



Historical development of crop-related water footprints and inter-regional virtual water flows within China

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China is facing water-related challenges, including an uneven distribution of water resources, both temporally and spatially, and an increasing competition over the limited water resources among different sectors. This issue has been widely researched and was finally included into the National Plan 2011 (the 2011 No. 1 Document by the State Council of China). However, there is still lack of information on how population growth and rapid urbanization have affected the water resources in China over the last decades. The current study aims at investigating (i) the intra-annual variation of green and blue water footprints (WFs) of crop production in China over the period 1978-2009 at a spatial resolution of 5 by 5 arc-minute; (ii) the yearly virtual water (VW) balances of 31 provinces within China, related water savings for the country, as well as the VW flows among eight economic regions resulting from inter-regional crop trade over the same period; and (iii) the development of the WF related to crop consumption by Chinese consumers.

Results show that, over the period 1978-2009, the total WF related to crop production within China increased by only 4%), but regional changes were significant. From the 1980s to the 2000s, the shift of the cropping centre from the South to the North resulted in an increase of about 16% in the blue WF and 19% in the green WF in the North and a reduction of the blue and green WF in the South by 11% and 3%, respectively. China as a whole was a net virtual water importer related to crop trade, thus saving domestic water resources. China's inter-regional crop trade generated a blue water 'loss' annually by transferring crops from provinces with relatively low crop water productivity to provinces with relatively high productivity. Over the decades, the original VW flow from the South coastal region to the Northeast was reversed. Rice was the all-time dominant crop in the inter-regional VW flows (accounting for 34% in 2009), followed by wheat and maize. The WF of the South related to crop consumption increased by 17% (~61 billion m³) while the increase in the North was 8% (~23 billion m³) from the 1980s to the 2000s. The national average annual WF per capita of crop consumption reduced by 8% (from 606 m³cap⁻¹y⁻¹ to 559 m³cap⁻¹y⁻¹) from the 1980s to the 2000s owing to the reduction in the WF per unit mass of a crop. However, because of the movement of the major agricultural areas to the North, the WF per capita in Inner Mongolia, for example, was increased (by 4% from the 1980s to the 2000s) due to the higher WF per unit mass of a crop locally, but with an increased level of self-reliance in crop consumption. Accounting for the different production and consumption characteristics across provinces is crucial for China's water governance.