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12. Region-specific management measures for crop and livestock production systems may achieve environmental targets cost effectively

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Introduction

Securing food production and environmental safety is a grand challenge[1,2], notably because of the vast regional heterogeneity in systems and environment[3,4], which demands for region-specific and cost-effective best management practices (BMPs). China is an interesting case here as it has diverse socio-economic and environmental conditions at the subnational level. With 19% of the world's population and a rapidly developing economy, improvements of China's crop and animal production systems will have significant impacts also on the global food systems' sustainability. The purpose of our study was to explore how current crop and livestock production systems in China can stay within set environmental boundaries for GHG emissions and N and P losses to water bodies at regional level simultaneously.

Methodology

First, we built the CLEANER model (Crop and Livestock optimization, Emissions Abatement, and Nutrient Efficient Recycling) to analyse the food production capacity and environmental impacts of crop and livestock systems, without and with BMPs at provincial scales in China. Second, we derived regional-specific thresholds for the 31 mainland provinces, using scientific principles and regional properties, the impacts of the current crop and livestock production systems were assessed relative to the set boundaries and associated economic costs. Third, 6 BMPs along the crop-livestock production chain (BMP1- improved animal production efficiency; BMP2- methane inhibitor in feed; BMP3- improved manure management; BMP4- improved crop husbandry and balanced fertilization; BMP5- enhanced-efficiency nitrogen fertilizers; BMP6- deep fertilization) were defined and implemented in an integrated manner along the whole chain. Then two implementation levels (i.e., modest implementation at large farms only and full implementation in all farms) of integrated BMPs packages were explored. Finally, we explored optimal combinations of regional-specific BMPs based on cost and effectiveness of BMPs. These optimal combinations of BMPs turned out to be highly cost-effective to achieve adequate food supply within the set environmental targets.

Results and discussion

For the 2016-2018 baseline situation, nearly all provinces exceeded two or three environmental thresholds, which had been defined province-specific for hydrological nitrogen and phosphorus losses and greenhouse gas emissions. A uniform and full implementation of 6 packages of BMPs would allow 26/31 provinces to stay within the set regional environmental thresholds, but at the additional cost of 17% of total agriculture production costs. By contrast, province-specific combinations of BMPs decreased total hydrological nitrogen losses by 5.3 Mt (-64%) and phosphorus losses 0.7 Mt (-66%) in a cost-effective way (only 0.7% of total cost), while all provinces stayed within the set hydrological thresholds. We argue that greater attention has to be given to the spatial heterogeneity in the effectiveness and costs of BMPs, and to the development of region-specific policies and instruments.

Conclusion

Our study provided insight into the agronomic and environmental performances of crop and livestock production systems at sub-national level in China, as well as into the cost and effects of best management practices on these performances. Optimal combinations of region-specific BMPs turned out to be much more cost-effective than a uniform modest or full implementation of 6 BMPs packages along the crop and livestock production system. This region-specific approach recognizes the heterogeneity of production as well as environmental impacts in provinces.

References

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