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Changes in global cropland area and cereal production: An inter-country comparison

Qiangyi Yu*, Mingtao Xiang*, Wenbin Wu, Huajun Tang

Key Laboratory of Agricultural Remote Sensing (AGRIRS), Ministry of Agriculture / Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, 100081, China

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ABSTRACT

Although cereal production is a linear function of cropland area in principle, the relationship between area change and production change is nonlinear at a larger geographical scale due to the spatially heterogeneous use of land. Based on globally gridded land cover maps between 2000 and 2010, this study presents a country-level comparison to understand how cropland area change contributes to cereal production variation across the world's major cereal producers. First, a map of potential cereal productivity is applied to represent the spatially varied biophysical capacity, and the cropland area change in primary and marginal locations are calculated separately for individual countries by adopting the country's average cereal productivity as a reference. Then the area-change-induced potential cereal production change is estimated and correlated with the actual production change at the country level. The results show that most countries increased cropland area in primary locations. A few countries decreased cropland area, and the area losses are mainly occurred in primary locations as well. Moreover, China and USA achieved a marked increase in actual production with an expected decrease in potential production. In contrast, Brazil, Argentina and Nigeria have a higher increase in potential production against a relatively lower increase in actual production. Combining these, a cluster analysis indicates that some countries better exploited cropland productivity (as represented by China), and some countries better allocated cropland area (as represented by Brazil). Although the former group has reduced hunger more significantly, sustainable cereal production requires balanced development in terms of both productivity-improvement and area-optimization, which simultaneously ensure production and minimize environmental effects. Consequently, the current comparative analysis provides a preliminary guideline for developing national-level strategies by comparing the performance of one country to that of others.

1. Introduction

Global demand for food is increasing with the fast-growing population and changed dietary structure; therefore, how to feed the world successfully has always been a big challenge (Foley et al., 2011; Tilman et al., 2011; Yu et al., 2012). Cereals – including wheat, rice, maize, and barley – are essential to global food security (Godfray et al., 2010) because they are not only staple crops with a rich source of proteins, carbohydrates, vitamins, minerals, fats and oils but also crops grown in greater quantities and provide more food energy worldwide than any other type of crop (World Bank Databank, 2018; Parry et al., 2004; Pfeiffer and McClafferty, 2007). Global cereal supply and demand, in terms of production, utilization, stock and trade, have been steadily increasing in the past decades (Dorosh, 2009; West et al., 2014; To and Grafton, 2015; FAO, 2017), and of these, maintaining cereal production has played an even more important role amid the process of global environmental change (Li et al., 2016; Reynolds et al., 2016; Wei et al., 2017).

Crop production (ton) is a linear function of cropland area (hectare) and productivity (ton per hectare), suggesting that any changes in cropland area or productivity could influence the total production (Foley et al., 2011; Reynolds et al., 2017). The production of cereal crops has tripled over the past five decades, with only a small increase in the land area cultivated (Rudel et al., 2009; Pingali, 2012). However, these small changes in area have contributed to approximately 12% of the total cereal production increase globally (Foley et al., 2005), suggesting that the relationship between changes in cropland area and cereal production is nonlinear at a larger geographical scale. This is mainly due to the spatially heterogeneous use of land, e.g., the quality, suitability and management intensity of cropland used for cereal

* Corresponding authors at: Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, 100081, China.
E-mail addresses: yuqiangyi@caas.cn (Q. Yu), xiangmt_caas@163.com (M. Xiang), wuwenbin@caas.cn (W. Wu), tanghuajun@caas.cn (H. Tang).

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