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Non-sustainable groundwater sustaining irrigation – a global assessment

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Irrigated crops play a vital role in securing global food production. It is estimated that 17% of agricultural lands are irrigated, yet they account for 40% of the global food production, sustaining the livelihood of billions of people (Abdullah, 2006). At the same time, water used by irrigated crops (i.e. crop water demand) and irrigation water demand are responsible for about 70% of the global water withdrawal and account for about 90% of the global water consumption, i.e. water withdrawal minus return flow respectively. Water demand for irrigated crops can be met by three different sources: 1) green water, being water from local precipitation that is temporarily stored in the soil, 2) blue water, being surface freshwater available in rivers, lakes, reservoirs and wetlands, and renewable groundwater, and 3) non-renewable or non-sustainable groundwater and non-local water resources. Here, we quantify globally the amount of non-renewable groundwater abstraction to sustain current irrigation practice. We use the global hydrological model PCR-GLOBWB to simulate gross crop water demand for irrigated crops and available blue and green water to meet this demand. We downscale country statistics of groundwater abstraction by considering the part of net total water demand that cannot be met by surface freshwater. We subsequently confront these with simulated groundwater recharge including return flow from irrigation to estimate non-renewable groundwater abstraction. Results show that non-renewable groundwater abstraction contributes approximately 20% to the global gross irrigation water demand for the year 2000. The contribution of non-renewable groundwater abstraction to irrigation is largest in India (68 km3 yr-1) followed by Pakistan (35 km3/yr), USA (30 km3/yr), Iran (20 km3/yr), China (20 km3/yr), Mexico (10 km3/yr) and Saudi Arabia (10 km3/yr). Results also show that globally this contribution more than tripled from 75 to 234 km3/yr over the period 1960-2000. These results suggest that available blue water resources have become extensively exploited for irrigation. Even though large numbers of reservoirs were constructed to supply water to irrigation, the increase in their storage capacities has been tapering off. Consequently, the contribution of non-sustainable groundwater to meet the gross irrigation water demand has been increasing rapidly, resulting in an increasing dependency on non-sustainable groundwater for irrigation in recent years.