

Student needed for: The shadow price of fossil groundwater

Introduction The extension of irrigated agriculture into areas with limited precipitation during the growing season has greatly increased the use of fossil groundwater. As a result, the depletion rate of fossil groundwater resources has shown an increasing rate during the last decades. Here, we use a global hydrological model and historical crop production data to assess, for the first time, the shadow price of non-renewable or fossil groundwater applied to major crops in countries that use large quantities of fossil groundwater.

Aim: To assess for the main groundwater depleting countries per crop type the shadow price of fossil (non-renewable) groundwater.

Rationale: The crops with the lowest shadow prices (i.e. low contribution of water to profit) are most wasteful from an economic and sustainability point of view. Changing the crop with the lowest shadow price with crops with higher prices provides opportunities to generate more profit at the same depletion rates, or better still, reduce groundwater depletion while keeping the profit constant.

Method: To derive the shadow price of water for each crop and each country we derive production functions whereby crop production data P (kg/yr) are related to renewable and non-renewable (fossil) groundwater use (m^3/yr) and a term correcting for other production factors that influence crop productivity. The derivative of the production function with respect to non-renewable groundwater use (kg/m^3) multiplied with the current country specific price ($\$/kg$) of the crop provides a shadow price of fossil groundwater used for that crop ($\$/m^3$). We reconstruct the production function using a historical analysis where we combine country-level production statistics (e.g. from FAOSTAT) with estimates of renewable and non-renewable water use (abstraction and consumption) obtained from a global hydrological model (Wada et al., 2012).

Time series of renewable and non-renewable water consumption per crop per country W_r , W_{nr} (data provided by Utrecht University) are linked to the production P of that crop from e.g. FAO-stat (provided by LEI). Countries: India, Pakistan, US, China, Iran, Mexico, Saudi Arabia, Turkey, Italy, Spain, Egypt, South Africa. These data will be available.

Student project

1. Using the data from the time series, for each country and each crop, a production function is estimated (see Figure), based on the appropriate model and estimation technique (e.g. a panel data model). The production function is given by

$$P = F(w_r, w_{nr}, \text{other inputs}).$$

2. Determine the shadow price at the current level of depletion rate.

