Implications of Groundwater Scarcity   
for Food-Energy-Water systems

Danielle Grogan, Iman Haqiqi, Thomas Hertel, Jing Liu

Introduction

Irrigated agriculture produces ~40% of the global crops using 20% of the global cropland (REF: FAO). ​Groundwater contributes to ~20% of global irrigation water withdrawal (Siebert et al, 2010).​ The depletion of groundwater aquifers across the globe has become a significant concern (Grogan et al., 2017)​. While groundwater scarcity has local impacts on water and agricultural systems, a widespread scarcity will increase the energy costs for pumping, agricultural production costs, and global market prices. This will affect the food system through rising costs, higher food prices and negative impacts on food security. The resulting changes in the food demand will affect the demand for agricultural products and may change the pattern of land use around the world.

The purpose of this study is to develop an integrated framework for investigating the implications of groundwater scarcity for the Food-Energy-Water systems. We integrate a global gridded hydrological model with a global gridded economic model of agricultural production, land use, and water use.

Methods

We employ the Water Balance Model (WBM) for hydrological modeling and SIMPLE-G for global agricultural production, land use, and water use.

Step 1: Historical modeling and validation. We look at 2010-2015 shocks to groundwater availability informed by WBM and estimate the irrigation responses from ​SIMPLE-G. We evaluate the impacts on water withdrawal​, irrigation efficiency​, irrigation area​, energy demand for pumping​, food production, and prices.

Step 2: Projections. We consider the 2010-2030 period in the integrated framework. The population, income, and productivity growth will determine the SIMPLE-G outputs for land and water use in 2030 (mainly based on SSP2). We take WBM outputs on the change in groundwater/surface water as SIMPLE-G inputs. The SIMPLE-G outputs on irrigation extension and irrigation efficiency will serve as the inputs of WBM. We repeat this to reach the convergence.

Expected results

We envision to:

* Identify the locations with high future water demand
* Identify the hotspots of future water scarcity
* Estimate the changes in the pattern of global irrigation area and global irrigation efficiency considering the linkage between the economic responses and the natural changes
* Quantify the uncertainty in future food production and prices.