The altered hydrologic cycle of the Mexico City Basin

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Rapid urbanization in recent decades has occurred in developing countries and is expected to continue in the coming decades. The Mexico City Metropolitan Area (MCMA, Fig.1) has exponentially grown. Its population is around 25 million and its spatial extent is close to 8000 km2, which makes it one of the largest cities of the world (INEGI, 2010). Until the late eighties, urban growth of the MCMA constituted a solid compound of urbanization. However, in recent decades urbanization takes places in a fragmented manner, forming “small islands” or settlements, in a kind of suburbs that eliminate natural vegetation around main the older part of the city.

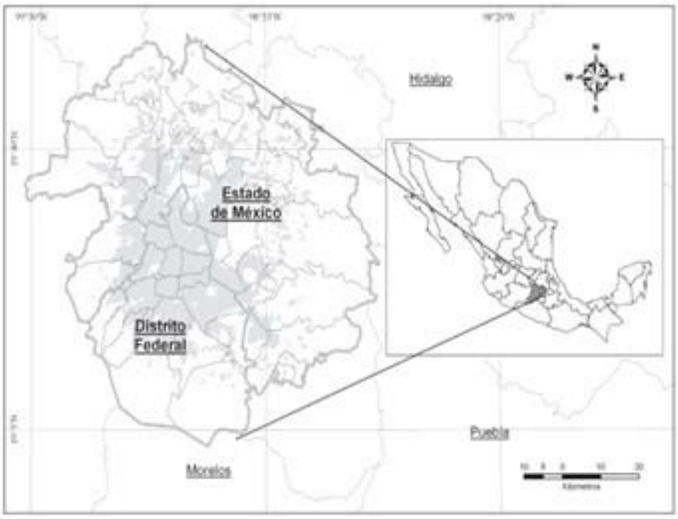

Figure 1. Studio site, Mexico City Metropolitan Area.
Adapted from (López, V. y Plata W., 2008)

Most of the urban expansion takes place in areas that are exposed to natural meteorological hazards such as intense storms or high temperatures. As a result, the number of the so-called natural disasters has increased significantly. If the impact of no-planning in the urban growth of a city like Mexico City is examined in a risk perspective, it is found that: on the one hand, the magnitude and frequency of hazards is increasing, and on the other hand, the level of vulnerability is increasing as well, which make its population to me at critical levels of risk more frequently.

For instance, the average value of annual temperature has increased in nearly 3°C during the most recent century, due to the Heat Island effect. (Fig.2)

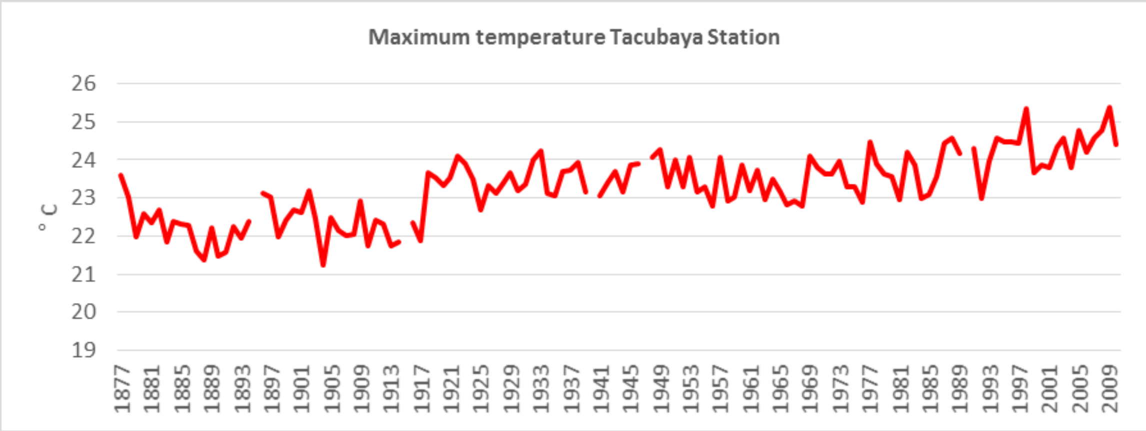

Fig. 2 Maximum temperature during 1877-2009, Tacubaya, Mexico City.

Along with such increase in temperature, annual precipitation is at least 40% higher now, in the west of the city, than at the beginning of the twentieth century (Fig.3). The increase in precipitation is related to the urbanization effect, that reduced atmospheric stability, but also to a higher concentration of precipitable water that results in more frequent intense storms (Aquino, 2012).

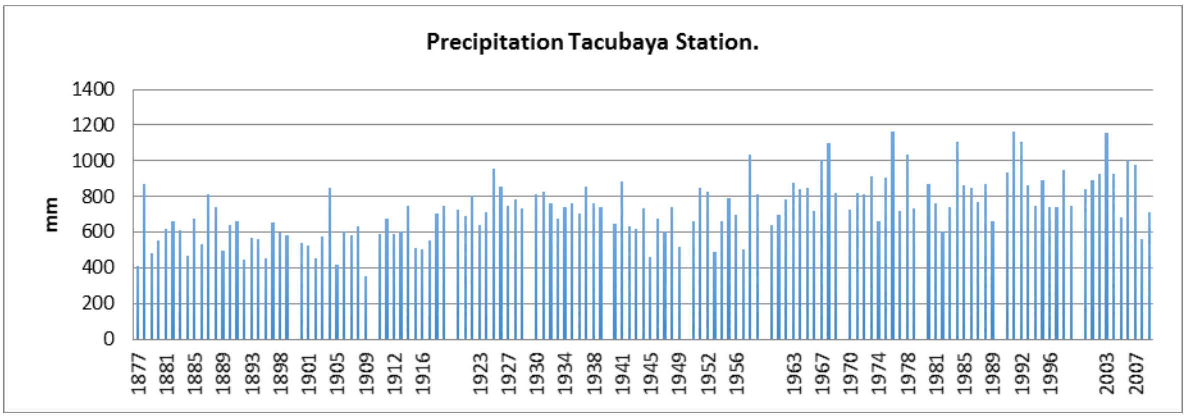

Fig. 3 Precipitation during 1877-2009, Tacubaya, Mexico City.

The combined effect of intense precipitation and exposure results in a higher risk for people. Land use changes correspond to replacement of grasslands, forests and agricultural areas by houses. These changes are recognized as factors that affect the temperature and humidity, as well as the composition of the boundary layer, at local and regional level (Oke, 1987); (Jáuregui, 2000). More intense storms in the MCMA occur to the mountains of the western part of the basin (Aquino, 2012), where irregular settlement where slopes are higher than 15º and landslides are frequent. Thus the MCMA constitutes an example of regional climate changes that increase risk to the population.

With a rapid population growth, demand for potable water has also increased, leading to a rapid depletion of the aquifer. This requires the transfer of water from water reservoirs in neighboring region to the MCMA (CONAGUA, 2010). In the MCMA, water consumption is approximately 272 liters per person per day (Morales, J. y L. Rodríguez, 2009), equivalent to 80m3/s, 70% of which comes from groundwater sources, 5% surface and 20% from external sources (neighboring basins). According to the World Health Organization, consumption of water required per person to guarantee their welfare is 100 liters per day. Therefore, average water consumption in the MCMA is much higher than international standards. So, while more intense precipitation is occurring in the Mexico City basin, there is not enough water for consumption that leads to overexploitation of the aquifer.

Risk management may include conjunctural and structural measures. The first kind of measures include early warning systems based on adequate severe weather forecasts at the local level, using meteorological models or radar short term forecasts. Structural risk management measures include any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems. One factor influencing the increase in risk is the loss of ecosystem services, rarely considered when urban expansion occurs. Recovering some of the ecosystem services such as regulating or provisioning services, lost by the effects of urbanization or deforestation, may as well serve to reduce risk to meteorological and climate hazards.

The urban expansion of the MMCA is contrasting. While in the north-east area characterized as a plain, the population and housing density is high, with a low tree density, the south-west regions of the MCMA is more sparsely populated with a much higher tree density, near the Sierra del Chichinautzin (soil conservation) with an uneven terrain that has allowed green spaces to be conserved (Fig. 4).

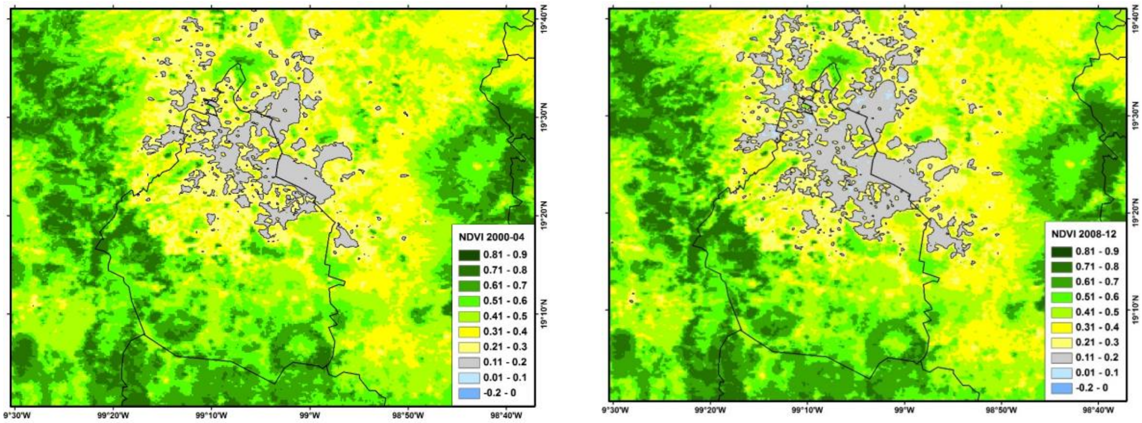

Fig. 4 The Normalized Difference Vegetation Index, gray the urbanized area is shown.

This part of the city appears to show a slower temperature trend in contrast to the northeast region, which makes it less exposed to heat waves. However, the continuous loss of vegetation has results in increased runoffs and floods in the lower parts of the MCMA.

Preliminary analyses indicate that maintaining an adequate tree cover or water bodies in an urban environment may serve to regulate climate and reduce the risk of natural disasters. Reforestation of the urban environment and surrounding areas may increase infiltration, reduce runoff and regulate extreme temperatures. But to what extent reforestation in the MCMA urban environment may be implemented? What is the magnitude of the impact of reforestation in temperature or the local hydrological cycle? These are some of the questions that we are in search of. Some preliminary results indicate the recovery of ecosystem services is possible and at a lower economic cost than the traditional structural risk management measures.

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