THE WATER-ENERGY-CLIMATE NEXUS IN MEXICO'S AGRICULTURAL USE OF GROUNDWATER

Introduction

Human water use is a main driver of the spatial distribution and temporal availability of water resources globally (Vörösmarty et al. 2000). In the specific case of groundwater sources there are three interlinked processes that drive water balances in diverse regions globally: 1) intensification of groundwater irrigation, 2) electrical energy supply for agriculture, and 3) climatic variability. These combined conditions make groundwater management highly challenging for policy makers. The scope of research and management of water has been broadening both in the academia and policy arenas to include energy considerations in the face of climate change phenomena (Colby and Frisvold, 2011; Kenney and Wilkinson, 2011; Fisher and Ackerman, 2011; Carter, 2010). In the present study (adapted from Scott, 2011) the nexus between groundwater balances and energy is established by the electricity pricing for the agricultural sector that drives water extraction.

The research approach in this study combines the interactive influences between physical and human dimensions of global change to better understand groundwater extraction and energy dynamics. The specific objectives are: 1) to quantitatively assess hydro-climatic and human use drivers of groundwater balances in Mexico, and 2) to explore energy power supply and pricing policies to address aquifer depletion.

Mexico was selected as the case of study because of its complexity in terms of water, energy, and climate challenges (CONAGUA 2010a) and the valuable lessons that can be offered to other countries struggling with similar challenges. In Mexico agriculture represents the largest user of groundwater, although overall agricultural productivity in per hectare profit terms is relatively low. Decreasing groundwater levels raise the costs of groundwater and further reduce agricultural profitability, especially for low-value crops such as grains, beans, cotton, and other basic commodities that are cultivated in large irrigation districts (ranging from 25,000 to 200,000 hectares each). The result of this situation is that farmers seek to shift from surface to groundwater for higher-value crop production that is usually oriented to international markets.

Agricultural groundwater use in Mexico is a pivotal driver of aquifer depletion. As long as climatic variability places surface water supply at risk, relying on groundwater sources becomes an adaptive strategy to keep agricultural production rates (Magaña and Conde 2000).

Additionally agricultural use of groundwater is increasingly in competition with other types of water uses (mainly urban water supply which has priority according to the Mexican water law), a trend that is expected to be more significant as population grows. A third condition that promotes aquifer depletion is the relationship between groundwater pumping and the pricing of electric power for pumping that currently enables overexploitation. Of the 653 aquifers in Mexico for which data are compiled and reported (CONAGUA 2010b), 101 experience extractions exceeding recharge by greater than 9.5% (the threshold to categorize it as "overexploited") as of December 2008. Of those that were overexploited, 10 also presented saline intrusion. Another 26 had extractions that surpassed the recharge at levels between 0 and 9.4% (these were listed as "underexploited" along with those that had positive recharge-extraction balances). Groundwater depletion is concentrated at the center and north of the country, where precipitation is low and variable, agricultural demand for water is high, and urban population growth exerts additional pressure on aquifers.

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