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Hotspots for nitrogen and phosphorus losses from food production to waters in China

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Food security is important in China because of the large population and the fast growing economy. Crop and animal production have been intensified to meet the increasing food demand. However, nutrient management in food production is generally poor in China. As a result, large amounts of nitrogen (N) and phosphorus (P) are lost to aquatic systems. Some of these nutrients are further transported by rivers to coastal waters. Increasing amounts of nutrients in rivers and coastal waters have caused water pollution resulting in eutrophication and harmful algal blooms. A better understanding of N and P losses from food production to waters can help to formulate effective nutrient management options to improve water quality in China.

This study aims to identify past and present hotspots for N and P losses to waters from food production in China. This was done in three steps. *First*, we quantified total N and total P losses from food production to waters in 1990 and 2012 for all Chinese counties (up to 3,000 counties) using the *NUFER* (**NU**trient flows in **F**ood chains, **E**nvironment and **R**esources use) model. *NUFER* was developed to quantify N and P flows, as well as the associated N and P use efficiencies in the food production-consumption chain of China. *Second*, we identified the hotspots for N and P losses from food production to waters using the results of Step 1. The level of 30% highest N and P losses in 2012 was used to define hotspots. This means counties that have N and P losses higher than this level are defined as hotspots for both 1990 and 2012. *Third*, hotspots were compared in terms of food production (e.g., fertilizer use, animal numbers, N and P use efficiencies) and socio-economic factors (e.g., urbanization, farmers' incomes). This helps to better understand reasons for high losses of N and P to waters in the hotspots.

Results show that the total area covered by hotspots increased fast between 1990 and 2012. The hotspot area almost doubled for N losses to water, and increased by a factor of 10 for P. In 2012, more than 60% of the total N and P losses to waters originated from the hotspots that covered only 11% of the land in China. Hotspots are located mainly in eastern China, particularly in North China Plain where agricultural activities are intensive. For example, the fertilizer use in the hotspots was around 60% of the national fertilizer use in China in 2012. The hotspots contributed to more than half of the national animal production in China in 2012. Results also show that food production in the hotspots is important for the local economies. For example, farmers' incomes in the hotspots were 40% higher than those in other regions. This indicates that food production needs to be secured in the hotspots to maintain the local economic growth. Therefore, we conclude that improving water quality in China will require to improve nutrient management to reduce nutrient losses to waters while securing food production in the hotpots.