Food security and food self-sufficiency in China: from past to 2050

Bishwajit Ghose
Institute of Nutrition and Food Science, University of Dhaka, Dhaka, Bangladesh

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Abstract
Reducing hunger and malnutrition and improving food security have come to the forefront of global political agenda. In the wake of recent spells of food price hike, national and supranational development organizations and governments have begun to express serious concerns about the world’s capacity to feed its burgeoning population. In response to the target of increasing food production by 70% in 2050, many countries are formulating their agricultural policies to promote domestic food self-sufficiency and many are building international networks for outsourcing food supply beyond national borders. In the face of massive demand for food for its growing population, China is both strengthening its food self-sufficiency strategies and relying on large-scale imports from international market which has been a major driver of food price inflation in recent years. In China, increase in income and socioeconomic status on one hand have dramatically improved dietary intake and overall nutritional status of the population, and are creating an enormous pressure on land and water resources and natural environments on the other. Maintaining food and water security and for its huge population with its limited resources while at the same time sustaining the economic growth momentum are offering significant challenges to China’s macroeconomic prospects. China’s domestic food production and self-sufficiency status have certain repercussions on the volatility of global agri-food market and food security in food-import and food-aid-dependent countries. The objectives of this study is to provide an in-depth overview of China’s food production and demand scenario with a particular focus on its challenging perspectives toward food secure 2050. The first half of the paper is designed to show recent trends in food production and consumption and the impacts on global food market. The second half describes the major challenges with a brief discussion on policy implication.

Introduction
Since the 2007–2008 global food price hike, which pushed around 400 million more people into poverty, increasing agriculture’s capacity to feed burgeoning global population has become at the forefront of global development agenda. High food price and food scarcity have already caused severe social and political unrest in many countries in Asia, Africa, and South America and is likely remain a worldwide concern for the next 50 years and beyond (Rosegrant and Cline 2003). Many researchers have explained the event from many perspectives such as drought in major wheat-producing nations, ban on grain export by many countries, rising per capita income, depreciation of dollar against foreign currencies, demand for corn for ethanol in Europe and the United States. Rising demand for food in India and China was indicated by some for the increase in world food prices. Increasing dependence on import and ban on export of food grains by Asian countries, especially India and China is very likely to aggravate global food crisis globally and can have significant implications for the poverty and malnutrition in the world (Keijiro 2013).
foundation of the republic in 1949 and the economic reform in late 1980s have been two most phenomenal events in China’s agricultural history. Economic reform commenced with agrarian reform, and the introduction of the “Household Responsibility System” (家庭聯產承包責任制: Jia¯ tíng lián chǎn chéng bǎo zé rèn zhì) has brought dramatic improvements in agricultural production and productivity. Since then China has been able to grow most of the food it needs and has become a number one producer and exporter of many agricultural products. In recent years, China’s socioeconomic progress coupled with rapid demographic and nutrition transition however have accelerated the demand for food and which contributed to a decline in self-sufficiency rate and a sudden rise in food price. Food prices in China present a similar pattern to the global food price inflation and interest rates were raised several times in 2011 to combat this inflation (Zhihao and Shida 2012). As of the end of September 2011, the overall consumer price index was 13% higher than in 2010, with sharp price increases of all type of foods- food grains (12%), meat (28%), eggs (14%), seafood (14%), fresh vegetables (2%), fresh fruits (6%), and oils and fats (18%) (Zhihao and Shida 2012). Increase in food price has considerable implications for consumers who spend a high proportion of income for food. Aside from maintaining a robust economic growth rate, China has made great strides in improving its food situation during last few decades. Feeding one fifth of the world’s population from less than a tenth of its arable land and freshwater is a daunting task, but this too has come at an expense of severe land and water pollution and many other environmental externalities. Biodiversity and environmental concerns have already reached a point to influence agricultural, food and trade policy making, and resource allocation strategies. To feed its 1.3 billion population with a per capita cultivated land far below the world average, China is already facing a great challenge of land scarcity. Farmland declined by about 11% between 1978 and 2006 (Fleming 2009). And accelerated urbanization along with explosive economic growth has further worsened the shortage of agricultural land over the last two decades (Jie 2007). While some agronomists and environmentalists believe that China should import more land-intensive food to reduce pressure on its already strained land and water resources, others express fear over the fact that China’s long-term dependency on foreign exports will fuel food price increase and worsen the food insecurity status in many resource poor countries who largely rely on foreign imports (Minghua and Yan 2009; Feng et al. 2010). However, till now, maintaining a grain self-sufficiency of 95% is the central theme of China’s food security blueprint. Since its accession to WTO in 2001, as world’s largest agri-food market, China has gradually become a key player in global agri-food policy making. Today, with 9% of world’s arable land and 8% freshwater resources, China produces 18% of the world’s cereal grains, 29% of the world’s meat, and 50% of the world’s vegetables (Jiang 2007). China’s agriculture is supporting a population of over 1.3 billion people today, compared to about 500 million in 1950, is projected to feeding around 1.4 billion by 2050 with a shrinking land base and water resource. As the population’s economic status is improving, the quantity and quality of food consumed has also increased and average household income almost tripled since 1989. Caloric intake now stands at 2830 kcal/person/day, putting China near the top of the developing countries and approaching the levels of high-income countries. On the one hand, remarkable income increase had been encouraging demands for more animal protein, high-quality vegetables and fruits in addition to sufficient subsistence grains, on the other hand, accelerated urbanization is enlarging the markets of high-quality food products because the urban population in China normally has a much richer, more diverse diet than the rural population (Jie 2007). Leveraging intensification, introducing better irrigation techniques, more transparent land administration, bioremediation, and better environmental protection strategies to curb pollution seem to be vital for ensuring sustainable food security for China in 2050.

**Self-Sufficiency in Grain**

The term “Food security” translates literally as grain security in Chinese (粮食安全: Liáng shí ān quán). Grain sufficiency has always been at the heart of national food security agenda in China as in most other Asian countries (Ghose and Sajeeb 2013). Figure 1 shows the trend in grain production and consumption in China. Its global importance is realized by the fact that Chinese agriculture supports staple food supply for around 22% of global population and produces 30%, 15%, and 17% of global production of rice, wheat, and corn, respectively (Xiong and Conway 2009). Rice is the most important grain followed by wheat and corn and together account for 99% of total grain production. While Corn enjoys highest productivity of all types of grain, soybean production is lowest in comparison with other major grains (Fig. 2).

China’s economic reform began with restructuring of the agricultural sector with a great emphasis on cereal grain production. Since decollectivization began in China in the late 1970s, both production and productivity of the farms have increased significantly and regional grain self-sufficiency was a major driving factor behind such gains (Justin et al. 1995). China’s history as a grain importer is long and it is also hard to know last when China was self-sufficient in grain, and the Grain import program of China has long been a controversial topic among many...
scholars (Xiao-yuan et al. 1995). In 1980s, grain import was attributed primarily to the inadequacy of domestic cereal production by some (Mah 1971) and to improved diet pattern by others (Ishikawa 1977). Today, when China boasts to be world’s leading cereal grain producer, it still remains a net importer of grains and the causes behind this constant dependency despite huge domestic production have become more complex and inevitable in some cases.

Global urban population exceeded their rural counterpart in 2008 and China took only three more years to achieve this trend. Urbanization was a major driving factor behind the increased demand for food as it brought changes in demand for agricultural products both from increases in urban populations and from changes in their diets and demands (David et al. 2010). China is now world’s second largest consumer of oil and the third largest producer and consumer of biofuel. Considering the need for energy to support the scale of industrialization China is undergoing, its decision based on trade-offs between outsourcing energy and achieving food self-sufficiency is a rather hard one. The situation is more complex for China compared to other major producers of biofuel because of its relatively the low per capita availability of agricultural land (Table 1) and a huge population burden. Though most of China’s biofuel is produced from animal fat or waste vegetable oil, the cost of production is still higher compared to other sources of fuel (gasoline) and imported ones due to expensive land usage. Moreover, China’s decision to produce biofuel has been criticized on the grounds that it will worse poverty (Qiu et al. 2012) and will have negative impact on food security and environment (Tatsuji 2013). It has been two decades now since some Chinese experts accepted that China will be forced to import 10% or more of its grain supply in the coming decades when it first became a net importer of oil for the first time in history in 1993 (Xiong and Conway 2009). China’s grain production has increased from about 200 kg per capita in 1949 to about 400 kg in the early 1990s (Jianhua 2011) and per capita food supply rose from 2328 calories per day in 1980 to 3029 calories in 2000, an overwhelming 30% increase in a space of two decades (Carter 2011). Grain production in 2010 was 80% above the 1978 level and since the 1980s until 1999, self-sufficiency rate of grain in terms of weight was never below 95%. The rate dropped sharply in 2000, and went slightly below 90% during 2001 to 2003 period (Junichi and Jing 2013).
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China is facing many far-reaching challenges to maintain its planned grain self-sufficiency of 95%, most prominent of them include loss of cultivated land, limited water resources, frequent natural disasters, impacts of climate change, vulnerable ecosystems, increased demand from population growth, improved standard of living, and outdated agricultural infrastructure (Minghua and Yan 2009). Some researchers suggest that to maintain a sustainable supply of cereal grains for its population, China may have to import increasing amounts of grain and this could trigger unprecedented rises in food prices globally (Lester and Linda 1995). In 2011, China harvested the largest grain crop of any country in history and 2 years later it became the largest importer of rice. Despite its grain output hit a record high of 601.94 million tons in 2013, China had to import another 15 million tons. China's population is projected to peak at 1.5 billion in 2033. If it is assumed that grain food per capita will increase from today's 400 to 470 kg in 2033, it will be necessary to increase grain production by at least 35% during the next 20 years (Jianhua 2011). A study reveals that the attainment of a 95% self-sufficiency rate would be quite challenging for China, unless the terms of trade in agriculture improve substantially in favor of producers (Junichi and Jing 2013).

Soaring Demand for Meat

To become world's largest meat-producing country from a state of limited ration of meat only for urban citizens, Chinese meat industry has gone through drastic changes in past three decades (Guanghong 2012). Although China has maintained a high degree of grain sufficiency, it seems to be influenced greatly by rising demand for animal feed. Though rice and wheat production is currently close to target, demand for corn and soybean has soared dramatically and account for bulk of the grain imports. In the 1960s about 80% of the corn was used for direct human consumption while in 1994, about 64% of the total corn production was used for animal feeds (Xiong and Conway 2009). Today, China's 70% of total corn production is used as animal feed and the demand is projected to rise by slightly less than 5% a year. China already reached its import limit of 2.88 million tons of corn this year and is not expected to get more corn until the end of the year. China is now world's largest single importer of soybean (Fig. 3) and the biggest customer of the United States who is currently the world's largest producer of soybeans. In 2013, soybean imports reached a record high of 60 million tons compared to 42.55 million tons in 2009 and 10 million tons in 2000. Corn used for feed increased from

### Table 1. Land statistics comparison of BRIC countries (km²/1000 population).

| Country | Land area | Agricultural land | Arable land | Water surface | Forest area |
|---------|-----------|-------------------|-------------|---------------|-------------|
| China   | 7.0       | 4.1               | 1.1         | 0.2           | 1.5         |
| Brazil  | 41.6      | 13.0              | 2.9         | 0.3           | 23.2        |
| India   | 2.5       | 1.5               | 1.3         | 0.3           | 0.6         |
| Russia  | 118.0     | 15.5              | 8.8         | 5             | 58.3        |

Table 1 shows different types land and water availability status of the BRIC countries. It is clear that China's land resources suitable for agricultural production and water availability is lower than average for most categories. Source: World Bank.

**Figure 3.** Trend in global soybean trade since 2004. China has been a major soybean importer since 2004 and since 2008 China's import amounted higher than those of all others nations combined. This explains the soaring demand for meat and meat products in China during last decade. Source: FAO, World Economic Outlook.
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53 million metric tons (mmt) in 1990 to 93 mmt in 2002 at an annual growth rate of 4.7%. Use of soybean for feed grew even faster, from 1.03 mmt in 1990 to 16.65 mmt in 2002 at an annual growth rate of 30% (Steven et al. 2004). China has opened up soybeans imports to meet its soaring demand for animal feed in the late 1990s which brought about mass deforestation in Latin America and millions of local small-scale meat producers were moved out of the industry. In 2010, China replaced the United States as world’s largest feed grain user and in 2011, its net import was five times as high as total domestic production (14 mmt). In 2012, China saw a 20-fold increase in soybean import since 1998 representing 64% of global soybean trade.

As people’s socioeconomic status continues to rise, so does their demand for meat- and animal-based products. In 1978, China’s meat consumption was one third of amount the consumed in the United States. Per capita meat consumption increased to 58.2 kg in 2009 from 14.6 kg in 1980. In 1990, total meat production was 30.42 million tons which was the largest in the world and per capita consumption reached world average in 1994 (Guanghong 2012). Between 1996 and 2007 total meat production went up by 50%, egg production by 30%, and milk production by 200%. In 1992, China overtook the United States as the world’s leading meat consumer and today, around 27% of all the meat produced worldwide is consumed in China. Improving social and economic conditions, of course, leads to an ever higher consumption rate for both rural and urban people (Fleming 2009). Meeting increased demand for meat and dairy products will continue to be a challenge for China as these products require more land and water resources per unit production (Carter 2011). It takes about 16,000 L of water for 1 kg beef, 6000 and 3500 L, respectively, for same amount of pork and chicken. Pork accounts for around 75% of total meat consumption in China (Fig. 4). In 2013, global pork consumption totaled 107 million tons and half of that occurred in China which is roughly six times as much pork as consumed in the United States. Many researchers have attributed the shocking rise in global grain prices in 2008 to China’s increased demand for meat. Since the 1990s, rising incomes, especially in cities, have led to significant increases in demand for nonstaple animal-based foods such as meat, fish, and dairy products. Given that the number of higher income earners is expected to increase rapidly, demand for nonstaple food will also expand, increasing pressure on domestic production and import from other countries. Though meat industry is developing quickly, there is a significant lack of development in private enterprises, government, research institutes and the standards of fresh meat and meat products is still less than optimal (Guanghong 2012).

Fish

Globally, fish provides an important source of food and nutrition security. In 2009, fish accounted for 6.5% of all protein consumed. In China, fisheries sector has always played a major role in national food security. Even in the 1950s when fisheries output was just above 3 mmt, it used to contributed significantly to national food supply. Since 1980, China experienced the fastest growth in annual per capita fish consumption with its per capita consumption increased by more than 300% and at an annual average growth rate of 9%. Today, China is world’s largest aquaculture and marine producer (Fig. 5) and has the highest number of fishers and fish farmers. China’s share in world fish production grew from 7% in 1960 to around about 70% today. In 1988, China’s annual fisheries output reached

Figure 4. Demand for meat by type. Demand for all type of meat has been rising since 1990. Pork is the most widely consumed meat in China followed by beef and chicken.
10 mmt mark for the first time in the country’s history and was the third country in the world by then to achieve that scale of production. Globalization of the fish trade and subsequent relaxation of other regulatory barriers facilitated fish trade between China and the West. Following its accession to the WTO in 2001, China has been the world largest exporter of seafood since 2002. Since 1980, China experienced the fastest growth in annual per capita fish consumption with its per capita consumption increased by more than 300% and at an annual average growth rate of 9%. Total seafood consumption rose from 10 kg per capita in 1990 to 30 kg in 2009. China has a long history in aquaculture dates back to 3000 years ago and its mariculture dates back to the Song Dynasty about 1000 years ago. In Chinese, the word “fish” (鱼: yú) is homonymous with the word “abundance/surplus” (裕: yù). Though these words have slightly different accent, people occasionally prefer to pronounce fish as “yù” instead of “yú” to express a sense of abundance and/or prosperity. Historically, fish constitutes a major part of the diet for Chinese people and the role of fish in Chinese diet is becoming increasingly important. Besides its role in the diet, aquaculture also contribute to household food security by providing employment to a considerable proportion of the workforce (~15 million people) and also been an important component of the national economy. China is blessed with a huge marine resource base with a coastline that extends more than 18,000 km. Fisheries and aquaculture have four subsectors- Inland (freshwater) catch, inland aquaculture, marine catch, and mariculture. Four seas (Bo Hai, Yellow Sea, East China Sea and South China Sea) surround the northeastern and southern territories and provide a great opportunity for marine catch and mariculture. Besides a huge marine water base, China is also rich in inland waters covering an area of 17.6 million ha, nearly one fiftieth of its land area. The country is crisscrossed by around 50,000 rivers and more than 2800 lakes and contains more than 4500 fish species. In the 1960s, marine capture fisheries accounted for the bulk of fisheries production. However, in recent years owing to rapid development in inland aquaculture, the proportion of marine capture has been decreasing. Total marine catch increased from 0.6 million tons in 1950 to 13.6 million tons in 2011 and marine culture increased almost 100-fold in the same period (Gongming and Mikko 2014). China’s inland aquaculture is dominated by Tilapia- a tropical freshwater fish (Oreochromis niloticus) from Africa. It is the most widely grown of all farmed freshwater fish across the world and is cultivated all year round. China is the biggest producer and exporter of tilapia and accounts 56% for its global production.

As the world’s biggest food producer, China also has the fastest growing share of fish and shellfish exports to EU and the United States (Qiu et al. 2012). Each year it processes a staggering 110,000 tons of cod products for the Europe and the United States markets which equates to approximately 15–20% of the global catch. It exported over USD 16 billion in seafood products in 2011. Besides being a major exporter, China also accounts for over a quarter of the world’s seafood consumption and per capita consumption is expected to reach 35.9 kg by 2020. Despite such impressive production and export figures, China remains a major importer of seafood. In 2005, China exported 7.2 billion worth of seafood and imported $3.2 billion resulting in a huge fish trade surplus. And in 2011, China became the third largest importer of seafood.

**Challenges for Food Security in China**

**Land**

To feed China’s huge population, small farmers are facing increasing challenges from diminishing land and water resource. Though China is the world’s third largest nation in terms of land area. However its per capita arable land is around half the world’s average and only 12.8% of total national terrestrial surface is available for agricultural activities (Jie 2007). Table 1 shows that China’s land resource suitable for cultivation is comparatively lower than other
major agri-food-producing countries. Pressure on agricultural land and land degradation has accelerated since 1978 due chiefly to rapid industrialization and urbanization (Yang and Li 2007). Between 1996 and 2008, cultivated land and grassland decreased by 6.4% and 0.59%, respectively, much of which was attributed to urbanization and industrialization (Ghose and Sajeeb 2013). Total cropland is expected to decline from 135 million ha in 2003 to 129 million ha in 2030 (Guanghong 2012). Since 2008, the central government has made urbanization, and agricultural and rural development a tactic to counter the global financial crisis and economic slowdown, as well as a long-term strategy for sustained economic growth (Ling 2011). The area of cereal production decreased from 97 million ha in 1978 to 93 million ha in 1995 due to the occupation of farmland for construction, and roads, and other developments (Xiong and Conway 2009). According to National Bureau of Statistics, China’s urban population outnumbered rural dwellers for the first time in history in 2011 down from 81% in 1979. Nobel laureate Joseph E. Stiglitz maintained that, as the biggest developing country in the world, the urbanization of China and the high-tech development of the United States would be two important topics which would profoundly influence human development throughout this century (Hongxiang and Zhijun 2009). This urbanization spree has its footprints across various social and environmental spheres some of which are already being felt. Since 1990, over 8 million ha of its arable land have disappeared and per capita cropland has decreased from 0.18 ha in the 1950s to less than 0.1 ha today (Jianhua 2011). China completed the Three Gorges Dam where over 60,000 ha of farmland was lost, and according to a local news media (China Daily Mail, May 3, 2012), China lost 70% of its rice and 50% of its grain production with this one bad decision.

Besides declining in quantity, the quality of the survived land is also under huge threat. Urbanization is enhancing the degree of soil pollution through improper disposal of domestic and industrial waste, and acid deposition derived from urban air pollution (Jie 2007). About 2.5% of total arable land (3.3 million ha) have already become too polluted for cultivation. Contamination of croplands and rivers with heavy metal such as cadmium (Cd), lead (Pb), and arsenic (As) has received widespread attention due to their potential impact on public health and ecological systems (Zhiyuan and Zongwei 2014). Heavy metals are well-known for their carcinogenic properties in multiple organs (Matês et al. 2010). A test carried out by Guangzhou Food and Drug Administration in 2013 found that a majority of rice in local restaurants contained excessive levels of Cd. Another study on ten heavy metals in Hunan province showed that the tested soil samples were severely contaminated by the investigated metals (Xiangqin et al. 2010). As contamination of food products especially of rice and vegetables has also raised serious food safety concerns nationwide as rice is the most widely consumed cereal in the country. Soil pollution by arsenic is the major source of As uptake by crops which is the main route for As to human food chain. Arsenic is widely recognized for its carcinogenic properties and is ranked first among all hazardous elements by the Agency for Toxic Substances and Disease Registry (Gao and Lai 2013). Though water is the main source of As contamination in most other Asian countries (Japan, Bangladesh, India, Thailand), a recent study showed that As intake for the Chinese population through rice (37.6%) is much higher than from drinking water (1.5%) (Feng et al. 2010), and suggested that issue must be dealt with more stringent policy making (Feng et al. 2010).

To avert such serious public health issues, in many areas where land and irrigation water is found to be highly polluted with toxic elements and pesticides are being discarded for cultivation. Thus, millions of hectares of agricultural land may become unsuitable for agriculture in near future and this will have grave impacts on agricultural output and domestic food self-sufficiency.

Aside from urbanization and pollution, land reform has been another heavily discussed topic in the context of agriculture and food security in China. Land administration is considered vital for food security (Georgina et al. 2013). Misappropriation of farmland in the rural areas is not a news in China. A nationwide campaign conducted in 2006 to regulate farmland allocation for commercial purposes detected 22395 illegal land appropriation cases (Jiang 2007). Since 1980s, prioritizing the need for land for nonagricultural purposes over the need for ones under agriculture has been serving as an implicit way to cater labor force for industrialization and urban development. And with the surge of more remunerative nonfarm market sectors, farmers are also becoming more unlikely to stick to the land to which their right is not firm.

Water

The concern over food and water insecurity is rising globally. Many countries have experienced decreasing agricultural yields recently due to diminishing stream flows and falling water tables. Drought in major food exporting regions like Australia and the United States was largely responsible for the global food price hike. Arab world is facing a huge food gap which is largely due to its incapacity to supply sufficient water for agriculture. And China appears to be no exception, and even has greater challenges owing to its fast ongoing urbanization and industrialization. According to WWF (World Wildlife Fund), 13% of China’s lakes have disappeared in last 40 years along with half its coastal wetlands. The United Nations also identified China as one of
13 countries faced with extreme water shortages. The main underlying causes behind this scarcity include huge demand from agriculture and urbanization, uneven distribution of water resources, and extremely high level of pollution. Industry and agriculture combined account for 85% of all water use in China. Adequate availability of water is critical for optimum agricultural productivity and water scarcity is already seriously impacting grain production especially in northern parts of the country (Tatsuji 2013). China’s annual per capita water resources is 2079 m³ compared to a global average of 6225 m³ which is expected to peak in 2030. While the Southern region enjoys 80% of the fresh water water resources, many regions in northern China are expected to run dry within 30 years which will have devastating impacts on the region’s agricultural production and food supply. To prevent this catastrophic happening, Chinese government has initiated an astounding South-North Water Diversion Project which is set to become world’s largest water diversion construction and the largest concrete structure on earth as well. The decision of going for this staggering $62 billion project in a situation where world economy is striving to recover from a deadly crisis speaks of the gravity of water insecurity in China (at least regionally). The channel is designed to divert about 45 billion m³ of water per year from the Yangtze River to the Yellow River basin in arid north once finished by 2050.

China’s fisheries sector is confronted with a host of challenge arising from widespread water pollution from numerous sources and concern about the food safety standards. Most rivers and lakes especially near urban and industrial areas is severely affected by eutrophication and contamination by urban and industrial discharge, various agrochemicals, antibiotic contamination, and carcinogens. The Yangtze River, once the lifeblood of the country, is already heavily polluted and has become unusable for crop production in many parts due to eutrophication by agricultural run-off and heavy industrial effluent content. Out of 18 largest lakes in China, 14 are already entirely eutrophic, which is not only affecting aquaculture, but also causing shortage of drinking and industrial water for the surrounding communities (Peiqiao et al. 2013). Aside from eutrophication, aquaculture also suffers from degradation of genetic resources due to the lack of selective breeding, land reclamation dam building, etc. Overfishing and increasing pollution are destroying marine resources in the East China Sea, where 81% of the fishing regions are rated category 4 for pollution. The coastal regions like Shanghai and Liaoqing have long been exposed to intense industrial activities and urbanization, and the people living in those areas are becoming more vulnerable to toxic contamination by consumption of local seafood. Mariculture is also facing a range of challenges including industrial pollution, loss of biodiversity, and increasing risks in food safety. Water quality of the Sanggou Bay, which is one of the most important mariculture regions in China, is facing severe deterioration due to overfishing which has resulted in reduced fish sizes and diminishing production (Tatsuji 2013).

Policy implications

Food security is a multidimensional concept which requires a range of factors to be considered for making long-term sustainable goals. China has been at the crossroads in its endeavor to design a long-term food security blueprint. For China, there exists a complex trade-off between outsourcing land and water intensive food for its population which makes it vulnerable to a volatile food market situation, and trying to stick to its self-sufficiency policy which is increasingly becoming more challenging and deleterious for the diminishing resources. Recent experience reveals that overdependence on imported food creates the preconditions for transmitting food price hikes in international market to the domestic market which has devastating impacts on low and middle-income families and also commonly leads to social disorder. Development specialists and think tanks around the world have been publishing extensively concerning the mammoth task of feeding 9.5–10 billion people in 2050 and suggest that food production needs to be increased by around 70%. Different countries have been adopting different measures to realize this nearly unachievable goal. China as a fast-growing country, and as a key player in global agri-food market is also faced with extraordinary challenges to meet its long-term food security goals. As China continues to rise as an economic superpower amid global crisis, this remarkable performance has in part overshadowed the critical challenges that came alongside this “rush development”. Oversight of the negative externality of unbalanced industrialization and urbanization has already begun to take huge toll on public health and environmental resources, and biodiversity. Though China’s population is projected to be decreasing by 2050, its urban population will continue to grow and very likely will outstrip the country’s catering capacity and increase strain on agricultural resources elsewhere. China’s goal of grain self-sufficiency is already at a stake due to a great extent to huge demand for meat. The benefit of one child policy (独生子女: Dú shēng zǐ nǚ) on reducing food demand is being offset by rapid urbanization and changing demographics. This indicates that besides improving its capacity to maximize agricultural yield and reducing population growth rates, China’s policy makers need to work on several other key areas which are not extant in the current food security framework. Food security specialists must innovate ways to feed the rapidly growing cities more safely and sustainably and curbing pollution at the
same time to tackle the looming challenges of food security in the coming decades. Rapid urbanization has resulted in loss of arable land, environmental degradation, and new dietary demands on food production (Fleming 2009). Though population is projected to be decreasing by 2050, the demand for food can actually be multiplied due to improved socioeconomic status and continued urbanization. Besides a declining ratio of food producers-to-consumers, urbanization increases the demand for more energy, land, water, and greenhouse gas emission-intensive food (David et al. 2010). Bringing a change in diet pattern can be effective in reducing pressure on meat industry which will also greatly help to achieve the grain self-sufficiency target. Many local experts have suggested that today’s western type diet is largely responsible for China’s chronic disease epidemic and Chinese people should revert to traditional high cereal and vegetable based diet with lower proportion of meat. On the supply side of the food security equation, sustainable intensification agricultural must be brought about by developing stress-resistant cultivars and climate-smart technologies. Better management of water resources and more transparent land administration are required, and community-based natural resource management (CBNRM) may also prove vital. Since China’s food security relies on sustainable use of land and water resources, it faces great imperatives to innovate better strategies for meeting its demand with the given resources. Overall success in addressing the food security challenges will be determined by the ability to implement policies which will require greater coordination among policy makers, researchers, mass-media, and civil society.

**Conclusion**

Despite the fact that food production has doubled during the past three decades globally, demand has also accelerated from highly populated and fast-growing economies like China and India. From this study, it is clear that China continues to be a major contributor to global food production and consumption. China’s past success in grain self-sufficiency doesn’t reflect its future vulnerability to food insecurity since the demand for crops for nonfood use is rising enormously. China is likely to remain self-sufficient in rice and wheat but will continue to be dependent on other countries for soybeans and corn to meet its growing appetite for meat and dairy products. Food and nutrition security scenario can worse due to demographic pressures coupled with climate change, extreme pollution, diminishing arable land, and depleting aquifers. Proportion of the population not involved in food production will continue to increase, and so will urban consumers whose dietary choice is becoming more energy, water, and land intensive. Unbalanced industrialization and poor management of land and water resources may cost dearly in future as soil and water pollution are already beginning to pose serious threats on food safety and on food security. Adoption of sustainable intensification techniques and developing better market strategies must be accompanied by high-level policy measures to strengthen environmental law enforcement and compliance to confront the challenges of food security in near future. Given the increasing phenomenon of global hunger and poverty, China, as a global economic powerhouse and major agrifood producer, is faced with an imperative of not only of feeding its own citizens, but also to contribute to structuring a more efficient and sustainable food and agricultural system and ensure better market balances, and a fairer allocation of resources and responsibilities among the global community so as to ensure food security for all and to improve the standard of living.

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**Conflict of Interest**

None declared.

**References**

Carter, C. A. 2011. China’s agriculture: achievements and challenges. AREUpdate 14:5–7.

David, S., M. Gordon, and T. Cecilia. 2010. Urbanization and its implications for food and farming. Phil. Trans. R. Soc. 365:2809–2820.

Feng, L., L. Yulan, Z. Guilin, et al. 2010. Total and speciated arsenic levels in rice from China. Food Addit. Contam. Part A 27:810–816.

Fleming, C. 2009. Food security, urbanization and social stability in China. J. Agrar. Change 9:548–575.

Gao, L. S., Q. L. Lai, et al. 2013. Arsenic, copper, and zinc contamination in soil and wheat during coal mining, with assessment of health risks for the inhabitants of Huaibei, China. Environ. Sci. Pollut. Res. 20:8435–8445.

Georgina, R., B. Rohan, and G. Liza. 2013. Land administration for food security: a research synthesis. Land Use Policy 32:337–342.

Ghose, B., S. Sajeeb, et al. 2013. Self-sufficiency in rice and food security: a South Asian perspective. Agric. Food Secur. 2:10.

Gongming, S., and H. Mikko. 2014. An overview of marine fisheries management in China. Mar. Policy 44:265–272.

Guanghong, Z., et al. 2012. China’s meat industry revolution: challenges and opportunities for the future. Meat Sci. 92:188–196.
Hongxiang, W., and H. Zhijun. 2009. Study on the County-level City in China. J. Polit. Law 2: 50–54.
Ishikawa, S. 1977. China’s food and agriculture: a turning point. Food Policy 3:90–102.
Jiang, Y. 2007. Chinese gov’t uncovers officials who misappropriate farmland. Available at http://news.xinhuanet.com/english/2007-12/10/content_7226605.htm (accessed December 1, 2014).
Jianhua, Z. 2011. China’s success in increasing per capita food production. J. Exp. Botany 32:1–5.
Jie, C. 2007. Rapid urbanization in China: a real challenge to soil protection and food security. CATENA 69:1–15.
Junichi, I. T. O., and N. I. Jing. 2013. Capital deepening, land use policy, and self-sufficiency in China’s grain sector. China Econ. Rev. 24:95–107.
Justin, Y., Z. Guan, and W. James. 1995. China’s regional grain self-sufficiency policy and its effect on land productivity. J. Comp. Econ. 21:187–206.
Keijiro, O. 2013. Food insecurity, income inequality, and the changing comparative advantage in world agriculture. Agricultural Economics 44:7–18.
Lester, R., and S. Linda. 1995. Who will feed China?: wake-up call for a small planet. W. W. Norton & Company, New York, ISBN-10 039331409X.
Ling, Z. 2011. Food security and agricultural changes in the course of China’s urbanization. China World Econ. 19:40–59.
Mah, F. 1971. Why China imports wheat? China Quart. 45:128–129.
Matés, J. M., J. A. Segura, F. J. Alonso, and J. Marquez. 2010. Roles of dioxins and heavy metals in cancer and neurological diseases using ROS-mediated mechanisms. Free Radic. Biol. Med. 49:1328–1341.
Minghua, Z., and C. Yan. 2009. Problems, challenges, and strategic options of grain security in China. Adv. Agron. 103:101–147.
Peiqiao, J., Z. Wenbo, and L. Qigen. 2013. Lake fisheries in China: challenges and opportunities. Fish. Res. 140:66–72.
Qiu, H., L. Sun, and J. Huang. 2012. Liquid biofuels in China: current status, government policies, and future opportunities and challenges. Renew. Sust. Energy Rev. 16:3095–3104.
Rosegrant, M. W., and S. A. Cline. 2003. Global food security: challenges and policies. Science 302:1917–1919.
Steven, T. Y., F. Cheng, and S. Shew-Juiuan. 2004. Household food demand in urban China: a censored system approach. J. Comp. Econ. 32:564–585.
Tatsuji, K. 2013. Biofuel and food security in China and Japan. Renew. Sust. Energy Rev. 21:102–109.
Xiangqin, W., H. Mengchang, X. Jun, X. Jianhong, and L. Xiaofei. 2010. Heavy metal pollution of the world largest antimony mine-affected agricultural soils in Hunan province (China). J. Soils Sediments 10:827–837.
Xiao-yuan, D., S. Terrence, and M. Michele. 1995. China’s grain imports: an empirical study. Food Policy 20:323–338.
Xiong, W., D. Conway, et al. 2009. Future cereal production in China: the interaction of climate change, water availability and socio-economic scenarios. Global Environ. Change 19:34–44.
Yang, H., and W. Li. 2007. Cultivated land and food supply in China. Land Use Policy 17:73–88.
Zhihao, Z., and R. H. Shida. 2012. Estimating the impacts of rising food prices on nutrient intake in urban China. China Econ. Rev. 23:1090–1103.
Zhiyuan, L., M. Zongwei, et al. 2014. A review of soil heavy metal pollution from mines in China: pollution and health risk assessment. Sci. Total Environ. 468–469:843–853.