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Global Implications of China's Future Food Consumption

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Summary

Rapid economic growth and urbanization in China have led to a substantial change in consumption patterns and diet structure of Chinese consumers over the past few decades. A growing demand for feed, fuel and fiber also places intense pressure on land resources. With continuing growth of China's economy and migration from rural to urban, the increase in food consumption and change in diet structure will likely continue, which will not only impose pressure on domestic land resources but also exert impact on land resources in other countries through import. This article applies a global multi-region input-output (MRIO) model to trace agricultural land use along global supply chains and examines the impact of China's future food consumption on global land use in 2030 against different socio-economic and technological scenarios. Our result shows that by 2030, China would need an additional 21% of cropland to support its increasing food

demand driven by population growth, urbanization and income growth and the associated diet structure change. Almost a third of cropland associated with household consumption (34 Mha) will be "outsourced" to foreign countries, such as Argentina, Brazil, United States and Thailand, for the consumption of cereal grains, soybeans and paddy rice. China also consumes 2.4 Mha cropland from Africa for its consumption of cereal grains and oil seeds. The dependence of domestic consumption on significant amounts of foreign cropland shows that China would face serious challenges to meet its grain self-sufficiency policy in the future, and at the same time this dependence would contribute to environmental and food security problems elsewhere.

Introduction

Although urban areas currently occupy less than 2% of global land areas (Schneider et al. 2009), their impact extends far beyond the city limits through environmental teleconnections linking local urban demand to global supply chains, resource extraction and pollution (DeFries et al. 2010; Hubacek et al. 2014; Seto et al. 2012). As the most populous country, China has the greatest urban population in the world, with an annual growth rate of 4% (The World Bank and Development Research Center of the State Council 2014).

Since 1978, rapid economic growth and structural change in China have led to significant changes of land use patterns, mainly represented by considerable expansion of the urban landscape (Jiang et al. 2013). The ratio of China's urban population has increased from 18% to 53% between 1978 and 2012 (UNDP 2013). It is estimated that over 12 million hectares (Mha) of cultivated land were lost between 1997 and 2008 due to urbanization and industrialization; and the losses of cultivated land have largely concentrated in the most productive farming areas of the country (OECD 2010; Cui and Kattumuri 2011). The conversion of agricultural land for urban purposes has resulted in rapid urban sprawl and consequent environmental issues (Hubacek and Sun 2001). For instance, urbanization increases the risk of soil pollution through waste disposal and acid deposition from urban air pollution (Chen 2007). Furthermore, degradation of arable land has intensified in China over the past decades because of desertification, salinization, natural disasters and industrial pollution (Hubacek and Sun 2001; Cui and Kattumuri, 2011). Loss of agricultural land has put a great threat to China's food security. Moreover, most of the urban dwellers have to buy food on the market, and in particular, low income urban consumers spend a considerable part of their income on food. Therefore, they will become more vulnerable to price shocks in food markets. This may cause food-related conflicts and threaten national security (Matuschke 2009).

Rapid economic growth and rural to urban migration also lead to change of consumption patterns and diet structure. More urbanized populations tend to have more diverse diets, with larger shares of meat, dairy products, processed food, which require more land to produce. For example, China consumes about 50% of global pork and 23% the global chicken supply, and most of them are from industrial farms fed with feed stocks (ChinaAg 2015). In addition, consumption of processed food may increase food waste during production, thus potentially use more land for production.

Furthermore, in a rapidly globalizing world, the demand of good and services is increasingly met by international trade involving countries that are situated in far geographical distances from one another. This imposes environmental impacts such as deforestation and other types of land conversions elsewhere (Cardille and Bennett 2010; DeFries et al. 2010; Kastner et al. 2011; Seto et al. 2012; Meyfroidt et al. 2010; Yu et al. 2013; Haberl et al. 2009; Reenberg and Fenger 2011). Therefore, China's food consumption exerts impacts not only on its domestic market, but also on global market via international trade (Cecilie and Anette 2010; Yu et al. 2013).

In this study, we apply a global multi-region input-output (MRIO) model to trace land use along global supply chains, i.e., embodied land in trade. Other studies also refer to embodied land as land displacement, virtual land, embedded land or land appropriation (Kastner et al. 2011; Lambin and Meyfroidt 2009; Meyfroidt et al. 2010; Yu et al. 2013). We develop a number of scenarios to assess changes in the global land use as induced by China's future food consumption. Our scenario designs take into full consideration the change in land productivity and technology, population growth, urbanization, and income growth and diet structure change. The reference year is 2007 and the year for scenarios analysis is 2030.

Methods and Data

Multi-Region Input-Output (MRIO) analysis

The MRIO approach is often used for examining economic interdependency of sectors and countries. It has been frequently applied to assess many human induced environmental issues, such as water use (Feng et al. 2011b; Feng et al. 2011c; Feng et al. 2011a; Yu et al. 2010; Lenzen et al. 2013; Cazcarro et al. 2013; Feng et al. 2014; Zhang et al. 2011; Lenzen 2009), land displacement (Weinzettel et al. 2013; Steen-Olsen et al.

2012; Yu et al. 2013) and carbon dioxide emissions (Davis and Caldeira 2010; Davis et al. 2011; Peters et al. 2011b; Hertwich and Peters 2009; Wiedmann et al. 2010; Barrett et al. 2013; Baiocchi and Minx 2010; Feng et al. 2013). One of the advantages of using MRIO analysis is that it allows capturing both direct and indirect environmental impacts of final consumption along international supply chains (Wiedmann 2009; Wiedmann et al. 2011a; Feng et al. 2011b). The other main advantage of MRIO analysis is that it includes the entire global supply chains within the system boundary and thus avoiding inter-sectoral cut-off effects suffered by life-cycle analysis (LCA) (Suh and Huppes 2005; Feng et al. 2011b; Suh 2003; Suh et al. 2004; Wiedmann et al. 2011b; Acquaye et al. 2011).

In a MRIO framework, countries are connected through international trade. The production coefficient matrix *A* is calculated by $a_{ij}^{pq} = z_{ij}^{pq}/x_j^q$ which represents the inter-sector monetary input from sector *i* in country *p* to sector *j* in country *q* to product one unit total output of sector *j* in country *q* ; x_j^q is the total output of sector *j* in country *q*. *Y* is a final demand matrix consisting of y^{pq} which refers to a vector of each sector's output produced in country *p* consumed by the final user in country *q*. x is a vector of sectoral outputs in all countries.

$$A = \begin{bmatrix} A^{11} & A^{12} & \cdots & A^{1n} \\ A^{21} & A^{22} & \cdots & A^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ A^{n1} & A^{n2} & \cdots & A^{nn} \end{bmatrix}; \quad Y = \begin{bmatrix} y^{11} & y^{12} & \cdots & y^{1n} \\ y^{21} & y^{22} & \cdots & y^{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y^{n1} & y^{n2} & \cdots & y^{nn} \end{bmatrix}; \quad x = \begin{bmatrix} x^1 \\ x^2 \\ \vdots \\ x^n \end{bmatrix};$$

Therefore, the MRIO model can be written as:

$$x = Ax + Y \tag{1}$$

To solve *x*, we obtain

$$x=(I - A)^{-1}Y \tag{2}$$

where $(I - A)^{-1}$ is the Leontief inverse matrix, which captures both direct and indirect inputs to satisfy one unit of final demand in monetary values; I is the identity matrix. To calculate the embodied land use in goods and services, we extended the MRIO table with land use coefficients in equation (3).

$$G = L(I - A)^{-1}Y \tag{3}$$

where G is a matrix of different types of cropland used in goods and services ultimately consumed for final demand. L is a matrix of direct land use coefficients, i.e. different types of cropland per unit of economic output.

Data sources

In this study, trade data and economic input-output tables are gathered from the most recent Global Trade Analysis Project (GTAP) version 8 for 2007. The GTAP database is a global database describing bilateral trade patterns, production, consumption and intermediate use of commodities and services. The GTAP-8 database was released in 2012 with 129 regions for 57 GTAP commodities/sectors for 2004 and 2007. In this study, we extract 2007 global MRIO tables from GTAP 8 following the approach in Peters *et al.* (2011a). GTAP-MRIO tables contain 8 agricultural sectors.

Agricultural land use data were collected from FAOSTAT (FAO 2012). FAOSTAT publish harvest areas for more than 100 agricultural products. We aggregated FAO agricultural products into 8 GTAP agricultural commodities.

According to the report “Preparing a National Strategy for Sustainable Energy Crops Development”, produced by the Asian Development Bank to the People’s Republic of China, there will be only an additional 7 Mha of suitable land for China’s future cropland expansion (Yan et al. 2009). However, with the economic growth and continuing urbanization, it is inevitable that some cropland will be lost for urban expansion. In this study, we assume that the 7 Mha of marginal land will only be able to compensate the cropland lost to urbanization, thus there will be no net cropland change by 2030. Any additional cropland required for the production of crops to satisfy the increase in household consumption will be from foreign countries through MRIO analysis.

Scenarios

Our scenarios are built upon previous work by Hubacek and Sun (2001) which was based on the national input-output table for 1992. We updated it based on the latest available data and using the global MRIO table for 2007. Table 1 introduces these scenarios step by step to show the specification of each major driving forces. It starts from the base year 2007, and a set of scenarios representing each of the driving factors is added to demonstrate its additional effects on land requirements. The baseline represents data for the base year 2007, with the land productivity, population, share of urban and rural population, and consumption pattern of 2007. Scenario 1 applies 2030 land use coefficients (land use per unit of economic output), which take into account the increase in land productivity between 2007 and 2030, but all other factors remain the same as in the base year. In Scenario 2, we add to Scenario 1 the final demand changes and additional direct land requirements caused by a medium variant population growth. In addition, Scenario 3 includes urbanization effect. Scenario 4 includes per capita income growth as well as lifestyle changes. Scenario 5 represents the effects of a lower population growth and a lower share of urbanization combined with Scenario 4. Scenario

6 demonstrates the overall effects of a higher population growth and a higher share of urbanization.

Table 1. Scenarios

Scenarios	Land productivity	Population	Urbanization level	Income and the associated diet structure change
Baseline	2007	2007	2007	2007
S1	2030	2007	2007	2007
S2	2030	2030 *m*	2007	2007
S3	2030	2030 *m*	2030	2007
S4	2030	2030 *m*	2030	2030
S5	2030	2030 *l*	2030	2030
S6	2030	2030 *h*	2030	2030

Note: *m* is the medium variant, *l* the low variant, and *h* the high variant.

Population and urbanization

When the People's Republic of China was founded in 1949, it had a population of 540 million. By 2030, China's population reached 1.36 billion(National Bureau of Statistics of China 2014). According to the projection of UN Population Division, China's population will increase to 1.45 billion (medium variant) and 1.53 billion (high variant) by 2030 (UN 2012). In 1978, only less than a fifth of China's population lived in cities and by 2012, urban residents accounted for 52% of the population. Over the last decade, China's cities have added an additional 100 million urban residents, and the annual growth rate of the urban population reached almost 4% (The World Bank and Development Research Center of the State Council 2014). It is projected that by 2030, the share of urban population will reach almost two-thirds of the total population (The World Bank 2012; The World Bank and Development Research Center of the State Council 2014). For our population and urbanization scenario, we followed the UN's projection on population growth (UN 2012) and The World Bank's forecast on urbanization (The World Bank 2012).

Income growth and diet change

Since the start of the economic reforms in 1978, China has been the most rapidly growing economy in the world. China's annual GDP growth rate averaged at about 10% during the 1990s and 2000s, which has resulted in a significant increase in living standards and a substantial decline in poverty (Dorrucci et al. 2013), but also huge environmental damage and a sizable increase in income inequality. Although China's economic growth has been very fast, different people have benefited to very different extents during the reform period. For example, the per capita income of urban residents has been on average about three times higher than that of their rural counterparts over the last two decades (Dallar 2007; The World Bank 2012). Between 1981 and 2005, the proportion of China's population living on less than 1$ per day (PPP) had dropped from 60% to 10% (Dallar 2007). China's share in global trade has grown from below 1% in 1980 to 9.1% in 2010 (Dorrucci et al. 2013). With more than 20% of the world population, China is now the second-largest economy in the world (The World Bank 2015; CIA 2015). It is projected that the annual growth rate of China's GDP will decrease steadily from an average of 10% today to around 5% in 2030 (The World Bank 2012).

China’s fast economic growth over the past decades has increased its demand for natural resources. Despite great efforts to improve resource efficiency, these efforts have not been sufficient to offset the additional resource demands generated by increasing per capita income. Increasing affluence is by far the most significant driver of resource pressures in China, far more important than population growth (West et al. 2013).

With income growth and urbanization, China’s food consumption patterns are undergoing great changes since the 1980s. In general, per capita consumption of grains and vegetables declined, while the consumption of animal products such as meat, eggs and dairy products has increased significantly (Zhou et al. 2012; Nath et al. 2015). Meat consumption in China grew by a factor of almost 9 from 8 million tons in 1978 to 71 million tons in 2012. This amount is more than double that of the United States, although on the per capita term, Chinese meat consumption is only about half of United States’ level (Earth Policy 2014). Between 1980 and 2005, China’s per capita consumption of meat quadrupled, consumption of milk increased by tenfold, and consumption of egg increased by eightfold (FAO 2012). Due to income differences, meat consumption (including pork, beef, mutton and poultry) in rural China has significantly lagged behind the urban level (Zhou et al. 2012; Zhou et al. 2014). In 2012, per capita consumption of meat by rural residents was 20.9 kg, which equals to the consumption level of urban residents in 1982.

In this study, the future food consumption and diet structure data are adopted from the study of Chinagro-II model (Fischer et al. 2007; Sun 2014; Tian et al. 2015). For rural household, in average per capita consumption of ruminant meat, poultry, and pork are projected to increase by about 87%, 60%, and 45% in 2030, respectively, compared with the consumption in 2005. In addition, per capita milk consumption is projected to increase by 4 times in 2030. However, there will be no big increase in cereal grain consumption. For urban household, in average per capita consumption of some staple food (e.g. milled rice) decreased slightly by 2030. There are still increases in meat consumption for urban households. For example, per capita consumption of ruminant meat and pork are projected to increase by about 48% and 38% in 2030, respectively. But, the increasing rate of per capita meat consumption for urban households is much smaller than the increasing rate for rural household. Per capita milk consumption for urban households is projected to increase by 72% in 2030 (see Table 2).

Table 2. Per capita consumption of commodities (kg/year)

Commodities	2005		2030		Total Growth	
	Rural	Urban	Rural	Urban	Rural	Urban
Milled rice	97.90	64.67	97.00	64.46	-1.0%	-0.3%
Ruminant meat	4.09	7.88	7.63	11.68	87%	48%
Pork	23.79	37.62	35.15	51.91	45%	38%
Poultry meat	7.22	15.37	11.52	25.01	60%	63%
Milk	5.85	43.96	24.78	75.49	324%	72%

Land productivity

In grain production, average yields in China are higher than in developing countries but are still well below the averages in developed countries. The average annual growth in land productivity in grain production was 2% from 1980 – 2011 (FAOSTAT 2014). Future estimations of annual land productivity growth in grain production vary between 0.5% and 2% based on factors such as investment in research and irrigation, world price impact, salinity and erosion, and labor costs (Long 1999; Hubacek and Sun 2001; Wang et al. 2013).

For our scenarios, we estimate future land productivity growth based on past trends during 1980 – 2011. We first calculate land productivities for eight agricultural products, including paddy rice, wheat, cereal grains, vegetables, fruits and nuts, oil seeds, sugar cane, plant-based fibers, and other crops, using production dividing by the harvest area from 1980-2011 for all 129 GTAP countries. Then, we project future land productivity based on changing trend in the past 30 years using business-as-usual scenario. The data of harvest area and production for 1980 – 2011 is obtained from FAO (2014).

Limitations

A few limitations in this study need to be noted. First, we assume that future production structure remains the same as in the base year 2007. It is very difficult to predict the future production structure as technology keep evolving and producing a product may require different material input in the future compared with the current production process. Second, we assume that the future trade patterns will be the same as the base year. We make this assumption because the future trade patterns have very large uncertainty due to the changes in future labor cost in different countries and governmental policies on land management and food security. Finally, the GTAP-MRIO table contains 8 aggregate crops which may lead to aggregation error. However, GTAP-MRIO has the most detailed crops than any other current MRIO databases, e.g. WIOD database (WIOD 2012), EORA database (EORA 2012). Therefore, we choose GTAP-MRIO in this study.

Results

Our results show that by 2030, China’s cropland consumption would increase significantly to support its increasing food demand driven by population growth, urbanization and income growth and the associated lifestyle change (figure 1). Compared with the Baseline, improved land productivity (Scenario 1) would potentially decrease China’s cropland consumption by 27% (24 Mha) by 2030, assuming that all other factors remain at the 2007 level. In contrast, the medium rate of population growth (Scenario 2) would result in an increase in cropland consumption by 10% (7 Mha) compared with Scenario 1. Urbanization (Scenario 3), representing current lifestyle and diet structure, would induce an increase in land consumption by 17% (12 Mha) compared to Scenario 2. Income growth and the associated diet structure change (Scenario 4) would drive an additional demand for cropland by 28% (24 Mha). The overall impact leads to a 21% net increase (19 Mha) in comparison with the base year. Under the low rate of population growth (Scenario 5), the net increase in cropland requirement would be about 14% (13 Mha) compared to the base year level. Under the high rate of population growth (Scenario 6), the net increase in demand for cropland would be as higher as 30% (See figure1). From figure 1 we can see that further urbanization (S3) may lead to much higher land consumption (46% or 22 Mha of increase) by urban household and the share of land consumption by urban households would increase from 66% in 2007 to 82% in 2030.

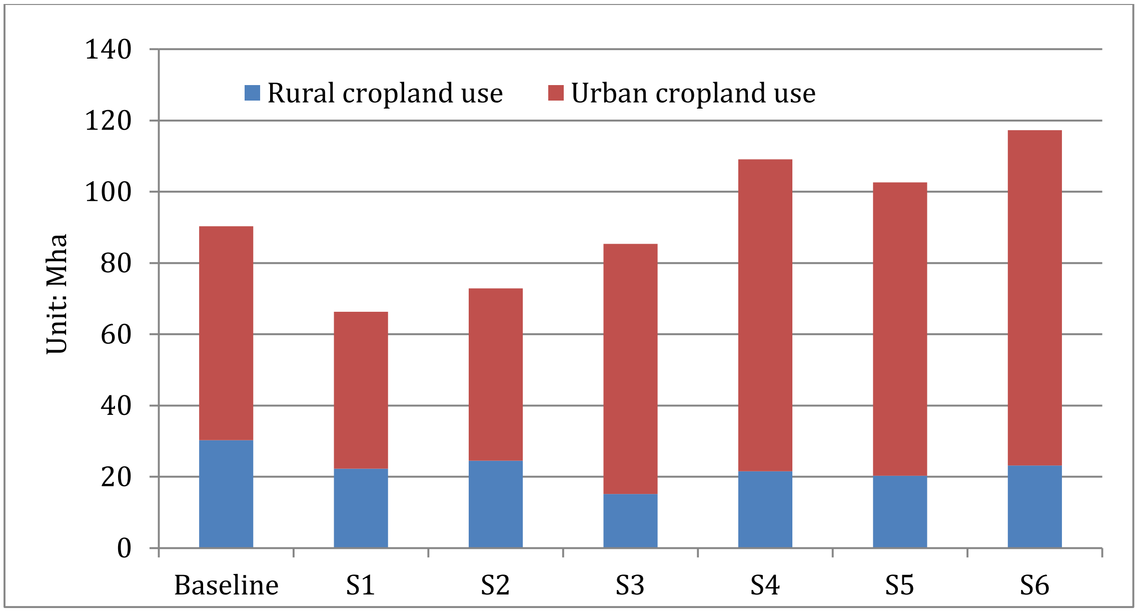


Figure 1. Total cropland use associated with rural and urban household consumption in China (Mha) (S1: Baseline (2007) + technology of 2030; S2: S1 + medium population growth; S3: S2 + urbanization; S4: S3 + income growth and the associated lifestyle change; S5: S4 + low population growth; S6: S4 + high population growth).

Figure 2 shows that China would depend on a large amount of cropland in foreign countries to satisfy its increased food demand as driven by population growth, urbanization and income growth. In the Baseline, Scenario 1, and Scenario 2, China would consume approximately 85% of its demand from domestic cropland and 15% from cropland in foreign countries. When urbanization is taken into account (S3), the share of foreign cropland consumption in the total increases slightly to 16% largely due to that the immigrates from rural to urban areas adopt the current (2007) urban life style and this lead to a moderate increase in total meat consumption and the associated import of crops for feedstock. When combined with the per capita income growth induced diet change and population growth (both low and high), the share of foreign cropland consumption in the total increases to 31%, 28% and 35% in S4, S5 and S6, respectively (see figure 2).

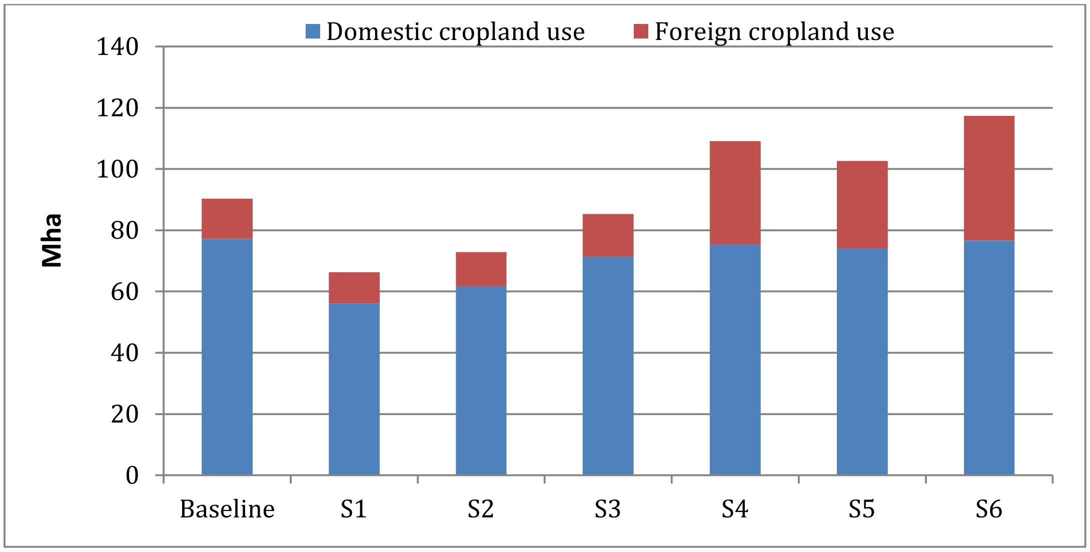


Fig. 2. Domestic and foreign cropland use associated with household consumption in China (Mha) (S1: Baseline (2007) + technology of 2030; S2: S1 + medium population growth; S3: S2 + urbanization; S4: S3 + income growth and the associated lifestyle change; S5: S4 + low population growth; S6: S4 + high population growth).

In figure 3, we select Scenario 4 (with medium rate of population growth) to show embodied cropland in China's import from foreign countries, as it represents the central tendency and is regarded as the most plausible scenario (Fischer et al. 2007; Sun 2014; Tian et al. 2015). Major exporters of embodied cropland to China include Argentina, Brazil, United States, Canada, Thailand, Vietnam, and Australia. From figure 3, it can be seen that taking all factors into account (S4), Latin America (33% of China's total demand for embodied foreign cropland), primarily Brazil and Argentina, will be the largest exporter of embodied cropland to China in 2030; followed by Southeast Asia

(22%), mainly Thailand, Vietnam and Malaysia; North America (19%), primarily the U.S.; and Australia (9%).

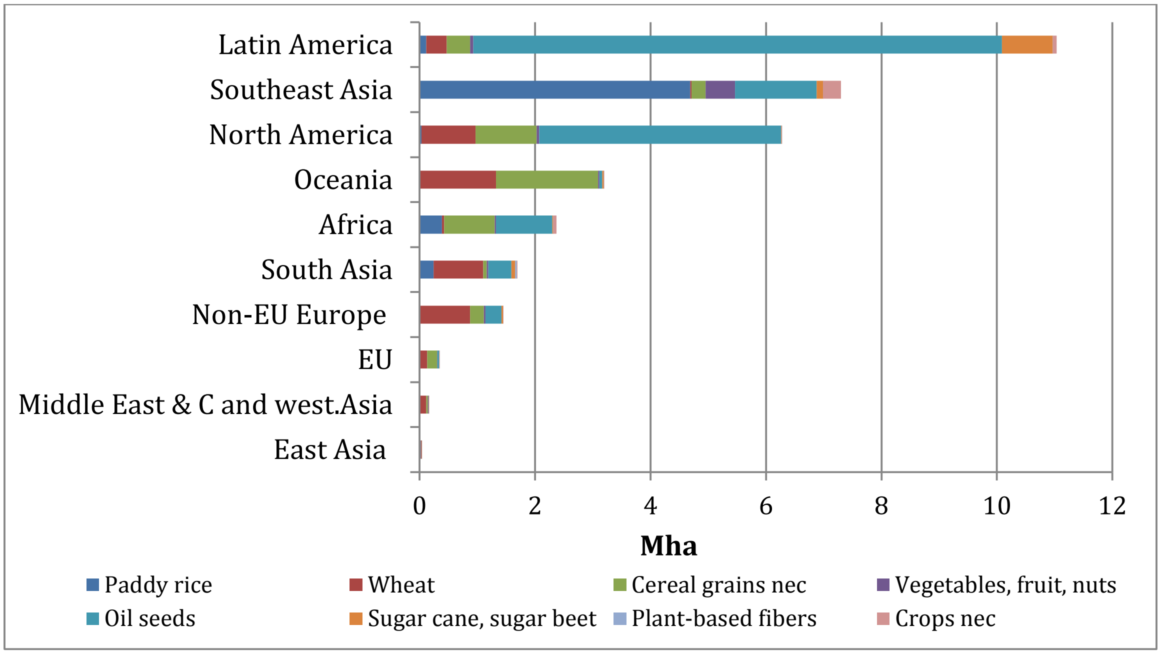
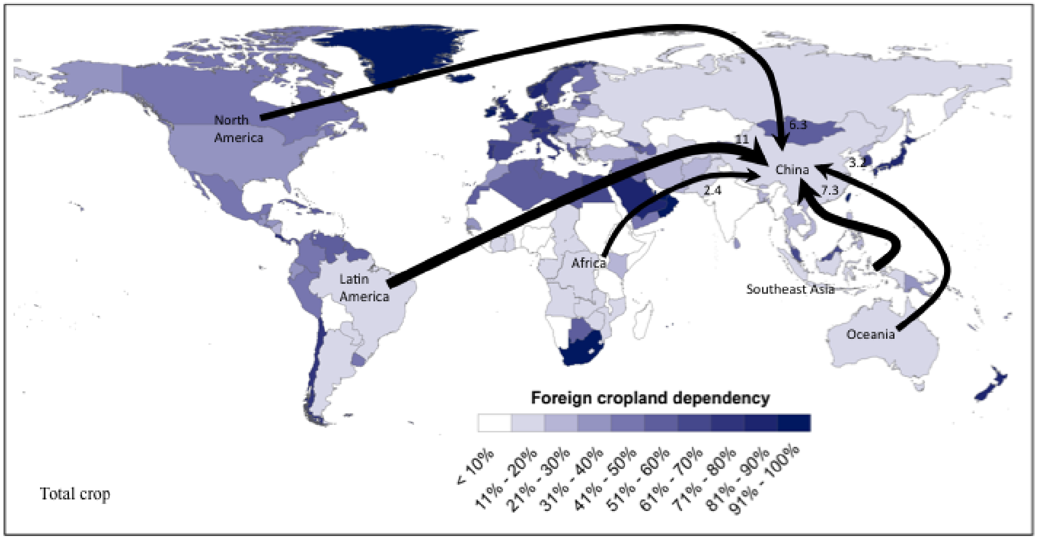
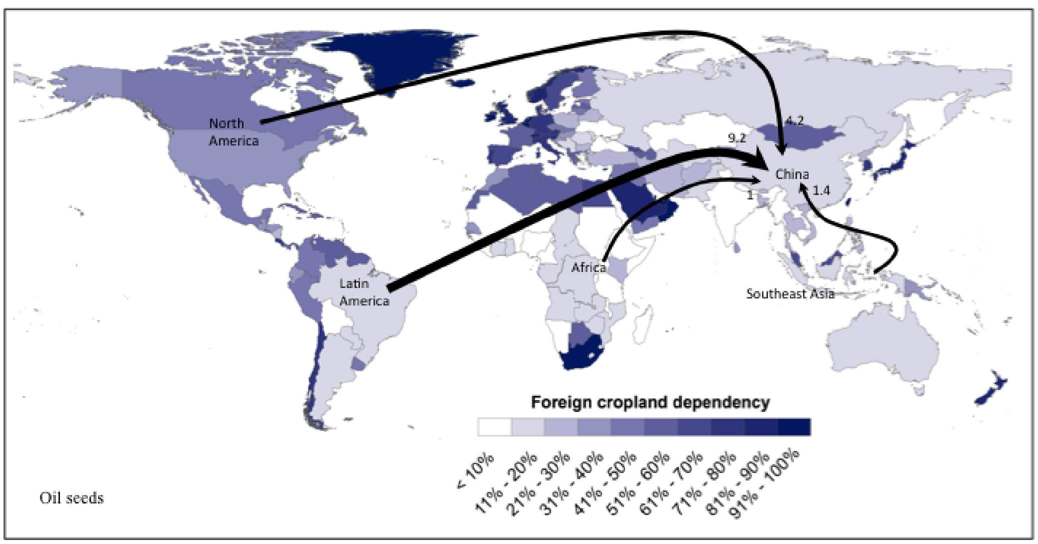
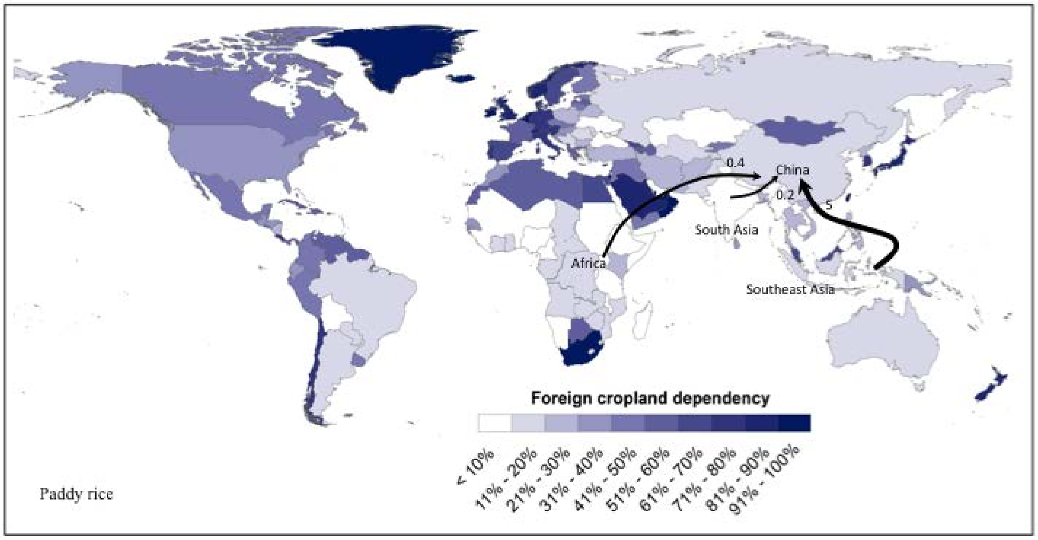


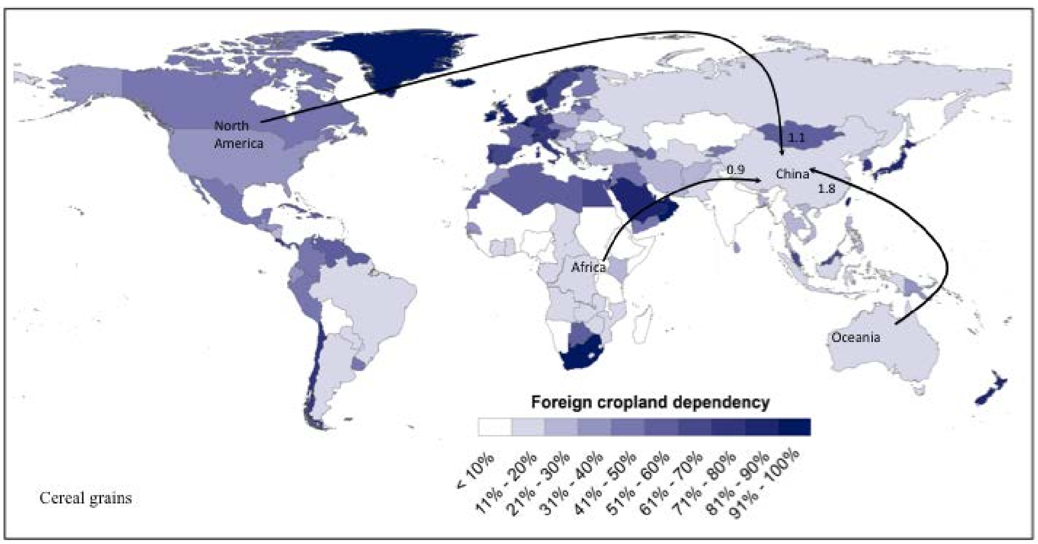
Figure 3. Embodied cropland in China's import in Scenario 4 (with medium population growth, urbanization, improvement in land productivity, and income growth and associated diet structure change) by region.

Figure 4 shows embodied cropland in China's import of the four major crops: oil seeds, paddy rice, corn and other cereal grains, and wheat. Latin America, primarily Brazil and Argentina, is the largest exporter to China and most of their exported embodied land is used for soybean production, which are 5.5 Mha (Brazil) and 3.3 Mha (Argentina), respectively. Southeast Asia is the second largest export to China because the region is the largest rice exporter to China (5Mha). In addition, China consumes a large amount of embodied cropland in the US to meet China's demand for soybeans and corn, which account for 4.2 Mha and 1.1 Mha, respectively. In terms of wheat, the top exporter of embodied cropland to China is Australia, followed by the US.






0.4
China
0.2
5
South Asia
Africa
Southeast Asia
Foreign cropland dependency
< 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Paddy rice


North America
1.1
0.9
China
1.8
Africa
Oceania
Foreign cropland dependency
< 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
Cereal grains

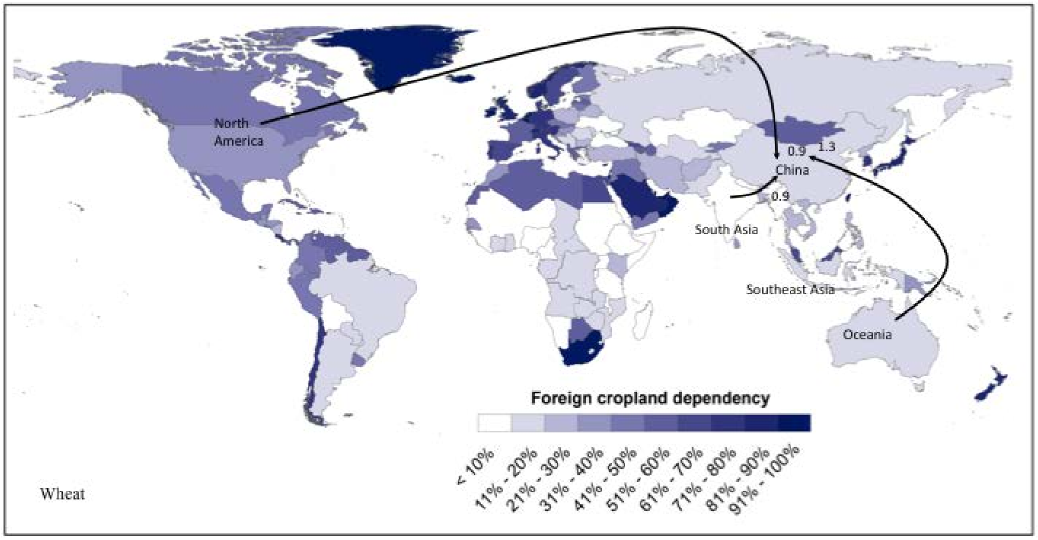


Figure 4. Embodied cropland in China's import of four major crops (oil seeds, paddy rice, corn and other cereal grains, and wheat) in Scenario 4. Background color reveals the foreign cropland dependency (the ratio of embodied cropland in import to total cropland requirement).

Discussion and conclusion

Based on a set of scenarios over potential futures for China, our simulation results based on a global MRIO model show that China would need to consume a large amount of foreign cropland to meet its increasing demand for food in the future as driven by population growth, urbanization, income growth and the associated lifestyle changes. In the base-year 2007, with nearly half of the population in urban areas, urban residents consume about twice as much cropland as their rural counterpart and the level of per capita meat consumption played the dominant role in accounting for the most of the difference. When further urbanization is taken into account and combined with population growth, urban residents consume up to five times more cropland than rural residents. More meat consumption is expected when the factors of income growth and the associated diet change as well as the high population growth act together (S4 and S5), which result in a great jump in demand for cropland. When we take all factors into account, including increase in land productivity induced by technology improvement, medium population growth, urbanization, and income growth, China would need to import large amounts of embodied cropland (21% of its total cropland consumption) to satisfy its demand for soybeans (16.5 Mha abroad), followed by paddy rice (5.5 Mha), corn and other cereal grains (4.9 Mha abroad), and wheat (4.6 Mha). The import of vast amounts of virtual cropland implies that China would face a big challenge to meet its strategic goal in maintaining grain self-sufficient, which was first introduced in the 1950s and was emphasized again recently in the strategic plan *Outline of the Program for Food and Nutrition Development in China* (2014-2020)(General Office of the State Council 2014). Recently observed and future forthcoming diet changes demand more meat, eggs, fishes, and dairy products, and this would make the goal of food self-sufficiency more difficult to achieve. In other words, China needs to support its increasing population in a new way, by supplying more meat, eggs, fishes, and dairy products. This new way lead to significant increase in demand for livestock feed, e.g. soybean and corn. Soybean has been China's largest agricultural import product in recent years and now accounts for some 50% of world trade of soybean (USDA 2013).

China has also become the world's largest consumer of corn, and its fast growing demand for protein-rich diets have changed the country from a net exporter of corn to a major importer of corn since 2009, with a net import scale of 3-5 million metric tons per year (USDA 2013). The reason underpinning this big shift is not only for food items but also for livestock feed. Urbanization and rising living standards have reduced rural labor supply and prompted livestock production from the traditional “backyard” production method to larger-scale, capital-intensive modes of farming which requires much more use of feed grains (Hubacek and Sun 2001; Sun 2014; USDA 2013). Another major driving factor on the demand side which emerges recently has been the non-food use of vegetable oils such as paints, detergents, lubricants and biodiesel (FAO 2012).

On the supply side, Chinese food production has constrained by not only the scarcity of cropland, but also environmental issues such as water availability and pollution. China’s per capita water availability is only about one-fourth of the world average. Moreover, China’s water resources are unevenly distributed spatially. Per capita water availability in northern China is less than one-fourth that in southern China, and one-eleventh of the world average (Xie et al. 2009; Hubacek and Sun 2005). The water constraint may lead China to increase imports of grain from other countries in the future and thus externalize water stress to other countries as its water demand grows (Yu et al. 2014). Other environmental problems, especially degradation and loss of farmland, can also exacerbate the supply problem and push China to externalize land stress to other countries.

While China’s food security challenges intensify the environmental pressure on its own domestic land resources, they also transfer pressure to other countries. When we consider all factors (S4), China would use vast amounts of cropland of Argentina (5.5 Mha) and Brazil (3.3 Mha) for its consumption of soybeans. Existing researches show that large cropland expansion was one of the main factors resulting in deforestation in the Brazilian Amazon (Motta and Amaral 1998; Morton et al. 2006) and such concerns may be still valid in the future. China's seeking of more accessible agricultural land in Southeast Asia may also place environmental pressure there, such as soil erosion, deforestation, loss of biodiversity, reduced water quality as well as increased methane levels (Luo et al. 2011; Fuller et al. 2011). Africa, where most of the countries are predicted to suffer food insecurity in 2050 (FAO 2012), is becoming an important exporter of embodied cropland to China and may provide 1 Mha and 0.9 Mha of embodied cropland for China's consumption of oil seeds and cereal grain in 2030, respectively. The predicted increase in food import and the associated land use from Africa may further stress the food insecurity issue in the region.

In summary, China's fast economic growth and urbanization does not only impose pressure on its domestic land resources, but also create land pressure and other environmental concerns in foreign countries. It is worth highlighting that the diet structure change toward more meat consumption in China is the top driver for the increase of China's future land consumption, thus changing to healthier diet for urban households in China may help to reduce global environmental pressure.

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