

Urbanization affects water and nitrogen use efficiencies in food chain

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ABSTRACT

Urbanization develops rapidly especially in the developing countries. As a consequence, an increasing amount of food, especially animal-derived food, has to be produced on a decreasing area of agricultural land. However, the impacts of these changes on water and nitrogen use efficiencies remain poorly understood.

Here, we analyze the complex relationship between urbanization and water use efficiency (WUE) and N use efficiency (NUE) in China, using a combination of conceptual relationships between urbanization and the whole food production – consumption chain, and the model NUFER (Ma et al., 2010; *J. Environ. Qual.* 39:1279–1289). We explored also various scenarios to increase WUE and NUE, as there is a pressing need to improve WUE and NUE in view of the need to feed a growing human population and to prevent large scale ecosystem degradation.

Urbanization affects WUE and NUE in various ways. A direct effect is that many young farmers become part-time farmers and have limited time for agriculture. Remaining farmers age and do not have the ability to utilize novel management techniques, which further depresses WUE and NUE. Further, an increasing number of landless animal production farms are situated near urban environments, which largely rely on imported animal feed and do not have the land-base for utilizing the nutrients contained in the animal manure. Hence, a large fraction of the manure is simply discharged into surface waters, with or without previous treatment. These farms itself have a relatively large WUE and NUE, but rely completely on virtual water and N, and swap inefficiencies to other areas and the environment. Finally, urbanization contributes to changes in human diets that greatly affects WUE and NUE. In 2005, China used some 750 km³ of water and 30 Tg of N to feed its 1.3 billion people. WUE was on average 0.8 kg m⁻³, and NUE was 26%. When animal protein intake would increase to the level currently in EU-27, water use will have to increase to some 1600 km³ of water (factor of 2.1) and N use to 70 Tg (factor of 2.3) in 2050, assuming current levels of WUE and NUE.

We conclude that optimization of water and N use in the food production –consumption chain must consider urbanization effects, as ignoring these effects may lead to biased interpretations. So far, most studies on WUE and NUE have focused on the plant and field levels and have not considered the complex interactions with the urban environment.

Keywords: water; nitrogen; urbanization; food