associated with the water supply system within the SPMA, from the late twentieth century to the present, to explain how water demand has influenced water availability, and vice-versa, for the Cantareira Reservoir System.

The challenges facing the human-water system in the region are of critical importance, given that it supplies water to more than 9 million people, and it supports economic activities that represent 12% of Brazil's Gross Domestic Product.

Volume @ Cantareira System (hm³)

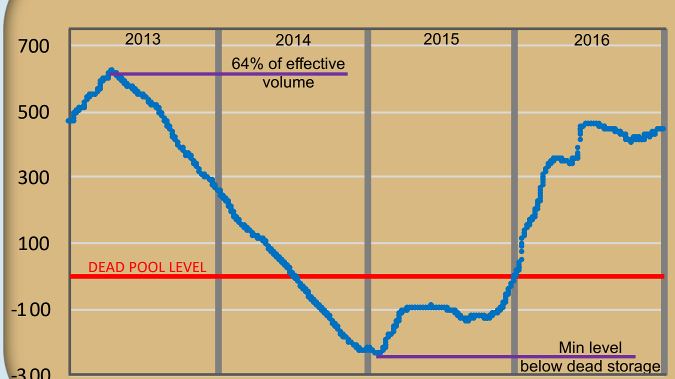


Figure 4 – Storage volume at the Cantareira System

Origin of the problem

Three facts together resulted in the worst water crisis in SPMA: i) dry months with precipitation below the historic records (Figure 5); ii) low inflows into the reservoir (Figure 6); iii) increasing demand because of population growth (Figure 7).

The Cantareira system alone does not deliver water to the entire population of the SPMA, but it was responsible to supply water to almost 9mi citizens.

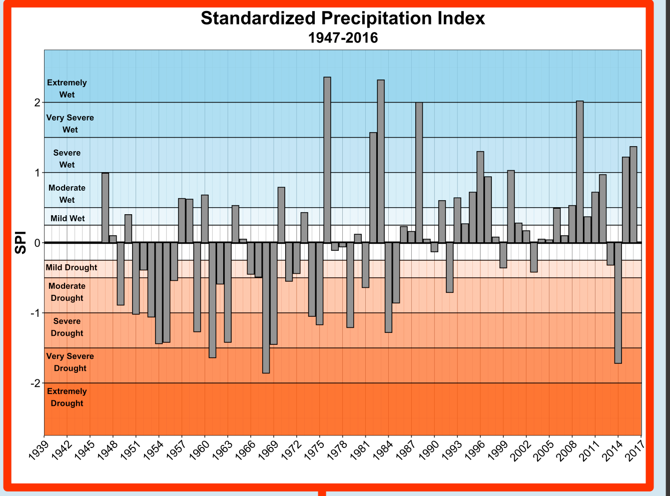


Figure 5 – SPI in São Paulo City

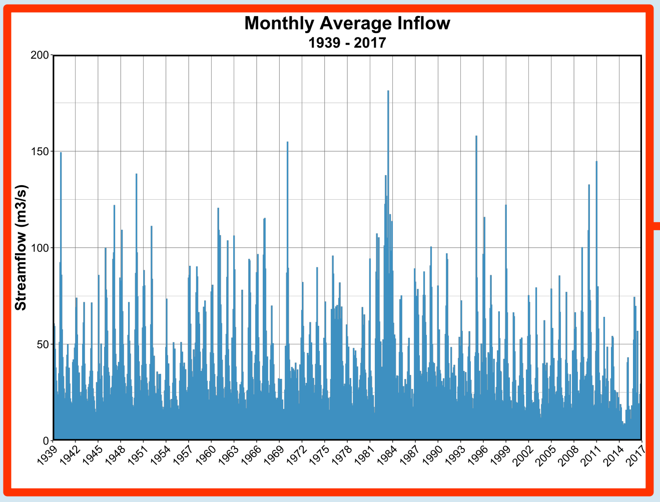


Figure 6 – Historical inflow into the Cantareira System

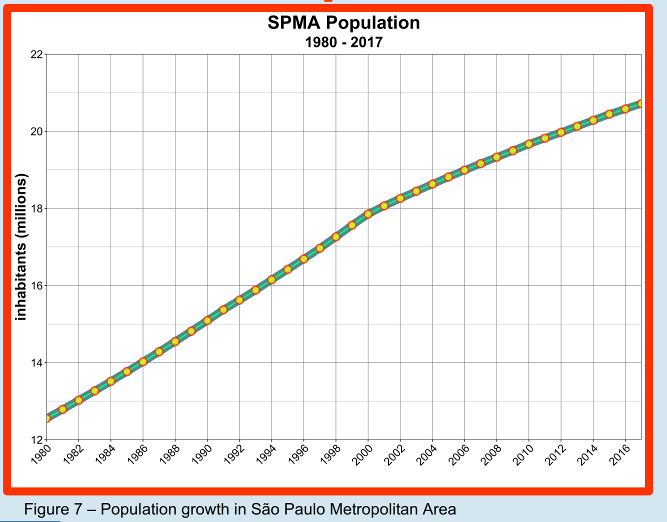


Figure 7 – Population growth in São Paulo Metropolitan Area

Decisions made to overcome the crisis

The local water facility, SABESP, successfully managed the crisis to avoid the complete water scarcity in the region. A sequence of structural and non-structural strategies were implemented to reduce the water consumption and fill up the Cantareira reservoirs (Figures 8 to 10).

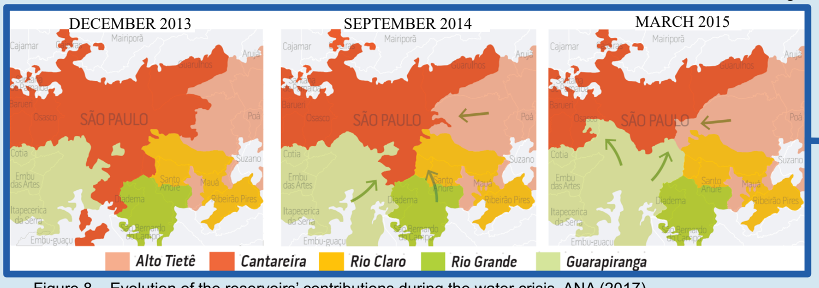


Figure 8 – Evolution of the reservoirs' contributions during the water crisis. ANA (2017)

Fewer people served by the Cantareira system

New pipelines and existing connections between reservoirs supplied water to the regions that were previously supplied by the Cantareira system.

Water conservation policies

Citizens reduced their consumption because of new tariffs and awareness campaigns.

Water consumption per residence (m³/month) in SPMA

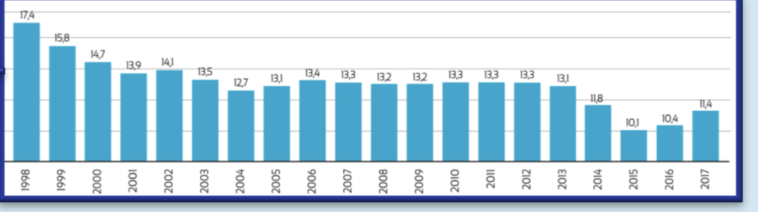


Figure 9 – Changes in domestic water consumption observed between 1998 and 2017. FABHAT (2019)

Leakage rate in SPMR (L/connection*day)

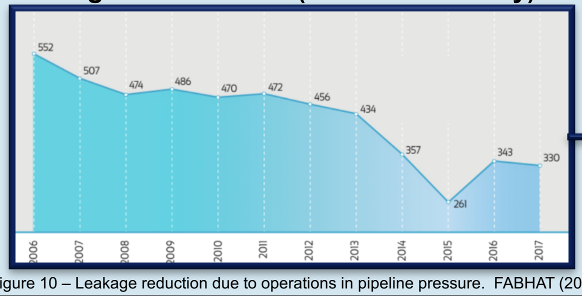


Figure 10 – Leakage reduction due to operations in pipeline pressure. FABHAT (2019)

Leakage reduction

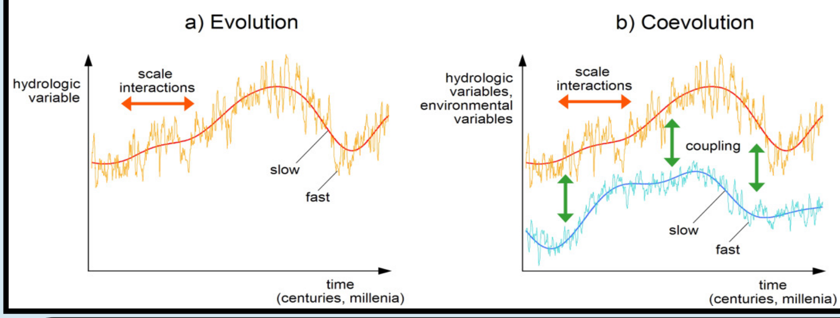
The water facility implemented new operations to reduce water pressure and, consequently, decline the leakage rate.

Why the socio-hydrology approach?

The causality relation between water availability and water consumption (Figure 12) illustrates the concept of coevolution between human-water systems described by Sivapalan and Blöschl (2015). The socio-hydrology approach can provide a broader understanding of the water supply dynamics within the São Paulo Metropolitan Area.

Although Figure 12 presents the total abstraction from the Cantareira system by the SPMA, in Figure 13 we observe that the consumption behavior is heterogeneous. Regions, with different social aspects, respond differently to the same water conservation policies and might have different willingness to pay/adapt.

Figure 11 – Sivapalan & Blöschl (2015)



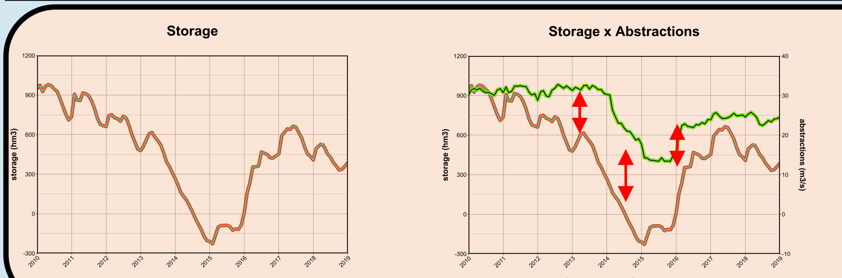


Figure 12 – Interactions between water availability and water abstractions from the Cantareira system.

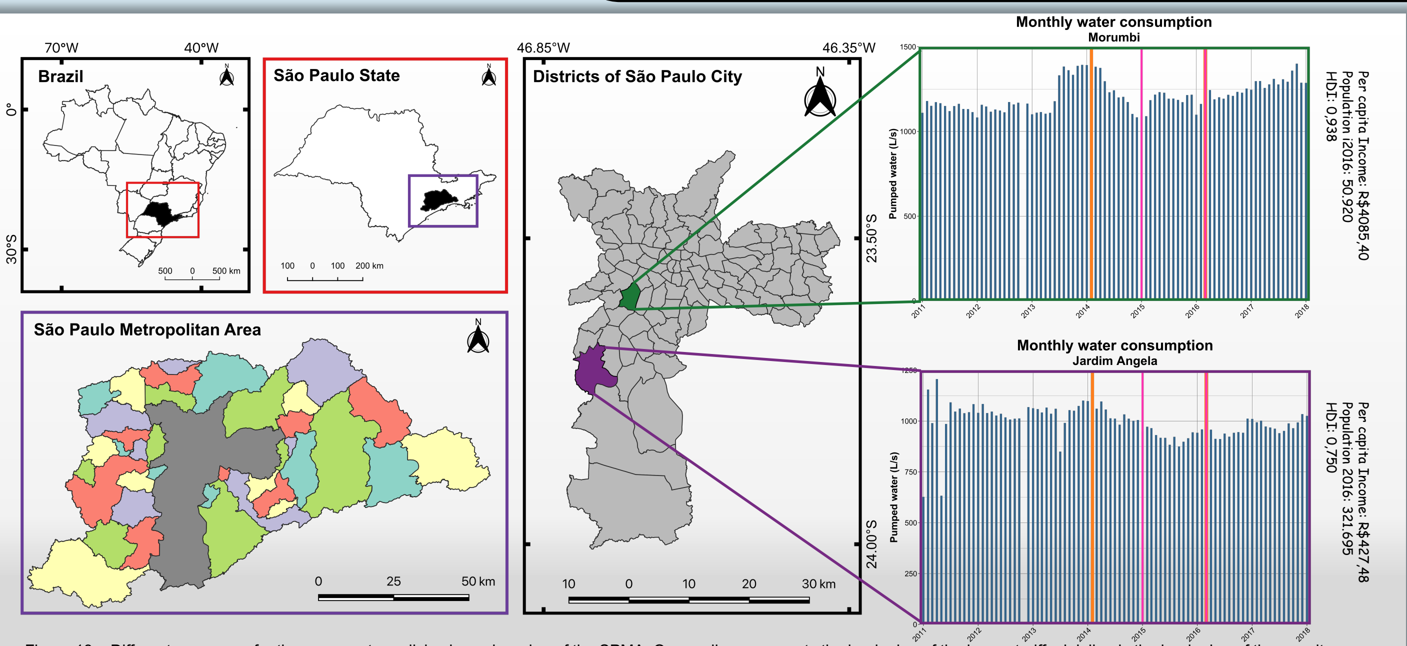


Figure 13 – Different responses for the same water policies in each region of the SPMA. Orange line represents the beginning of the bonus tariff, pink line is the beginning of the penalty tariff and the red line is the end of both tariffs. Per capita income (IBGE census, 2010), Population (SEADE, 2020), Human Development Index (RAIS, 2015).

Conclusion

We conclude that modelling the interactions and feedbacks between water availability and consumption can provide more realistic storylines to implement strategies to address water scarcity than merely considering long-term demand scenarios, as it is normally done. In addition, policies implemented to promote water savings can have different responses at sub-regional scales and this can be explored also in the context of long-term scenarios (INCT-MC2). Thus, the next step consists on implementing the causal loop diagram (Figure 14) as a socio-hydrological distributed model of the Cantareira system to capture the feedbacks at regional scale.

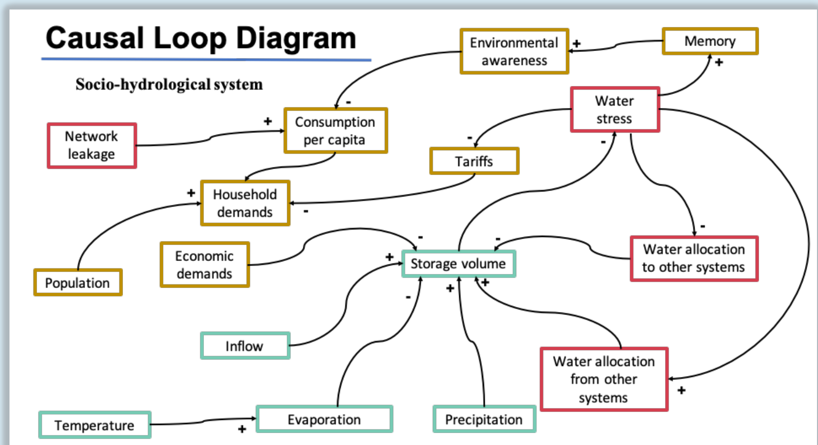


Figure 14 – Causal loop diagram of the SPMA's socio-hydrological system

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Acknowledgements:

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