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Climate threats, water supply vulnerability and the risk of a water crisis in the Monterrey Metropolitan Area (Northeastern Mexico)

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ABSTRACT

This paper evaluates the risk of a water crisis – a substantial, sudden reduction in water supply – in the Monterrey Metropolitan Area (MMA), posed by climate threats and the vulnerability of its water supply system. Our analysis of long-term precipitation, water supply and water availability data reveals that the MMA is highly vulnerable to recurring periods of exceptionally low precipitation and scarce surface water availability. We identify two episodes in the recent past (1998 and 2013) when the MMA water supply system almost collapsed as reservoirs neared depletion in the face of abnormally dry weather. Furthermore our climate projections point to warmer and drier future conditions for the region and consequently, heightened climate threats. We conclude that the risk of a water crisis in the MMA is substantial and probably will increase due to climate change. This establishes a clear and pressing need for a comprehensive package of adaptation measures to mitigate the consequences of a water crisis should one occur as well as to reduce the likelihood of such an event.

1. Introduction

1.1. Background

Water crises – in the form of significant declines in water availability resulting in harmful effects on human health and/or economic activity – are considered the number one risk the world currently faces in terms of impacts (WEF, 2015). This paper evaluates the risk of a water crisis posed by climate threats and the vulnerability of the water supply system in the Monterrey Metropolitan Area (MMA), State of Nuevo León (Northeastern Mexico).

In the face of a semi-arid climate, the MMA and its water supply and distribution system have grown massively over the last six decades. In 1954, the MMA water company served 29,630 customers (homes, businesses, factories and other types of water users connected to the distribution system) and only 55% of the slightly less than 0.5 million (M) inhabitants had access to piped water at home (CAPM, 1977). At that time, the MMA's water supply came entirely from wells located within (or at a short distance from) the urban area. Today an extensive, diversified portfolio of underground and surface water sources (including three reservoirs: La Boca, Cerro Prieto and El Cuchillo) supplies the metropolis through about 400 km of aqueducts and water ring mains (Fig. 1). The water company serves almost 1.3 M customers and over 99% of the 4.5 M inhabitants have access to piped water at home.[1]

Water issues in the MMA reach far beyond the local sphere. The MMA is Mexico's third largest urban population center and an industrial-commercial powerhouse of national importance. As the largest water user in the middle part of the San Juan River Basin (SJRB), the MMA has been at the center of regional water conflicts, in particular with downstream agricultural producers in the neighboring state of Tamaulipas (Scott et al., 2007). Furthermore, although the Treaty on the "Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande" of 1944 between the U.S.A. and Mexico (IBWC, 2015) does not contemplate the SJRB, the basin plays a significant and complex role in the bi-national relationship with respect to shared water resources. The SRJB is a sub-basin of the Rio Grande Basin and San Juan River flows that enter the Rio Grande automatically become treaty water. Moreover Mexico has had recourse on occasion to SJRB waters to satisfy its treaty obligations.

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[1] Information obtained from *Servicios de Agua y Drenaje de Monterrey* (SADM), the public water company that has served the MMA since 1954.

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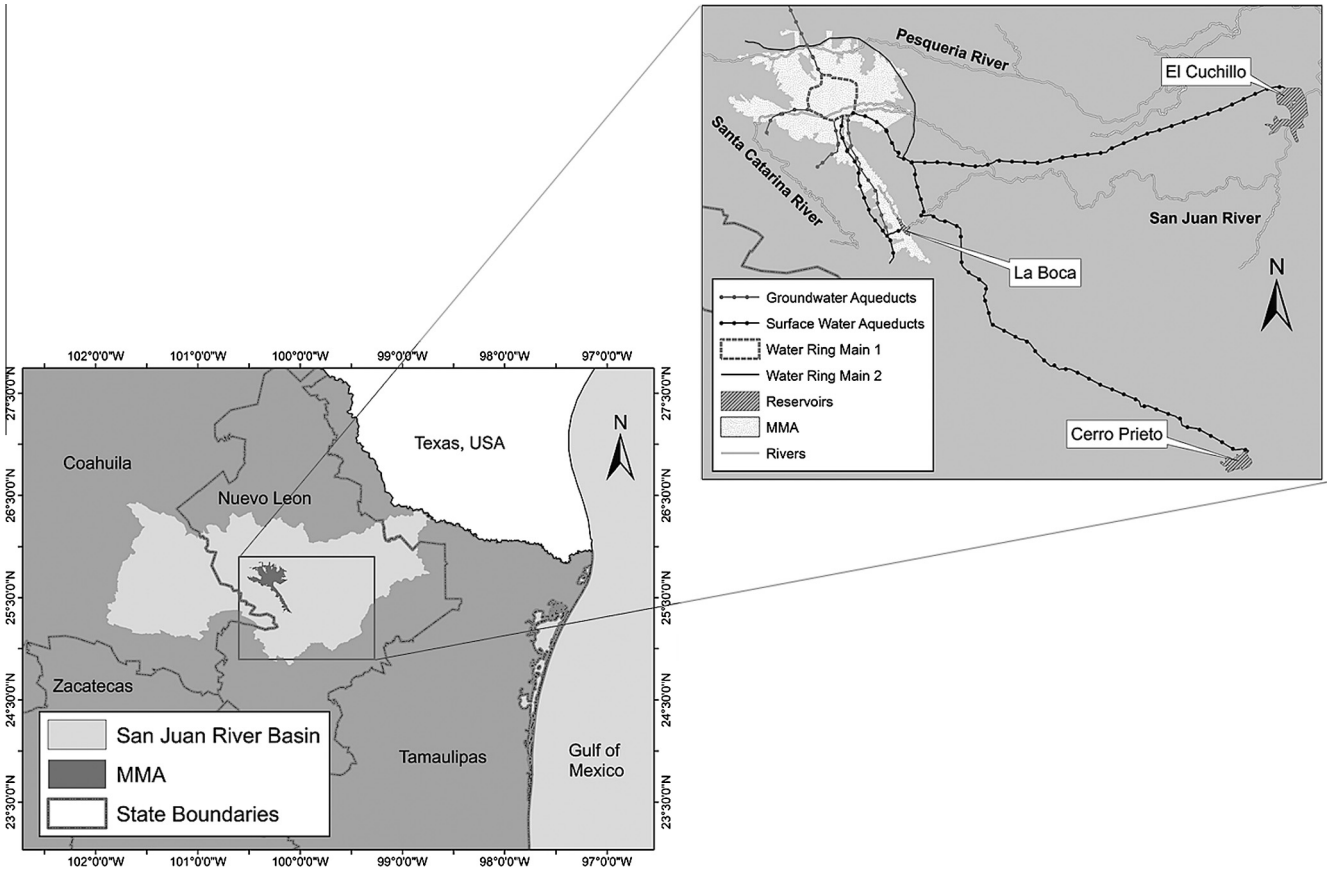

Fig. 1. San Juan River Basin (SJRB), Monterrey Metropolitan Area (MMA) and MMA water supply system. *Source:* Authors' own.

1.2. Objectives

This paper's main objective is to evaluate the risk of a substantial, sudden reduction in the supply of water to the MMA. We consider this risk a function of both exogenous climate threats and the vulnerability of the MMA water supply system. To this end, the paper proposes the following three specific objectives:

(1) To identify climate threats to the water supply system.
(2) To assess the system's vulnerability to these threats.
(3) To evaluate current and future levels of risk.

The rest of the paper is organized as follows. Sections 2.1 and 2.2 deal with the first two specific objectives, respectively. Section 2.3 tackles the third objective using historical data and Section 2.4 brings in regional climate projections. Section 3 sums up, outlines several adaptation measures to manage the risk of a water crisis and offers some final remarks.

2. Results and discussion

2.1. Climate threats

To identify climate threats to the MMA's water supply system we use monthly precipitation data for the central part of Nuevo León, where the water sources that supply the MMA are located. The precipitation data set consists of the historical records from seven weather stations operated by the *Comisión Nacional del Agua* (CONAGUA, the Mexican federal water authority).[2] Each record contains the cumulative precipitation (in millimeters per month, mm/mo) observed at a particular weather station from January 1941 to December 2014.

We use this data to compute a Standardized Precipitation Index (SPI) as originally exposed in McKee et al. (1993). This method transforms raw precipitation data into deviations with respect to a normalized historical mean value. As such, the index offers an effective means for the detection of exceptionally dry (or wet) periods in historical precipitation data series (WMO, 2012). An index value of between 1 and −1 indicates near normal conditions; values below 1 (above 1), exceptionally dry (wet) conditions. Table 1 presents the SPI value table and Table 2, basic descriptive statistics for our raw precipitation data as well as our calculated SPI values (for further details on the SPI computation procedure applied here, see the Appendix A).

The region's precipitation regime displays two main characteristics. First, overall dryness: average yearly precipitation amounts to only 616.1 mm, with a median of 567.6 mm/yr. Second, a high degree of variability: 44% of monthly precipitation observations are below half of the historical mean and almost 14%, more than twice that mean. Fig. 2 reports the monthly precipitation data and Fig. 3, the monthly SPI values.[3] The latter figure clearly reveals marked fluctuations in the precipitation regime, in particular several prolonged, exceptionally dry periods. From a careful review of SPI values we identify three such periods of particular relevance for this paper's purposes:

[2] The weather stations include: 19012 (Ciénega de Flores), 19124 (Higueras), 19069 (La Boca), 19033 (Laguna de Sánchez), 19052 (Monterrey), 19054 (Rinconada) and 19058 (Santa Catarina).

[3] The SPI may be calculated for different time scales, from one up to 24 months. Because of its strong association with surface flows and reservoir levels, we use here a 12-month SPI.

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