Sector Profile: China

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A. Overview[1]

Largely driven by industrial manufacturing and services growth, China's GDP has grown at an average annual rate of almost 10% in the last decade. Agricultural value added contributes about 10% of GDP, so agriculture represents a relatively small proportion of aggregate economic activity[2]. Agricultural employment has declined from 69% of the workforce in 1980 to around 34% today[3]. Yet agriculture is crucial to the national economy, sustaining just under one fifth of the world's population on about 8% of the world's arable land[4], with per capita water availability at about 10% of the global average[5].

China's demand for food products has increased significantly in recent decades (Figures 1a and b). This change in demand has not been driven significantly by population growth (which has declined in recent years, due in part to the One Child Family Planning policy), but by increasing urbanization and rising incomes. In 1980, 19% of the population was urban, but in 2011 the proportion was over 51%[6]. Between 2000 and 2010, real per capita income growth in urban areas averaged 9.7% and in rural areas 7.1%[7]. As a result, demand for staple foods (e.g. rice, wheat, maize and root crops) has declined, while demand for vegetables, fruit, livestock products and feed grains has increased.

Most of this increase in demand has been met by increased domestic production of the main crop and livestock products (see Figures 2a and 2b). On the one hand, this is due to major changes in the structure of crop production (Figure 2c): fruit and vegetables have increased from around 8% of total cultivated area in 1990 to over 20% in 2011. On the other hand, increased productivity has been a key source of increased domestic supply: total arable land area has increased by around 0.3% p.a. since the 1980s, while output of the major agricultural crops has increased by more than 4% p.a. in the last decade (Table 1). Livestock product supply has also increased markedly, particularly for poultry, dairy products and pork, with output growing faster than animal populations (Figures 2b and 2d). Overall, China has maintained >90% self-sufficiency in most major food crops and livestock products. However, there have been some significant exceptions.

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[1] This report draws substantially on analysis elaborated in Garnett, T. and Wilkes, A. *Appetite for Change: Social, Economic and Environmental Transformations in China's Food System.* Food and Climate Research Network and Social Science Research Council, 2014.

[2] *The World Bank: World Development Indicators*. 2013. Available at: http://data.worldbank.org (accessed 2013-14).

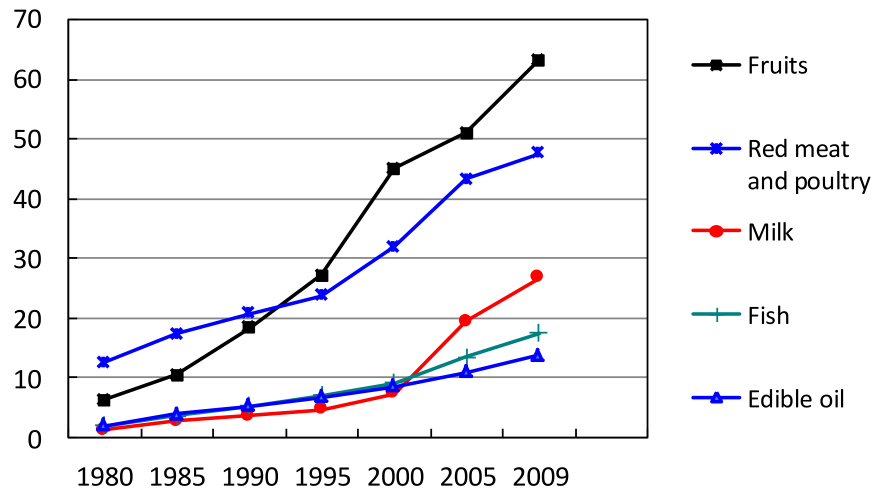
[3] Ibid.

[4] *Food and Agriculture Organisation: FAOSTAT*. 2013. Available at: http://faostat.fao.org (accessed 2013-14).

[5] *Food and Agriculture Organisation: AQUASTAT*. 2013. Available at: http://www.fao.org/nr/water/aquastat/data (accessed 2013-14).

[6] *The World Bank: World Development Indicators*. 2013. Available at: http://data.worldbank.org (accessed 2013-14).

[7] National Bureau of Statistics of the PRC. 2011. China Statistical Yearbook 2011. China Statistics Press, Beijing, China.



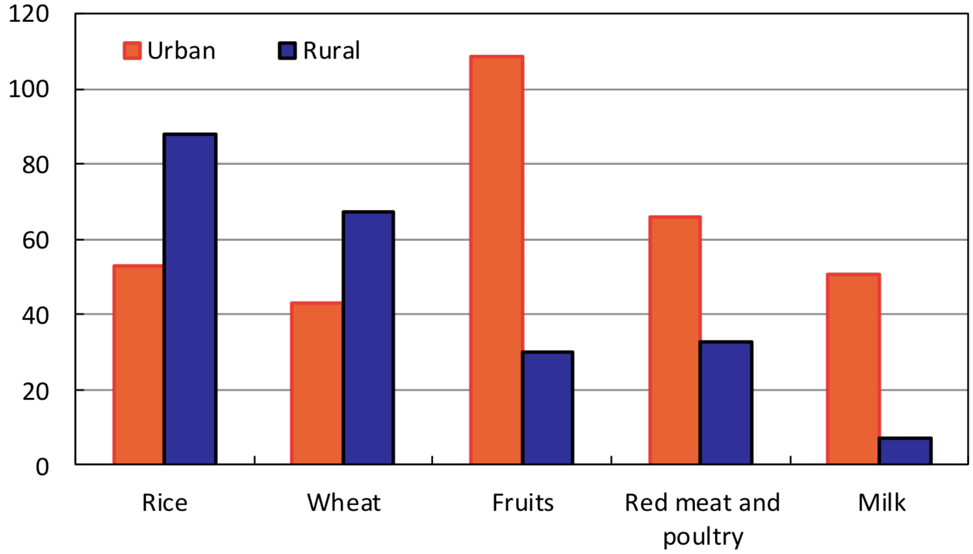


Figure 1a and b: (a) per capita consumption of major food products (kg per year), (b) urban and rural per capita food consumption in 2009 (kg per year).[8]

[8] Norse, D., Lu, Y. and Huang, J. "China's food security: Is it a national, regional or global issue?" In *China and the EU in Context* by Brown, K. London: Palgrave Macmillan, 2013.

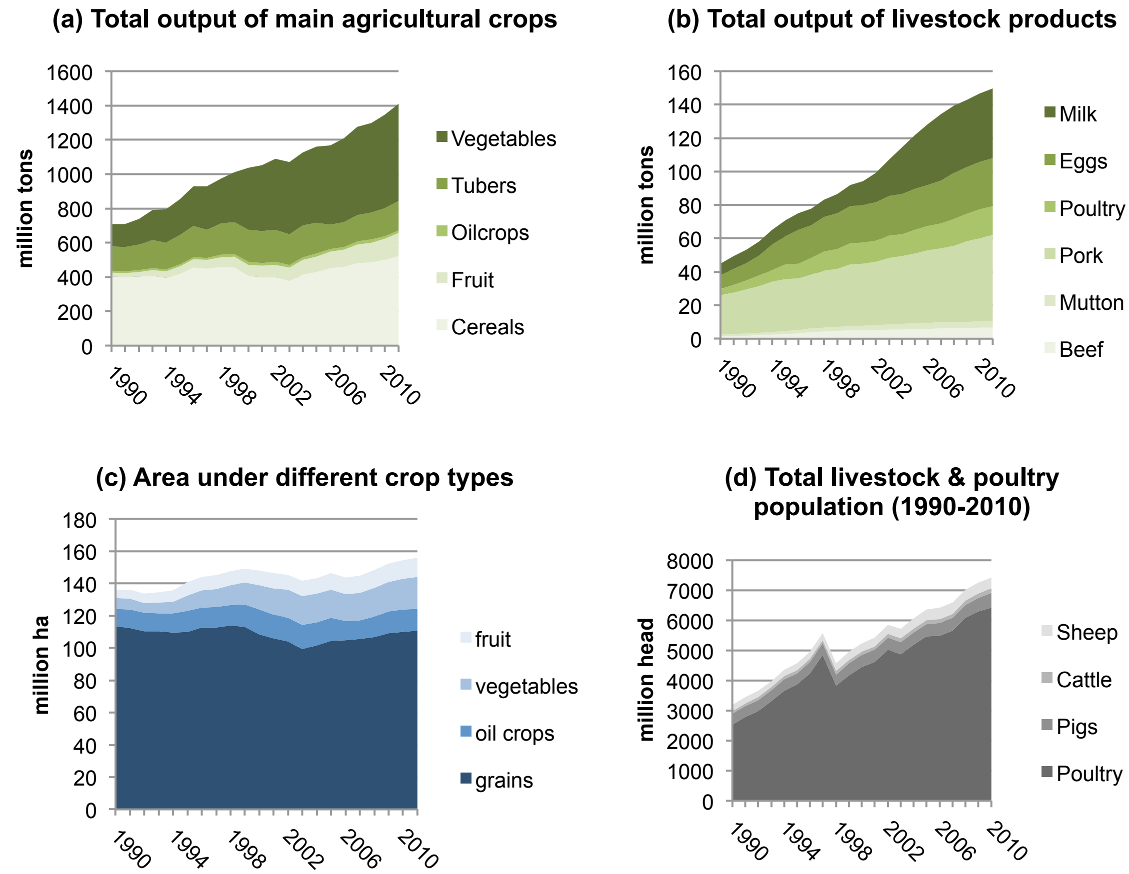


Figure 2: Total output of (a) main agricultural crops (Mt) and (b) main livestock products (Mt); (c) total area under different crop types (Mha) and (d) total livestock population (million head) (1990-2010).[9]

China has become a major exporter of fruit, vegetables and aquatic products (e.g. fish), as well as processed foods, but has started to import large quantities of oilseed (i.e. soy) and grain crops (i.e. maize). In 2010, China's imports of soybeans accounted for about 59% of total global trade in soybean[10]. Data on China's maize imports are inconsistent, but suggest annual imports in the range of 1.6 – 5.2 million tons in recent years (i.e. ca. 1-5% of global maize trade)[11]. These imports are driven largely by animal feed demand. It is not known when China's per capita meat consumption will level off: it is currently ca. 58 kg per annum, compared to 46 kg in Japan and

[9] Sources: (a), (b) and (d) from *Food and Agriculture Organisation: FAOSTAT.* 2013. Available at: http://faostat.fao.org (accessed 2013-14); (c) Ministry of Agriculture data.

[10] Rabobank. *Structural Challenges in US Soy Crushing*. Rabobank, Utrecht: 2010

[11] *Food and Agriculture Organisation: FAOSTAT.* 2013. Available at: http://faostat.fao.org (accessed 2013-14); United States Department of Agriculture Foreign Agriculture Service (USDA-FAS). 2012. Grain: World Markets and Trade. United States Department of Agriculture Foreign Agriculture Service. Circular Series FG 11-12; Food and Agriculture Policy Research Institute (FAPRI). *FAPRI-ISU 2012 World Agricultural Outlook. Food and Agriculture Policy Research Institute*. Ames, United States: 2012.

120 kg in the USA.[12] Most projections suggest that increased food demand in the coming decades will be met by a domestic supply of agricultural products, except for soy, maize, milk and possibly sugar[13]. Some studies have examined the environmental footprint of China's food imports, looking at impacts on deforestation (e.g. in Amazonia), water and land use[14]. Chinese firms have been increasingly engaged in agricultural production overseas, though media reports often overstate the scale of investments, and actual effects on local food security and environment have yet to be properly assessed[15].

Other components of China's food system have also been changing rapidly. The food processing industry has been growing at a rapid rate and accounted for 4.6% of GDP in 2010[16]. Logistics and retail patterns have been changing. An estimated 20-30% of food sales are now supermarket based[17]. In urban areas, domestic refrigerator ownership is close to 100%. In large cities, around 30% of meat is sold in chilled form. Although refrigeration can reduce waste due to spoilage, total food waste has been increasing rapidly. Around 12% of grain produced in China is wasted, mostly at the harvest and storage stages. Household waste is only a small proportion of grain losses, but total household food waste is growing. Urban residential food waste has increased four-fold since the 1980s[18], and with a rise in dining out, catering waste is increasing rapidly. One estimate suggests that annual catering waste in China leads to loss of more than 8 million tons of protein and 3 million tons of fat, and an equivalent of 200 million people's annual grain consumption[19]. Energy use in domestic and catering food cooking has been estimated to account for more than a quarter of GHG emissions in China's food system[20].

Economic growth in China has begun to slow and is projected to fall to around 5% p.a. by 2030[21]. However, sustained growth from an already large base, with a population size that will eventually begin to decline, coupled with continuing urbanization, implies a continued shift in diets. In particular, China's demand for livestock products, fruit and vegetables will continue to drive significant changes in crop structure, the use of crops for feed, production methods, resource use efficiency, and demand for feed and livestock product imports.

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[12] *Food and Agriculture Organisation: FAOSTAT.* 2013. Available at: http://faostat.fao.org (accessed 2013-14). FAO data are for supply of meat. Consumption surveys report slightly lower levels of consumption, but the basic comparison with other countries' consumption levels remains similar.

[13] Norse, D., Lu, Y. and Huang, J. "China's food security: Is it a national, regional or global issue?" In *China and the EU in Context* by Brown, K. London: Palgrave Macmillan, 2013.

[14] Fearnside, P., Figueiredo, A. and Bonjour, S. "Amazonian forest loss and the long reach of China's influence." *Environment, Development and Sustainability*, 2013: 1-14; Liu, J., Sehnder, A. and Yang, H. "Historical trends in China's virtual water trade." *Water International 32(1*), 2013: 78-90.

[15] Buckley, L. *Chinese agriculture goes global: food security for all? International Institute for Environment and Development (IIED) Briefing*. London: International Institute for Environment and Development, 2012.

[16] National Development and Reform Commission (NDRC) and Ministry of Industry and Technology (MITI). *Twelfth Five Year Plan for the National Food Industry*. Beijing: National Development and Reform Commission (NDRC), 2011.

[17] Zhang, Q. and Pan, Z. "The transformation of urban vegetable retail in China: wet markets, supermarkets, and informal markets in China." *Journal of Contemporary Asia*, 2013.

[18] Garnett, T. and Wilkes, A. *Appetite for Change: Social, Economic and Environmental Transformations in China's Food System*. Food and Climate Research Network and Social Science Research Council, 2014.

[19] Cheng, S., Gao, L., Xu, Z., Tang, C., Wang, L. and Bijaya, D. "Food waste in catering industry and its impacts on resources and environment in China." *China Soft Science 7*, 2012: 106-114.

[20] Garnett, T. and Wilkes, A. *Appetite for Change: Social, Economic and Environmental Transformations in China's Food System*. Food and Climate Research Network and Social Science Research Council, 2014.

[21] The World Bank. *China 2030: Building a Modern, Harmonious, and Creative High-income Society*. Washington, D.C.: The World Bank, 2012.

B. Major influences and trends

Productivity increases, transformation of production and supply systems, and constraints on natural resources are the three major features of China's ongoing agricultural development.

B.1 Drivers of productivity increase

In the 1980s, reforms in land tenure[22] and market liberalization were the major drivers of productivity increase. Since then, technological change – particularly development of high yielding grain crop varieties – has been the major driver of agricultural productivity growth[23]. Average grain crop yields (Table 1) and total factor productivity in the crops sector grew by 2-3% p.a. between 1980-2010.

	Pre-reform 1970-78	Reform period				
		1979-84	1985-95	1996-00	2001-05	2006-10
Agricultural GDP	2.7	7.1	4.0	3.4	4.3	4.5
***Output*:**						
Grains	2.8	4.7	1.7	-0.7	1.1	2.5
Cotton	-0.4	19.3	-0.3	-1.9	5.3	-0.9
Oil crops	2.1	14.9	4.4	5.6	0.8	2.7
Fruits	6.6	7.2	12.7	10.2	21.0	5.9
Meats	4.4	9.1	8.8	6.5	4.9	2.3
Fishery	5.0	7.9	13.7	10.2	3.6	3.9
Planted area:						
Vegetables	2.4	5.4	6.8	9.8	3.1	2.0
Orchards (fruits)	8.1	4.5	10.4	2.0	2.4	8.1

Table 1: Annual growth rates (%) of China's agricultural economy, 1970-2010; Grains include cereals, tubers, soy and other beans in China. Meats include pork, beef and poultry.[24]

Some of the key drivers include:

Agricultural research and development and extension. Public agricultural research and development (R&D) has been identified as the major driver of productivity growth. Investment in agricultural R&D tripled between 1990 - 2010, and China has developed one of the largest public agricultural research systems in the world[25]. Although China retains a public agricultural extension system, its effectiveness remains an issue[26]. Private sector R&D and private extension services (e.g. fertilizer companies, farmer organizations) have been increasing, but by no means replaced the government system in most sectors.

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[22] From the late 1970s, communes were disbanded and the 'household responsibility system' introduced, which gave farmers land use rights and control over agricultural decisions.

[23] Huang, J. and Rozelle, S. "Technological change: rediscovering the engine of productivity growth in China's agricultural economy." *Journal of Development Economics 49*, 1996: 337-369; Fan, S. "Effects of technological change and institutional reform in production growth of Chinese agriculture." *American Journal of Agricultural Economy 73(2)*, 1991: 266-275; Fan, S. and Pardey, P. "Research productivity and output growth in Chinese agriculture." *Journal of Development Economics 53*, 1997: 115-137.

[24] Huang, J., Yang, J. and Rozelle, S. "China's agriculture: drivers of change and implications for China and the rest of the world." *Agricultural Economics 41(1),* 2010: 47-55.

[25] Hu, R., Liang, Q., Pray, C., Huang, J. and Jin, Y. "Privatization, public R&D policy, and private R&D investment in China's agriculture." *Journal of Agricultural and Resource Economics 36(2)*, 2011: 416.

[26] Hu, R., Yang, A., Kelly, P. and Huang, J. "Agricultural extension system reform and agent time allocation in China." *China Economic Review 20(2),* 2009: 303-315.

Irrigation infrastructure. The proportion of arable land under irrigation increased from 46% in 1980 to about 56% in 2011[27]. Irrigated land now accounts for about 70% grain area and 80% of grain production[28]. Water use efficiency remains low, and less than half of irrigation water is actually used on crops because of losses to evaporation and leakages in irrigation infrastructure[29]. Investment in existing and new water infrastructure has been a main focus of national policies in recent years[30], with a national target to increase irrigation use efficiency to 60% by 2030.[31] Ground and surface water irrigation energy use causes about 36-54 $MtCO_2e$ of emissions p.a., accounting for more than half of all agricultural energy use[32].

Fertilizer inputs. Along with modern crop varieties, use of fertilizer has increased significantly. Average per unit area application of fertilizer in China is now several times higher than in the USA[33], with particularly high application rates on vegetables and fruits[34], the area of which have been growing. Although increased fertilizer application was instrumental in increasing yields until the 1990s, the efficiency of fertilizer use has greatly decreased. It is estimated that 30-50% of nitrogen fertilizer is in excess of plant growth requirements[35], and pollution of soils and water by fertilizers is a widely recognized problem. Fertilizer production and use causes about 450 $MtCO_2e$ emissions p.a.[36]. About 45% of N fertilizer related GHG emissions occur in manufacture. Policies are reducing the proportion of total production due to smaller, inefficient factories, and technology upgrading programs are promoting lower energy intensity in ammonia synthesis processes in the larger factories.

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[27] *The World Bank: World Development Indicators*. 2013. Available at: http://data.worldbank.org (accessed 2013-14).

[28] Wang, X., Liang, D., Wang, X., Peng, S. and Zheng, J. "Estimation of greenhouse gas emissions from dairy farming systems based on LCA." *Transactions of the Chinese Society of Agricultural Engineering 28(13)*, 2012: 179-184.

[29] Peng, S. "Water resources strategy and agricultural development in China." *Journal of Experimental Botany 62(6),* 2011: 1709-1713.

[30] State Council of the PRC. *Decision of the Party Central Committee and the State Council on Hastening Water Reforms and Development.* Beijing, China: State Council Information Office, 2011.

[31] *The Central People's Government of the People's Republic of China*. 2013. Available at: http://www.gov.cn/zwgk/2012-02/16/content_2067664.htm (accessed 2013-14).

[32] Zou, X., Li, Y.E., Li, K., Cremades, R., Gao, Q., Wan, Y. and Qin, X. "Greenhouse gas emissions from agricultural irrigation in China." *Mitigation and Adaptation Strategies for Global Change*, 2013: 1-21.

[33] *Food and Agriculture Organisation (FAO): FAOSTAT.* 2013. Available at: http://faostat.fao.org (accessed 2013-14).

[34] Zhang, W., Dou, Z., He, P., Ju, X., Powlson, D., Chadwick, D., Norse, D., Lu, Y., Zhang, Y., Wu, L., Chen, X., Cassman, K. and Zhang, F. "New technologies reduce greenhouse gas emissions from nitrogenous fertilizer in China." *Proceedings of the National Academy of Sciences of the United States of America 110(21*), 2013: 8375-8380.

[35] UK-China Sustainable Agriculture Innovation Network (SAIN). *Improved nutrient management in agriculture: a neglected opportunity for China's low carbon growth path.* SAIN Policy Brief No. 1, 2010.

[36] Zhang, W., Dou, Z., He, P., Ju, X., Powlson, D., Chadwick, D., Norse, D., Lu, Y., Zhang, Y., Wu, L., Chen, X., Cassman, K. and Zhang, F. "New technologies reduce greenhouse gas emissions from nitrogenous fertilizer in China." *Proceedings of the National Academy of Sciences of the United States of America 110(21*), 2013: 8375-8380.

B.2 Transformation of production systems

Changes in the scale of production. Agriculture in China is dominated by a large smallholder sector, with 200 million smallholder farmers. With the disbanding of the communes in the early 1980s and subsequent market liberalization, rights to use farmland, to decide what crops to produce and to benefit from market sales were given to the farmers, in what is known as the 'household responsibility system'. Arable land cannot be bought and sold. In the cropping sector, the household responsibility system resulted in small and fragmented farms. Average farm size is 0.6 hectares, mostly with 3 to 4 main plots, and 60% of plots are less than 0.1 hectares in size[37]. Small farms are seen in policy circles as an impediment to agricultural development, and there is some evidence that fewer modern inputs are used on smaller land plots[38], and that fertilizer use efficiency is lower[39]. To overcome small farm size, farmers increasingly use land rental markets to adjust the scale of farm operations[40]. Farmer cooperatives, contract farming and vertical integration with agribusinesses have been increasing rapidly[41], and the majority of cash crops are grown on small farms, illustrating that small farm size is not necessarily an impediment to economically productive agriculture. Reforms announced in 2014 will enable farmers to transfer land rights to agribusinesses and cooperatives in order to facilitate conglomeration of land plots, and will link rural and urban land markets.[42]

In the livestock sector, although most pork and beef (which account for about 75% of meat production) is produced by small-scale producers, a number of factors are leading to increased scale of farm operations (see Figures 3a and b), namely: (i) increasing costs of farming and more lucrative non-farming incomes, causing smallholders to exit commercial livestock production[43]; (ii) processing firms' strategies to promote vertical integration[44] and secure quality supplies[45]; and (iii) government support for large-scale operations that are seen as easier to monitor for environmental, veterinary epidemiology and food safety purposes. With significant economies of scale in poultry production, increase in average scale of operation in poultry production has been more rapid than in other livestock supply chains, and only 15% of poultry are now raised in backyard production systems[46]. Because feed concentrate is a higher proportion of rations in intensive livestock and poultry systems, the pace of change in scale of livestock and poultry

[37] Huang, J., Wang, X. and Qiu, H. *Small-scale farmers in China in the face of modernisation and globalisation.* London: International Institute for Environment and Development, 2012.

[38] Tan, S., Heerink, N., Kruseman, G. and Qu, F. "Do fragmented land holdings have higher production costs? Evidence from rice farmers in Northeastern Jiangxi Province," *P.R. China. China Economic Review 19*, 2008: 347-358.

[39] Zhou, Y., Yang, H., Mosler, H. and Abbaspour, K. "Factors affecting farmers' decisions on fertilizer use: a case study for the Chaobai watershed in Northern China." *Consilience: The Journal of Sustainable Development 4*, 2010: 80-102.

[40] Gao, L., Huang, J. and Rozelle, S. "Rental markets for cultivated land and agricultural investments in China." *Agricultural Economics 43*, 2012: 391-403.

[41] Zhang, Q. "The political economy of contract farming in China's agrarian transition." *Journal of Agrarian Change 12(4),* 2012: 460-483.

[42] State Council of the PRC. *Several Opinions on Comprehensively Deepening Rural Reform and Hastening Modernization of Agriculture Central Government Document No. 1*. Beijing, China: State Council of the PRC, 2014.

[43] Rae, A. and Zhang, X. "China's booming livestock industry: household income, specialization, and exit." *Agricultural Economics 40(6),* 2009: 603-616.

[44] E.g. through equity investments, buy-outs or long-term contracts with suppliers, as well as sharing of common information and logistic management systems.

[45] Han, J. *Supply chain integration, quality management and firm performance in the pork processing industry in China.* Wageningen: Wageningen Academic Publishers, 2009.

[46] Mo, H., Jiu, H., Wang, J. and Bai, J. "Factors influencing livestock waste disposal methods in China." *Agri-Environment and Development 6,* 2011:59-64.

production is a significant driver of increased commercial feed demand, including inputs such as soybean products[47]. From a lifecycle perspective, most GHG emissions in meat production occur in feed production[48]. Although the intensity of GHG emissions (i.e. GHG emissions per unit output) in larger operations is often lower[49], increase in scale has not always led to increasing productivity, with technical improvements often more important than scale per se[50]. Regional concentration of livestock production and concentration in peri-urban areas, also poses environmental threats from livestock waste[51].

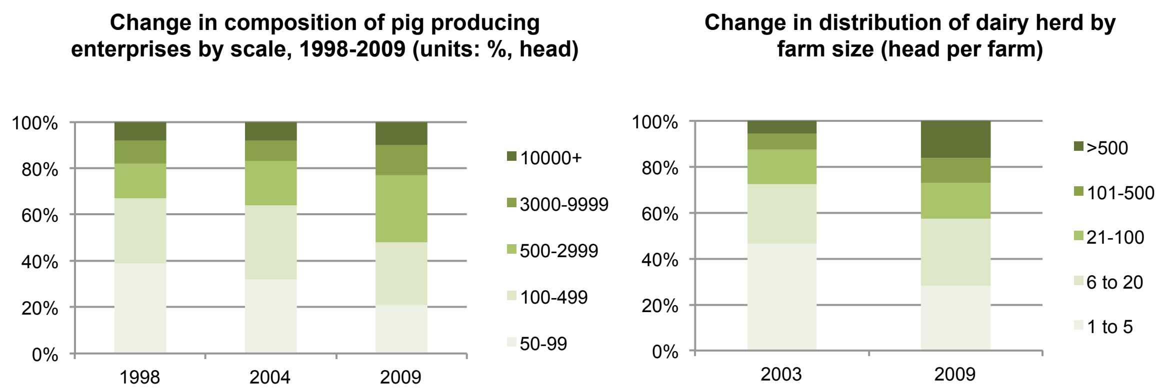

Figure 3: (a) change in scale of pig farms and (b) change in distribution of dairy herd by farm size (various years).[52]

Transformation of supply systems. Although the majority of fresh produce is still sold in traditional urban wet markets, growth of supermarket retail sales has been rapid. Processed and packaged food sales are also growing rapidly. Supply systems, including logistics systems and cold chains, are increasingly resembling supply chains in western countries. English language media accounts often stress the importance of multinational food producers and retailers, but the largest producers and retailers in most sub-sectors are Chinese firms. Government support for domestic food processing industries and development of food supply logistics systems is also a major driver of changes, many of which have implications for GHG emissions throughout China's food system. Food processing and manufacture, for example, accounts for over 3% of China's total manufacturing sector energy use[53].

[47] Xing, L. *Estimating the non-commercial – commercial feed gap in China and its impact on future world demand for soybeans*. Master's Thesis at University of Illinois, 2009.

[48] Wang, J., Rothausen, S., Conway, D., Zhang, L., Xiong, W., Holman, I. and Li, Y. "China's water-energy nexus: greenhouse gas emissions from groundwater use for agriculture." *Environmental Research Letters 7(1),* 2012: 014035; Zhang, Y., Xia, S., Zhou, S., He, Z., Meng, R. and Xi, B. "Lifecycle environmental impact assessment for a large-scale pig farm." *Journal of Environmental Engineering Technology 2(5)*, 2012: 428-431.

[49] Li, Z., Xuan, H. and Hu, S. "Estimation of pollutant emissions from large-scale livestock zones as compared to dispersed household production." *Environment and Sustainable Development 37(6),* 2012.

[50] Liang, Y. and Wang, Y. "Identifying optimal scale for dairy production." *Animal Economy 48(10),* 2011: 44-48.

[51] Gerber, P., Chilonda, P., Fraceschini, G. and Menzi, H. "Geographical determinants and environmental implications of livestock production intensification in Asia." *Bioresource Technology 96(2),* 2005: 263-276.

[52] Shen, Y. and Wu, J. "Development trends and driving factors in large-scale China's hog production." *China Animal Husbandry Journal 47(22),* 2012: 49-52; China Dairy Association. *China Dairy Yearbook 2010.* Beijing, China: China Agriculture Press, 2010.

[53] National Bureau of Statistics of the PRC (NBS). *China Energy Statistics Yearbook 2010*. Beijing, China: China Statistics Press, 2010.

B.3 Resource constraints and environmental challenges

Land resources. Although much of China's arable land is poor quality, soil organic matter has in most areas been increasing[54]. However, in recent years, urban residential and industrial land area has expanded, often at the expense of productive farmland. This is a major concern, because of the limited availability of productive arable land. Limits on conversion of arable land have often not been observed by local governments, which are reliant on revenues from land development[55]. Official policy stresses that farmland area should not fall below 120 Mha in order to maintain food security[56]. Soil erosion on arable land remains a concern in specific areas, but soil acidification, much of which is caused by inappropriate fertilizer use[57], and soil pollution by heavy metals (from mining and industrial sources as well as livestock waste) are increasingly widespread problems,[58] with significant proportions of crops sold in urban markets having heavy metal traces in excess of safe level[59]. In contrast to arable land, there is widespread rangeland degradation in China. While between 1980 and 2000 arable land and forest soils sequestered 706 Mt of carbon (C), soil organic carbon in rangelands declined by 3560 Mt C[60]. The majority of China's rangelands are degraded to some degree, limiting the carrying capacity of grasslands and provision of a range of environmental services[61]. Average incomes in pastoral areas are below the national rural average, and increasing stocking rates is a common short-term income generation strategy, which drives overgrazing. Limited biomass productivity in degraded rangelands constrains herders' livelihood development – and limits the ability of grassland-based livestock husbandry to contribute to national efforts to reduce livestock reliance on grains.

Water resources. Agriculture accounts for around 62% of total water use, and 60% of this is for animal feed production[62]. In many areas, irrigation is dependent on groundwater tables, which are falling significantly[63], but agricultural water use efficiency remains low (ca. 45%)[64]. Fertilizer use

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[54] Xie, Z., Zhu, J., Liu, G., Cadisch, G., Hasegawa, T. and Chen, C. "Soil organic carbon stocks in China and changes from 1980s to 2000s." *Global Change Biology 13(9),* 1989-2007.

[55] Guo, L., Lindsay, J. and Munro-Faure, P. "China: integrated land policy reform in a context of rapid urbanisation." *Agricultural and Rural Development Notes, Issue 36*, 2008.

[56] State Council of the PRC. *National Medium- and Long-term Food Security Plan 2008-2020*. Beijing, China: State Council Information Office, 2008.

[57] Guo, J., Liu, X., Zhang, Y., Shen, J., Han, W., Zhang, W., Christie, P., Goulding, K., Vitousek, P. and Zhang, F. "Significant acidification in major Chinese croplands." *Science 327,* 2010: 1008-1010.

[58] Results of a recent national survey on heavy metal pollution of soils were not released, being classified a 'state secret', which perhaps hints at the scale of the problem. Recent statements by officials indicate that there are 3.3 million ha of moderately and heavily polluted soils, which are not suitable for crop cultivation, though no statement has been made on the extent of lightly polluted soils. "Wang Shiyuan: Moderate and heavily polluted arable land covers 50 million mu, annual investment of several billion will be made in restoration." *Xinhua*. 30 December, 2013. Available at: http://news.xinhuanet.com/fortune/2013-12/30/c_125933269.htm.

[59] Liu, X., Song, Q., Tang, Y., Li, W., Xu, J., Wu, J., Wang, F. and Brookes, P. "Human health risk assessment of heavy metals in soil-vegetable system: A multi-medium analysis." *Science of the Total Environment 463,* 2013: 530-540.

[60] Xie, Z., Zhu, J., Liu, G., Cadisch, G., Hasegawa, T. and Chen, C. "Soil organic carbon stocks in China and changes from 1980s to 2000s." *Global Change Biology 13(9),* 1989-2007.

[61] Squires, V. *Towards sustainable use of rangelands in North-West China*. London: Springer Verlag, 2010.

[62] Qin, W., Ma, L., Zhang, F. and Oenema, O. "Urbanization affects water and nitrogen use efficiencies in food chain." *Agro Environment,* 2012.

[63] Wang, J., Huang, J., Huang, Q. and Rozelle, S. "Privatization of tubwells in North China: Determinants and impacts on irrigated area, productivity and the water table." *Hydrogeology Journal 14(3),* 2006: 275-285.

[64] Wu, P., Jin, J. and Zhao, X. "Impact of climate change and irrigation technology advancement on agricultural water use in China." *Climatic Change 100*, 2010: 797-805.

and livestock waste are the leading sources of water pollution nationwide[65]. About 50% of water bodies are eutrophic[66], a third of rivers are rated as 'poor quality', 56% of groundwater sources have excess mineral, nitrates and ammonia[67]. Competition for water use from urban and industrial sectors is increasing, and the further reductions in water resources due to climate change may have significant impacts on future agricultural production[68].

Feed use efficiency. Given the increasing importance of livestock to grain and oilseed crop use in China, the efficiency of feed use is a key concern. Feed use efficiency (i.e. the ratio of kg meat produced per kg feed consumed) in dairy farms is 25-30% lower than in developed countries using the same breeds, and feed-meat conversion rates in pork production are higher than in developed countries[69]. Consequently, the land area required to produce each unit of livestock product in China is roughly twice that used in developed countries, while the water requirement is several times higher[70]. Although current policies are aggressively promoting larger scale operations (i.e. concentrated animal feeding operations, or 'CAFOs'), research suggests that technical efficiency in larger scale operations is not increasing as rapidly in small and medium sized farms[71]. Future trends in feed use efficiency will have major implications for maize and soy bean imports, for total feed demand and water use, as well as for livestock waste pollution of water and emissions of ammonia and GHGs.

C. Agricultural policies

C.1 Overview

China implements a five-year planning system[72]. National development plans are drafted by the National Development and Reform Commission (NDRC) in consultation with ministries. Specific plans are developed for each sector and for specific industries or issues within each sector. For major, strategic issues, policies are issued in the form of State Council decisions, or as medium or long-term strategic plans. Five-year plans are generally in line with the priorities outlined in these policies or strategies. The five-year plans and key policy statements provide the basis for ministries to negotiate with the Ministry of Finance for program or project funding. Government spending has been roughly equivalent to 13% of GDP in recent years[73], of which central government funds are just under 50%. Thus, government policy priorities translate rapidly into implemented programs.

China has issued several strategic plans and policy statements to guide the development of agricultural production, including the Medium and Long-term Plan for National Food Security

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[65] Ministry of Environmental Protection of the PRC (MEP). *State of China's Environment 2011.* Beijing: Ministry of Environmental Protection, 2012.

[66] Jin, X., Xu, Q. and Huang, C. "Current status and future tendency of lake eutrophication in China." *Life Science 48*, 2005: 948-954.

[67] Ministry of Environmental Protection of the PRC (MEP). *State of China's Environment 2011*. Beijing: Ministry of Environmental Protection, 2012.

[68] Xing, L. *Estimating the non-commercial – commercial feed gap in China and its impact on future world demand for soybeans*. Master's Thesis at University of Illinois, 2009.

[69] Norse, D., Lu, Y. and Huang, J. "China's food security: Is it a national, regional or global issue?" In *China and the EU in Context* by Brown, K. London: Palgrave Macmillan, 2013.

[70] Zheng, W. *Land and water requirements for meat production in China*. Master's thesis at University of Goreningen, Germany, 2010.

[71] Ma, H., Liu, W. and Oxley, L. "Productivity growth and policy implications for China's dairy farms." *China Economic Policy Review 1(1),* 2012: 1250004 (20 pages).

[72] China is currently implementing the 12th Five Year Plan (2011-2015).

[73] *The World Bank: World Development Indicators*. 2013. Available at: http://data.worldbank.org/ (accessed 2013-14).

(2008-2020), and current plans that guide agricultural investments, such as the National Plan for Modern Agricultural Development (2011-2015) and the 12th Five-Year Plan for National Economic and Social Development (2011-2015). Many of the actions promoted for agricultural development purposes have GHG mitigation benefits. Specific agricultural mitigation policies are discussed in the next section.

C.2 Agricultural policies, plans and programs

The key objectives of the Medium and Long-term Food Security Plan (2008-2020) are to stabilize the arable land area at 120 million ha; to maintain grain self-sufficiency at >95%; to maintain strategic grain reserves; and to establish a modern grain logistics system. Key actions outlined in the plan that have clear GHG implications include: (i) protecting arable land from conversion; (ii) investment in water conservation and irrigation infrastructure to increase water use efficiency from 0.5 in 2010 to 0.55 in 2020; (iii) increase per unit area yield through crop technology innovation; (iv) promote non-grain based livestock production through use of crop residues and pasture, aquaculture and oilseed crop production, livestock genetics and promotion of large-scale livestock production zones; (v) improve the grain storage, logistics and distribution system to reduce grain losses; (vi) improve livestock feed processing, formulation and preparation; and (vii) establish stable cooperation with the main grain and oil crop producing countries, and encourage agribusiness enterprises to invest overseas to strengthen domestic food security.

Many of these strategic actions were further specified in the National Plan for Expansion of Grain Production Capacity by 50 Million Tons (2009-2020), issued in by NDRC in 2009, and in subsequent five year plans, on the basis of which the Ministry of Finance can allocate state budget funds. The current National Plan for Modern Agricultural Development (2011-2015), for example, proposes to increase the area under irrigation, and the proportion under water-saving irrigation techniques; to increase the proportion of large-scale dairy (>100 head) and pig (>500 head) farms to 38% and 50% respectively; to promote adoption of soil nutrient testing as a basis for fertilizer formulation; to promote agricultural mechanization; and a range of agri-environment interventions, such as bans on crop residue burning, promotion of organic manures and other forms of recycling of agricultural products (e.g. crop residue use), support for biogas, and retirement of inefficient agricultural machinery. In addition to agricultural production-focused plans, plans for 2011-2015 have also been drawn up for several related sectors, including:

- the 12th Five Year Plan for the Fertilizer Industry, issued by the Ministry of Industry and Information Technology (MIIT), aims to eliminate inefficient producers, and includes the target for 2015 that >80% of N-fertilizers will be produced in large and medium enterprises, and >70% of phosphate fertilizer in large-scale enterprises, and also promotes use of coal gasification, polygeneration and other clean production technologies; it also includes a specific target for the energy intensity of ammonia synthesis.
- the 12th Five Year Plan for the Food Industry, issued by NDRC and MIIT, aims to promote large-scale processing firms, and intends to retire the use of energy inefficient machinery and processes in grain and meat processing, fermentation, brewing and dairy sectors and to further develop energy-efficient technologies for key processing activities.
- Policy Guidance for Promotion of the Catering Industry during the 12th Five Year Plan Period (issued by the Ministry of Commerce), promotes among other things reductions in food waste, recycling of catering waste, use of energy efficient lighting in restaurants etc.

Many of these and other agricultural development activities are supported with significant government investments. Chinese government subsidies to agriculture in 2011 have been estimated at around USD 87billion, which although only 0.01% of GDP is around 11% of the value of agricultural output.[74] Figures 4a and 4b give a breakdown of this investment by general purpose of the subsidies (Figure 4a) and by the sub-sector targeted (Figure 4b). Specific agri-environment investments are a very small proportion of total government investments (not including the USD 2-2.5billion in subsidies to fertilizer production or other subsidies to related sectors).

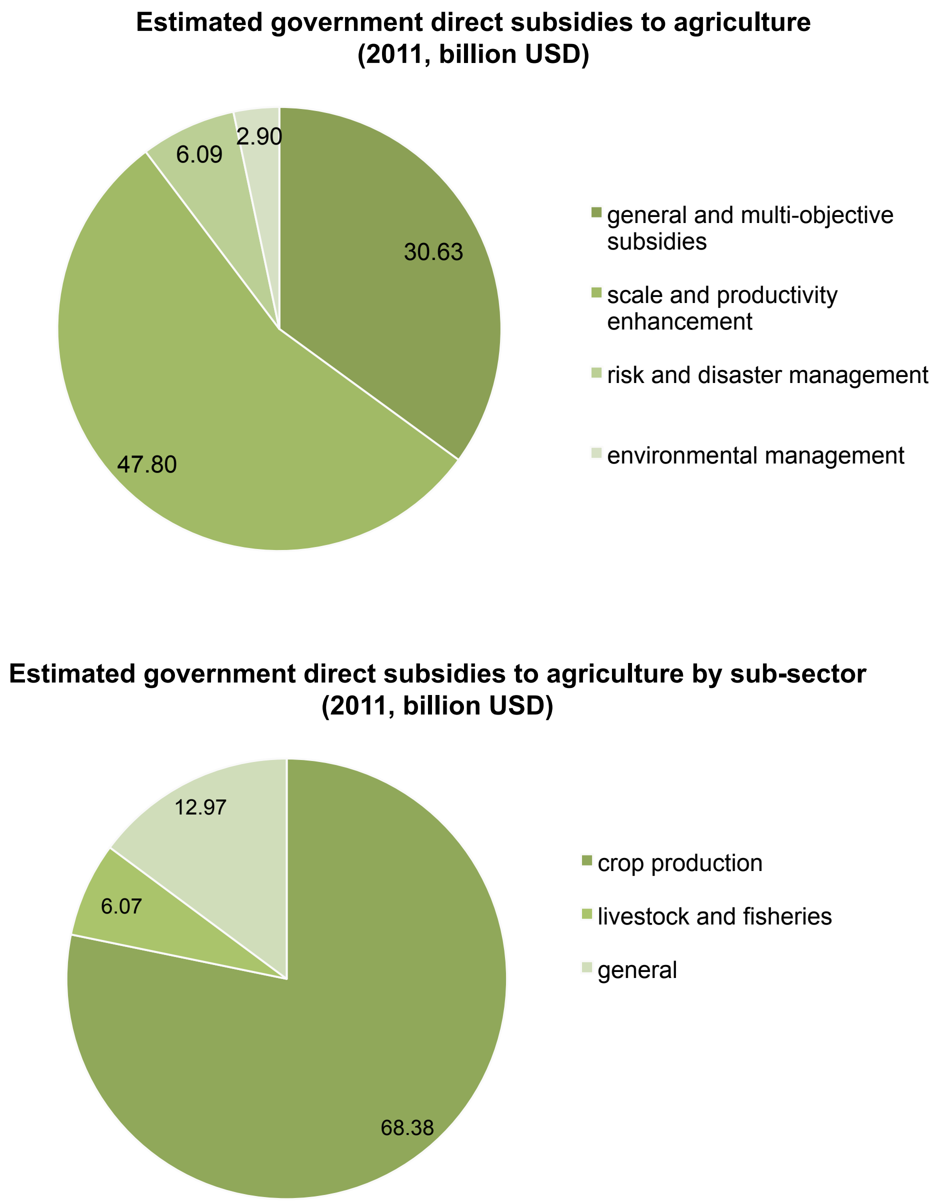

Figure 4: Composition of total government subsidies to agriculture (a) by objective and (b) by sub-sector[75]

[74] Gale, F. "Growth and Evolution in China's Agricultural Support Policies." *USDA Economic Research Report 153,* 2013. Estimates government support to agriculture at $73 billion, but was unable to identify specific funding levels for certain programs. When funding for these programs is included, the total comes to $87 billion.

[75] Sources: Gale, F. "Growth and Evolution in China's Agricultural Support Policies." *USDA Economic Research Report 153*, 2013; supplemented by Government of China policy statements.

Box 1: Policies on fertilizer manufacture and emissions in China

Before economic reforms, China had promoted domestic fertilizer production mainly through small-scale factories using “appropriate” but inefficient technologies (Wong 1986). In 1982, more than half of national fertilizer output was produced by 1,227 small-scale factories. Although policy makers have long been aware of the inefficiencies of smaller plants, relative prices of energy and other investment costs enabled smaller factories to continue to be economically viable. Eradicating inefficient small-scale production was difficult also because until 1998, fertilizer production was a state monopoly sector. By 2000, 30% of N-fertilizer output was still due to more than 1000 small scale plants.

The 10th Five Year Plan (2001-2005) began the process of eliminating high energy consuming, polluting and economically inefficient small-scale plants by converting enterprises to engaging in agricultural input services or secondary fertilizer processing, while also promoting medium and large-scale plants. The 11th Five Year Plan (2006-2010) further focused on adjusting the structure of production to improve resource use efficiency, promoting reuse of resources in fertilizer production processes and adoption of clean production processes. During the 11th FYP period, a number of large-scale (>1 million tons) enterprises developed, and large and medium scale enterprises accounted for >70% of production, with 68% of urea production in large-scale enterprises. A number of specialized fertilizer product markets also developed. However, energy use and energy prices were still a constraint, especially for N-fertilizer production, with rising energy prices limiting enterprise profitability. Outdated production processes continued to be common, and there were still about 250 small-scale ammonia synthesis enterprises with poor energy efficiency.

The 12th Five Year Plan for the Fertilizer Industry (2011-2015) aims to further eliminate inefficient producers. The goal is that by 2015 >80% of N-fertilizers will be produced in large and medium enterprises; and >70% of phosphate fertilizer in large-scale enterprises. Coal gasification, polygeneration and other clean production technologies are being promoted, and there is a specific target for the energy intensity of ammonia synthesis. China’s largest fertilizer manufacturers are also enrolled in the ‘Ten Thousand Enterprises’ program, in which enterprises with energy use >10,000 t of coal equivalent have been set energy use targets. Preferential credit and subsidies are available to support adoption of new technologies to achieve these targets.

Policies on fertilizer use and management

The main policy to reduce overuse of N-fertilizer is the National Soil Testing and Fertilizer Program (STFR). The STFR covers all 2498 agricultural counties and around $1 billion has been invested. In brief, the program involves testing soil properties and crop fertilizer needs to make location- and crop-specific fertilizer recommendations, on the basis of which specialist NPK mixture fertilizers are produced by 100 participating fertilizer firms. Fertilizers are then supplied to by firms to farmers and guidance provided in their application.

There have been no comprehensive assessments of the effectiveness of this policy. However, according to one academic study N fertilizer application rates have been decreasing in provinces with a large proportion of arable land area participating in the STFR program, leading to apparently large reductions in N_2O emissions (Sun and Huang 2012). Using provincial data, their analysis suggests that synthetic N application rates for cereal crops decreased from 179-203 kg N/ha in 1998 to 157-175 kg N/ha in 2008, with annual reduction rates of 3.2 kg /ha/year for rice, 2.5 kg /ha/year for wheat, and 5.1 kg /ha/year for. They also find that reduced N application increased crop yield, so the crop yields per unit of N applied increased from 31, 21, and 26 kg grain/kg N in 1998 to 38, 30 and 35 kg grain/kg N for rice, wheat and maize crops, respectively.

Sources: Wong, C. “Intermediate technology for development: small-scale chemical fertilizer plants in China” *World Development 14(10/11),* 1986: 1329-1346; Sun W., and Huang Y. “Synthetic fertilizer management for China’s cereal crops has reduced N2O emissions since the early 2000s” *Environmental Pollution 160: 24-27*, 2012.

C.3 Climate change policies

Shortly before the UNFCCC CoP in Copenhagen in 2009, China pledged to reduce its carbon intensity (CO_2 emissions per unit of GDP) by 40 - 45% by 2020 compared to 2005 levels.[76] The 12th National Five-Year Plan for Social and Economic Development (released in March 2011), is the first national five-year plan to explicitly address this commitment. It sets out targets for increasing energy efficiency and carbon intensity, as well as targets for increases in water use per unit of agricultural value and decreases in agricultural pollution sources (see Table 2).

In the agriculture sector, in 2011 the Ministry of Agriculture of the PRC issued a policy statement on rural energy conservation and emission reduction (see box 2 below). In addition, the National Modern Agricultural Development Plan (2011-2015) recognizes the importance of "low-carbon technologies", and the 12th Five-Year Plan for a Circular Economy promotes agricultural technologies and practices that reduce production inputs and increase resource use efficiency.

What is notable in these plans and targets is that national policy priorities for agricultural emissions relate to a broad range of environmental impacts of agricultural production. Specifically, sources of non-point pollution of water resources (primarily livestock waste and excess N fertilizer application) are included in the agricultural emissions mitigation plans, but quantified in terms of non-GHG emissions. Also, interventions that address key resource efficiency constraints (e.g. water-saving irrigation methods) are promoted. These priorities address key long-term sustainability needs of national importance (e.g. water availability and quality).

Although the Ministry of Agriculture is aware of the importance of agricultural GHG emissions, its focus is mostly on developing agricultural production and adaptation to climate change. The ministry addresses GHG mitigation mostly where this has a contribution to agricultural resource efficiency objectives (e.g. reducing excess use of fertilizer, improving feed use efficiency). The ministry is to some extent wary of activities that extend too far into the remit of other ministries, such as GHG mitigation, which is the mandate of the National Development and Reform Commission.

Outside the agriculture sector, two policy initiatives of possible relevance to mitigation in agriculture include:

Initiation of pilot carbon markets. In October 2011, NDRC instructed seven cities and provinces to develop pilot regional emission trading schemes in preparation for a possible national carbon market to emerge between 2016 and 2020. These schemes are cap-and-trade systems, and in general only industrial sectors are included. Most schemes began operation in late 2013. In 2012, NDRC also issued national guidelines for voluntary carbon trade. These guidelines essentially establish a domestic standard, modeled on the Clean Development Mechanism, for producing issuing and trading government-approved carbon credits (known as Chinese Certified Emission Reductions, or CCERs). Most of the pilot regional carbon markets will allow a certain proportion of emission reduction targets for each firm to be met through purchase of CCERs. Agriculture is an eligible sector for CCERs. One methodology for sustainable grassland management was approved in January 2014, and a number of other agriculture-related methodologies are under preparation by Chinese research institutes and NGOs.

[76] 2005 is the year of China's latest reported national GHG inventory; National Development and Reform Commission (NDRC). *Second National Communication on Climate Change of the People's Republic of China.* Beijing: National Development and Reform Commission, 2012.

Indicator	11th FYP target (% decrease on 10th FYP)	11th FYP target achieved end 2011	12th FYP target set (% decrease on 11th FYP)
Increase in energy efficiency (%)	20	19.1	16
Decrease in carbon intensity (%)	(no target)	n/a	17
Decrease in water consumption per unit VAIO (%)	30	36.7	30
Non-fossil fuel in primary energy consumption (%)	n/a	8.3	11.4
Decrease in chemical oxygen demand (%)	10	12.45	8
Decrease in sulfur dioxide emissions (%)	10	14.29	8
Decrease in ammonia nitrogen (%)	(no target)	n/a	10
Decrease in nitrous oxide emission (%)	(no target)	n/a	10
Forest cover (%)	20	20.36	21.66
Increase in forest stock (million m^3)	(no target)	137	143

Table 2: Climate-related targets in the Eleventh and Twelfth Five-Year Plans of the People's Republic of China; FYP = Five Year Plan; m^3 = cubic meter; n/a = not applicable; VAIO = value of agricultural and industrial output.[77]

Release of national guidelines for carbon labeling. In April 2013, NDRC issued guidelines governing the use of low-carbon product claims. The regulations establish a government-recognized carbon footprint certification system. Standard procedures and criteria for low-carbon certification of products will be issued by the government. Reportedly,[78] the relevant agencies have begun formulating standards and criteria relating to some industrial products, but although there is some interest in low-carbon product marketing strategies among Chinese food producers and processing firms, agricultural product standards will not be released soon. The main reasons for this are: (a) high heterogeneity of emissions in agricultural products, and (b) a lack of agreed methods for conducting life cycle analysis (of agricultural products). LCAs have rarely been conducted by Chinese academics in the agriculture sector.

[77] Yu, G. and Elsworth, R. *Turning the Tanker. China's changing economic imperatives and its tentative look to emissions trading*. London: Sandbag Climate Campaign, 2012.
[78] Li Chongyi, CBEEX. (Personal Communication).

Box 2: Agricultural mitigation policy in the PRC

Targets

"By 2015, compared with 2010, total agricultural chemical oxygen demand emissions reduced by 8%, ammonia nitrogen emission reduced by 10%; coverage of national soil nutrient testing program reaches 60% and fertilizer use efficiency increased by 3%; and unified pest and disease prevention and control covers 30% of major crops by 2015; promote green pest and disease prevention and control and abolish high-pollution, high-residue pesticides; promote energy conserving cultivation methods and reduce high-energy consumption procedures; over 50% of intensive livestock farms or livestock-raising communities are equipped with waste treatment facilities; households with biogas reach 55 million, and annual biogas consumption reaches 21.6 billion m^3; phase out high-energy consumption and high-pollution machines and fishing boats; and upgrade township enterprises for energy conservation and increase rural production energy efficiency."

Actions areas

1. Energy saving in agricultural production

- Enhance energy saving in agricultural machinery and fishing boats
- Promote energy saving in crop planting systems
- Promote energy saving in township enterprises
- Promote energy saving in rural domestic life

2. Actively prevent and control agricultural non-point pollution

- Disseminate technologies for fertilizer, pesticide and water conservation
- Disseminate technologies for ecological livestock raising
- Disseminate technologies for healthy aquaculture

3. Establish Initiatives to Promote Reuse of Rural Waste

- Develop rural biogas
- Implement rural clean-up programme
- Use crop residues comprehensively
- Collect and reuse mulching plastic film

4. Provide effective enabling measures for rural and agricultural energy conservation

- Strengthen the leadership and consensus
- Design and improve relevant policies and regulations
- Increase financial inputs (including project funds, investments, agri-environment funds)
- Strengthen technical support
- Initiate extensive training and dissemination

Source: Ministry of Agriculture of the PRC. *Opinion on Further Strengthening Agricultural and Rural Energy Conseervation and Emission Reduction Work.* Beijing: Ministry of Agriculture, 2011.

D. Voluntary initiatives

Domestically, the most active non-government initiatives related to agricultural mitigation include:

- **Research**. The various institutes of the Chinese Academy of Sciences conducts basic research on GHGs and carbon cycling; the Chinese Academy of Agricultural Sciences and numerous agricultural universities conduct research on the response of GHG emissions to changes in agricultural practices.
- **Carbon market actors.** In 2009, the China Beijing Environmental Exchange established the Panda Standard as a voluntary carbon standard. The explicit focus was on agriculture and forestry, with the idea that industrial and urban emissions could be offset through

agricultural mitigation activities primarily conducted in the poorer, western parts of the country. The standard has been superseded by the national CCER standard. However, a number of draft methodologies and pilot projects were developed by Chinese research institutes, often together with international organizations or NGOs.

- Some consumer **retail companies** have undertaken and communicated about their low-carbon strategies and practices, and some industry associations are actively involved in promoting energy- and resource-saving activities among their members (e.g. China Cuisine Association).

There are a number of research and action-research initiatives related to agricultural mitigation in China, including:

- International organizations (e.g. UN FAO and Asian Development Bank) and NGOs (e.g. Environment Defense Fund) have supported international and national research organizations to develop agricultural carbon accounting and monitoring protocols for agricultural mitigation activities in China.
- A UK-China Sustainable Agriculture Network undertook research on a range of related topics from 2009 to 2013, producing estimates of GHG emissions and mitigation potentials from fertilizer and irrigation and analysis of the cost-effectiveness of a range of specific mitigation practices.
- Some Chinese researchers also participate in some international initiatives such as the Global Research Alliance on Agricultural GHGs.

On the international side, there are several initiatives addressing sustainability of traded food commodities. China is a major importer of both soy and palm oil. The government of the PRC has no direct engagement with the Round Table on Responsible Soy or the Roundtable on Sustainable Palm Oil. However, some major state-owned companies involved in the trade have begun to engage, sometimes with international support, and some have become members of these initiatives. However, it should also be noted that many multinational firms are also major importers of these products to China[79].

[79] Schneider, M. *Feeding China's Pigs.* Minneapolis: Institute for Agriculture and Trade Policy, 2012.

E. Actors

	Actor
Government	Ministry of Agriculture
	National Reform and Development Commission
	Ministry of Environmental Protection
	Provincial agriculture and animal husbandry departments
Research & technical assistance service providers	Chinese Academy of Agricultural Sciences
	Chinese Academy of Sciences
	China Agriculture University
	Nanjing Agriculture University
	Private consulting firms
Associations & cooperatives	Industry associations (e.g. China Dairy Association, China Pig Association, China Feed Industry Association, China Industrial Energy Saving and Clean Production Association, China Nitrogen Fertilizer Industry Association)
Agribusiness	Major feed traders and producers (e.g. COFCO, Cargill, Bunge etc.); Major retailers (e.g. China Resources Enterprises, Walmart, Carrefour etc.)
Financial institutions	China Banking Regulatory Commission
	Agricultural Bank of China
	Industrial Bank
NGOs and Think Tanks	Environmental Defense Fund; Oxfam HK;
Others	International agencies (e.g. UN FAO, ADB)