



Government
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 Foresight

The Future of Food and Farming

Foresight Report's Implications for China

Foresight, Government Office for Science

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The Future of Food and Farming

– Foresight Report's Implications for China¹

Introduction

Notwithstanding the substantial differences in the structure and maturity of agriculture in the two countries (the UK and China), they both face all of the global challenges identified by the Foresight Report. Moreover, all of the priority actions for policy makers proposed by the Foresight Report apply to both countries to a greater or lesser degree either domestically or internationally, and so their policy and R&D responses to the challenges have wide international relevance.

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Part I

The key challenges

The Foresight Report concludes that there are five key challenges facing the global food system and food security over the next 40 years that in the main have also been a cause for concern over the past 40 years or more (Box 1). All of them are highly relevant to China's future well-being, although there are limits to the extent to which they can be considered as separate challenges because of the substantial cross-linkages, inter-relationships and interdependencies between them in terms of the causative factors and the Government of China's (GOC's) strategies and policy actions to address them, as laid out in the Medium- and Long-term Plan for National Food Security 2008–2020 (Annex 1). The first two challenges, for example, have been a major focus of GOC policies for the past 20–40 years. More specifically, the stability and affordability of basic foodstuffs, which is a component of both challenges, has been a central objective of the GOC since the 1960s. This was initially implemented by setting production targets at the provincial and local level and by the maintenance of large carry-over stocks from one harvest or year to the next. The agricultural reforms of 1978 relaxed the role of production targets and increased the role of the market and of commodity price incentives to farmers, but a range of policies continue to support food supply stability and affordability and these have been very successful. Although there have been major crop production shortfalls from extreme events – mainly droughts and floods during the past 20 years, domestic grain supply and prices have been relatively stable. Furthermore, these policies have provided major benefits to the global food system: first, because if China had had to go on to the world market to make up for domestic production shortages this would have driven up international commodity prices to levels that could have limited imports by low-income food deficit countries; and second, for most of the past decade China has been a net exporter of wheat and rice and more recently a food aid contributor.

Box 1 Key challenges to the global food system

A. Balancing future demand and supply sustainably – to ensure that food supplies are affordable.

B. Ensuring that there is adequate stability in food supplies – and protecting the most vulnerable from the volatility that does occur.

C. Achieving global access to food and ending hunger. This recognizes that producing enough food in the world so that everyone can *potentially* be fed is not the same thing as ensuring food security for all.

D. Managing the contribution of the food system to the mitigation of climate change.

E. Maintaining biodiversity and ecosystem services while feeding the world.

The relevance of the five challenges, and their individual components, to China is illustrated in the following sections by an analysis of the main causative factors and the responses that the GOC has already made to overcome them.

Balancing future demand and supply sustainably – [to ensure that food supplies are available and affordable]. The report highlights five classes of action to address this challenge: improving productivity using existing knowledge; increasing R&D; reducing waste; promoting better governance and fully functioning markets; and changing people's diets. These are all relevant to China and, with the exception of the last, are being actively addressed by the GOC, but further action is needed in a number of areas:

- (i) There is a significant applications gap regarding existing management practices and technologies. This is in part a consequence of the inadequate involvement of social scientists in the identification of constraints to uptake (for example, farm labour shortages) and in part the result of a weak extension service that has undergone some reforms in recent years but as yet with no significant progress (Hu et al, 2009). Hence, greater policy innovation is required to encourage both increased efficiency of the conventional extension systems and to introduce new technological or institutional new modes of communication.
- (ii) Although agricultural R&D has been increasing in real terms, and as a proportion of GDP it is far greater than in most other developing countries, it is still less than the world average, and private sector research is a low but growing proportion (Chen & Zhang, 2011). There are still some areas that are under-researched, for example livestock production and water use efficiency (Chen & Zhang, 2011), and there are institutional problems regarding the sharing of information across China's diverse research system.
- (iii) Productivity per unit of land has been rising but factor productivity has been declining, particularly nitrogen fertilizer use efficiency (Ma et al, 2009) and water use efficiency (Fang et al, 2010), partly as a consequence of (i) and (ii) above but also because of perverse subsidies for fertilizer production and use and for irrigation water.
- (iv) Sound resource management is constrained by the overlapping responsibilities of government bodies. For example, 10 ministries have responsibilities for and programmes relating to water management and quality (Table 1).

Notwithstanding these last limitations, China's research system has been very successful and has contributed positively to South–South technology transfer and regional food security by providing high-yielding rice varieties, etc. These contributions are likely to continue, with the planned expansion of crop breeding to raise yield ceilings and the improved focus on the sustainability of production (see Part II). Moreover, the reduction of waste has been given high priority, first by the introduction of the Circular Economy Law in 2008, which was subsequently implemented at least in part by the Ministry of Agriculture (MOA) and other central and local government bodies through a number of action plans, including a very extensive and well-funded programme for anaerobic digestion of wastes (see Annexes 4.1 and 4.3).

Ensuring that there is adequate stability in food supplies

The GOC's approach is very comprehensive, with both domestic and foreign components covering short-term perturbations from extreme events and longer term production potential. At its centre is the objective of maintaining circa 95% self-sufficiency in basic food stuffs (down from 100% in the 1990s and early 2000s). Its basic components are fourfold. First is the priority given to agricultural R&D discussed above. Second is the protection of its arable land. In the past the measures were

Table 1 Complexity of government structures responsible for resource management and the food system: the case of water

Ministry	Responsibilities
National Development and Reform Commission (NDRC)	Strategic planning
Ministry of Water Resources (MWR)	Water resource planning and development, flood control, drought relief, guidance on irrigation, drainage and rural water supply
Ministry of Environmental Protection (MEP)	Environmental pollution prevention and control.
Ministry of Agriculture (MOA)	Irrigation and the use of water for agricultural purposes, wetland development, fisheries
Ministry of Housing and Urban–Rural Development (MHRUD)	Waste water treatment and use of urban groundwater
Ministry of Land and Resources (MLR)	Monitoring and prevention of overextraction and contamination of groundwater
Ministry of Health (MOH)	Water quality standards
Ministry of Transport	Water pollution control relating to the transport sector
State Forest Administration (SFA)	Watershed management and water-borne soil erosion
Ministry of Finance	Finance of water development and water pricing

Ministry of Science and Technology (MOST)	Funding of R&D, e.g. on water use efficiency
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inadequate. Although the land laws have been strengthened progressively since the 1990s, these have been flouted or weakly implemented by local officials responsible for urban and industrial development. This issue is being addressed by the 12th 5-year Plan, which aims to prevent the total area falling below 120 Mha, although the prospects for success are not good (see Part III – section on safeguarding the resource base). Third is the maintenance of large grain stocks across China (150–200 Mt), which are equivalent to about 6 months’ demand. In addition, exports of synthetic fertilizers are controlled so that there are no shortages, and efforts have been taken to diversify the sources of food imports, particularly oilseeds. Fourth is that the removal or reduction of agricultural taxes and increased production subsidies have helped to boost farm incomes but appear not to have had a major impact on farmers’ decisions about the allocation of land to grain production or use of fertilizers. The grain subsidies do not appear to have increased the area planted, and the fertilizer subsidies have not increased application rates (Huang et al, 2011). Fifth is supporting agricultural development in countries that could become important suppliers of food and feed grains, e.g., Zambia and Mozambique to China and the world market.

Ending hunger and improving diets

Many of the key measures for this objective have been covered in the above supply-related actions, but demand aspects are also a central concern of the GOC. In the past the focus was on ensuring low food prices for those employed in manufacturing. This still remains but the emphasis is more on limiting food price inflation. Health aspects are now being given more attention in part because of: (i) cases of intentional food adulteration (e.g. baby foods); (ii) a number of serious heavy metal poisoning incidents (some 20% of farmland is polluted by heavy metals); (iii) the increasing incidence of obesity in children, particularly in urban areas; and (iv) iron deficiency anaemia in rural areas. In one sense China is better placed to meet this challenge than many developed countries because diets are still broadly rice, vegetable and white meat based with limited consumption of red meat and dairy products. A major public information campaign could help to limit a switch to high red meat diets.

Managing the contribution of the food system to the mitigation of climate change

China has not yet developed a low-carbon transition plan equivalent to the UK’s and neither has it developed with key stakeholders an action plan for a reduction in agricultural greenhouse gas (GHG) emissions. The last (11th) 5-year Plan addressed climate change but focused on raising energy efficiency in other sectors and largely ignored agriculture. It has, however, devoted substantial resources to developing

climate change impact models to estimate when, where and how climate change may affect food production (Wang et al, 2009). There have also been large plant breeding programmes initiated to reduce the impact of climate change on crop yields, to increase the efficiency of nitrogen fertilizer use and to address other targets that will reduce GHG emissions. However, China has been developing the conceptual basis for a low-carbon growth strategy since 2004, that is, in advance of similar thinking in the UK (HM Treasury, 2007; Stern, 2007). The NDRC² and various ministries have been taking steps to put the concept into practice. In 2007, for example, the MOA launched an action plan for 'circular agriculture' to increase resource use efficiency and reduce environmental pollution. The next (12th) 5-year Plan to be discussed in Part II is a significant step forward with ambitious targets for energy efficiency gains and GHG emissions reduction by 2015, including binding reduction targets for ammonia and nitrous oxide that come primarily from agriculture.

Maintaining biodiversity and ecosystem services

In the early days of the People's Republic, as with most other countries, food production was expanded with little thought for the environmental consequences of arable land expansion (e.g. deforestation in ecologically fragile areas) and input use (e.g. widespread increase in non-point (dispersed) pollution (Ongley et al, 2010) and accumulation of pesticide residues). Since the 1980s much has been done to reverse the adverse trends, although progress has been patchy. Afforestation has been very successful with a substantial reduction in watershed degradation and an increase in carbon sequestration since 1990 (Piao et al, 2009). An important component of the afforestation has been the grain-for-green programme (the conversion of cropland to forests and grassland) through which some 14 Mha of fragile (generally steeply sloping) land has been taken out of cultivation. Some cropland has been taken out of production and returned to its former state as wetlands or lakes, thereby restoring their buffer capacity for flood mitigation. There has been a major increase in the area of protected terrestrial ecosystems, and recently the number of national marine reserves has been increased to include seven ocean parks in addition to the 21 special marine reserves and 33 national marine nature reserves. There have been piecemeal efforts to control non-point pollution, ban persistent and toxic pesticides, and encourage integrated pest management but much more needs to be done (Zhu et al, 2006) The other deficit area is livestock where: (a) overgrazing of natural pastures and overcutting of hay from them has led to serious erosion and loss of species richness; (b) point and non-point pollution from small- and large-scale production is becoming the most serious cause of environmental degradation through impacts on aquatic ecosystems (e.g. eutrophication, red tides and harmful algal blooms) (Norse, 2005; Li et al, 2009); and (c) there is impact from ammonia and GHG emissions on acid rain, soil acidification (Guo et al, 2010) and climate change.

² The NDRC is the premier development strategy and policy formulation body of the GOC and is responsible for coordination of measures to shift the energy, industry and agricultural sectors on to a low-carbon pathway.

The rankings

It is difficult to be strictly objective about ranking the Foresight Report's key findings in terms of their relevance to China because conclusions are a function of the selection criteria used. If the findings are judged in terms of food supply vulnerability in the long-term then the most relevant are: the loss of arable land if current trends persist; the growing competition for water between agriculture and the urban/industrial sector; the negative impact of climate change and land degradation on crop yields; and the increasing dependence of the livestock sector on feed imports.

Part II

The Foresight action plan and China's evolving strategy for future food security

The pre-eminent document regarding the GOC's plans to safeguard future food security is the 12th Five-Year Plan for 2011–2015 (hereafter referred to as the 12th Plan) formulated by the NDRC on behalf of the State Council (Annex 2). It provides the strategic framework and targets for protecting food security and the environment. MOA, MOST, MWR, MEP and other central, provincial and local government bodies must take account of this 12th Plan when preparing their own actions plans, policies and activities. At the outset it should be pointed out that: (a) many of the key targets of the 11th 5-year Plan were achieved (Fulton, 2011; Hu & Liang, 2011); and (b) the 12th Plan signals a further step forward in China's shift towards a green, low-carbon economy, and for the first time gives clear recognition to the issue of climate change. It contains a number of new measures relating to the Foresight key priorities, notably targets for nitrogen oxide and nitrogen dioxide, ammonia and heavy metal soil contamination reduction, establishment of improved systems for GHG and environmental monitoring and evaluation, and plans for resource consumption fees and environmental taxes.

The rest of Part II relates the 12th Plan to the Foresight Report's 12 key priorities for action for policy makers (Box 2), all of which appear in the Plan and to a greater or lesser degree are covered by the proposed activities of relevant line ministries.

Box 2 Twelve key priorities for action for policy makers

1. Spread best practice.
2. Invest in new knowledge.
3. Make sustainable food production central in development.
4. Work on the assumption that there is little new land for agriculture.
5. Ensure long-term sustainability of fish stocks.
6. Promote sustainable intensification.
7. Include the environment in food system economics.
8. Reduce waste – in both high- and low-income countries.
9. Improve the evidence base upon which decisions are made and develop metrics to assess progress.
10. Anticipate major issues with water availability for food production.
11. Work to change consumption patterns.
12. Empower citizens.

China's over-riding priority is to maintain 95% national self-sufficiency in food grains in the long-term, and the 12th Plan is consistent with this objective. This is contrary to the

position of the Foresight Report, which in general argues against self-sufficiency policies and in favour of accepting international comparative advantage. In the short to medium term 95% self-sufficiency should not be a problem because: (a) per capita demand for rice is going down; (b) for most of the past 10 years China has been a net exporter of wheat; and (c) there is potential to raise yields. The longer term situation is less clear and the Minister of Agriculture, Han Changfu, is concerned that it may be increasingly difficult to raise rice yields. Some analysts believe that climate change will reduce China's ability to raise or maintain grain yields sufficiently to meet projected demand. Others analysts including plant breeders are more optimistic, and with the projected decline in per capita demand for rice and wheat to 2050, it seems likely that there will not be a major supply gap for food grains, although feed grain and soyabean imports may continue to increase if feed use efficiency does not improve substantially.

The relevant components of the 12th Plan are given in Annex 3, and the responses of key ministries and government agencies are given in Annexes 4 and 7. In the main they follow the pattern of the 11th and earlier 5-year plans, which have all given priority to food security. Table 2 relates some of them to the Foresight priorities for action and gives brief details of how ministries and government agencies are responding or will respond to the 12th Plan, constraints to action, and additional policy responses.

Table 2 makes it clear that the GOC has a comprehensive set of measures in place or planned that are consistent with Foresight's 12 priority actions and could be the basis for discussions at a joint China–UK seminar on the future of food and farming in China. It also highlights where the sharing of the UK's policy experience with China could be beneficial, as the UK has been grappling with some of the problems of agricultural intensification for a long time, e.g. the formulation of science-based policy, the control of non-point pollution and the competition for land and water.

Given the nature of the Foresight key priorities (FKPs), the key implementers of the 12th Plan are the MOA and the MOST and the academies that undertake much of the R&D for policy and technology development and selection, namely the Chinese Academy of Agricultural Science (CAAS) and the Academy of Sciences (CAS). Both ministries have published their response to the 12th Plan and formulated programmes to implement those components of the Plan that they are responsible for.

The MOA's main objective is to safeguard national food security (FKP 3) by maintaining 95% self-sufficiency for food grains, moving to self-sufficiency in sugar and aiming to prevent edible oil self-sufficiency falling below 40%. Arable land area will not be allowed to fall below 120 Mha (FKP 4) and small increases in irrigated area and water use efficiency are planned (FKP 10). Substantial increases in intensive livestock production (primarily pork, poultry, eggs and milk) and biogas generation are planned (FKP 8), with both positive and negative implications for agricultural sustainability and the environment. The greatest proportion of the MOA's programme concerns the modernization of agriculture and sustainable intensification (FKPs 1, 2, 3, 5, 6, 7, 8 and 9). Full details are given in Annex 4.1. More recently the MOA have responded to the State Council's National Work Plan on Energy Saving and Emission Reduction (ESER) by setting targets for ammonia and nitrous oxide emission reduction by 2015, and

outlining the main actions to achieve these targets (Annex 4.2). The MOA's programme is complemented by those of other government bodies, notably those regarding national grain security (Annex 5) and food safety (Annex 6).

The MOST's proposals (Annex 7.1) for the implementation of the 12th Plan follow closely those of the MOA but with the emphasis on support for basic and applied agricultural research and the development of agriculture-based industries of strategic importance, particularly agricultural biotechnology, biomedicine and bioenergy. Their proposals also include actions to improve the uptake and commercialization of agricultural technology through better methods of communication with farmers and greater support to cooperatives and small-scale enterprises. As noted in Table 2, there is a clear overlap in the responsibilities and programmes of MOA and MOST, which is not ideal.

Table 2 Ongoing or planned measures to address the Foresight Report’s 12 priorities for action

Foresight priority actions for policy makers	Relevance to China	Main constraints	Enabling state decisions, laws, ministry policies and programmes	Possible additional policy responses
1. Spread best practice	Very high: there are many effective technologies and management practices that are not widely adopted	Ineffective extension system; technology gaps in needs of small farmers; lack of economic incentives and perverse subsidies; lack of training and knowledge renewal for extension personnel; small farm size; overlapping responsibilities weak coordination between ministries	Those for extension reform and relaxing constraints on activities of farmers associations; MOAs agricultural modernization programmes; national programme on balanced fertilization and integrated pest management	Further revisions to the land law to encourage consolidation; wider use of payments for environmental services; establish accreditation system for agricultural extension services; encourage private sector involvement in extension

<p>2. Invest in new knowledge</p>	<p>Very high: Chinese R&D very well funded compared with the UK</p>	<p>Overlapping responsibilities of ministries; poor cooperation and information sharing between ministries, academies and other research institutions; inadequate R&D for raising livestock productivity</p>	<p>State Council's mid- and long-term S&T development guideline (2006–2020); MOA's 12th 5-year Plan on agricultural S&T development; MOST's Fund for Agricultural S&T transformation; MOSTs biotechnology programme</p>	<p>Better coordination between responsible ministries to limit duplication of research; greater data and information sharing between different sectors and academies</p>
<p>3. Make sustainable food production central in development</p>	<p>Very high: food security</p>	<p>As for 1 and 2 above</p>	<p>12th Five-Year Plan new component on people's livelihood and welfare to reduce income disparities; MOST programme to promote agricultural SMEs</p>	<p>Protection of natural resource base (land, water and biodiversity)</p>
<p>4. Work on the assumption that there is little new land for agriculture</p>	<p>Very high: basic premise of GOC policies</p>	<p>Local governments sometimes do not implement laws protecting cropland strictly</p>	<p>Law to protect cropland; state and provincial support for coastal land reclamation; conversion of cropland to forests and grassland (grain-for-green) programme; 'Four</p>	<p>Impose large fines on local officials giving permission for developments on prime farmland</p>

			Wastelands' Policy; MOAs arable land improvement programme	
5. Ensure long-term sustainability of fish stocks	High	Lack of effective control of lake, river and marine pollution caused by non-point source pollution from crop and livestock production as well as industry and domestic activities	12th Five-Year Plan, Chapter 5, section 2, and Chapter 14 section 2 MOA's 12th Five-Year Plan for Fishery Development	Enhance water ecosystem monitoring and protection; reduce non-point pollution from land-based food production activities
6. Promote sustainable intensification	Very high	Inefficient use of inputs and degradation of resources (fertilizers, land, water, etc.) threaten long-term sustainability Lack of incentives for smallholders to make long-term investment in improved management practices	12th Five-Year Plan, Chapter 7, section 2 re. water conservation and irrigation improvement; MOA plan of action for agricultural modernization; programmes on non-point pollution control; MOE plan on groundwater protection	Integrate GHG mitigation into low-carbon development plan
7. Include the environment in food	Very high	Lack of awareness of	Watershed Eco-	Better monitoring and

system economics		nature and value of ecosystem services	Compensation Programme; national and local eco-compensation policies and programmes NDRC and MOA's target on energy saving and emission reduction	evaluation of environmental costs in food production
8. Reduce waste	Very high	Outdated facilities and technologies for planting, harvesting, storage and processing; nutrition gap – (malnutrition and overnutrition) between different groups of people	State Law on Circular Economy; MOA Action Plan for Circular Agriculture; biogas programme; State Grain Administration (SGA) programme for improved on-farm storage; SGA's food waste reduction guideline	Investment in essential facilities Coordinated multiple actions on food waste reduction across food supply chain, include market incentives, consumer awareness
9. Improve the evidence base upon which decisions are made and develop metrics to assess	Very high	Poor data sharing between ministries; infrequent national surveys of key parameters	National and international think tanks (such as CCICED) carrying out strategic research advising the	

progress			government	
10. Anticipate major issues with water availability for food production	Very high	Poor infrastructure and low water use efficiency; water pollution	As in 6 and 7 above	Investment in adaptation capacity; water price, water governance reform
11. Work to change consumption patterns	High	Lack of awareness of negative consequences of unbalanced diets	MOH's nutrition standard programme National guideline on food and nutrition development	Better food information to public; awareness raising on negative consequences of unbalanced diets; better food labelling
12. Empower citizens	High	Legal restrictions on farmers associations and cooperatives		Food system information, such as production, nutrition, safety. etc. accessible to public

CCICED, China Council for International Cooperation on Environment and Development; SMEs, small and medium-sized enterprises; S&T, science and technology.

CAAS and CAS form a large part of the research support system of MOA and MOST respectively. These two academies are heavily engaged in addressing the Foresight challenges and priorities and have also started to formulate their responses to the 12th Plan.

The academies in turn are supported by the National Science Foundation of China (NSFC). Although the NSFC's primary role is to fund basic research, its priorities match those of Foresight to a large degree (Annex 7.2), and they will be doubling research support over the next 5–10 years.

CAAS will support the 12th Five-Year Plan by focusing its science and technology innovation initiatives on the following:

- 1) collection and exploitation of germplasm resources, as well as breeding of new varieties of plants and animals
- 2) prevention and control of major agricultural biological hazards
- 3) efficient use of agricultural resources and environmental management of key regions
- 4) agricultural mechanization technology and intelligent equipment
- 5) agro-products quality and safety and processing
- 6) agricultural economic and science and technology policy

CAAS will put great effort into making breakthroughs in core technologies for modern agriculture development: strategic high technologies that will enhance the international competitiveness of China's agriculture by securing national food security and agro-products' quality and safety and ecological safety; and generic technologies of public interest in agricultural and rural economic development.

Part III

Areas of uncertainty and limited consensus

China's 12th Five-Year Plan provides a strong policy framework for the development of food production to ensure its 95% food self-sufficiency goal. However, the long-term sustainability of the food production system can be achieved only if the resource base is protected and agriculture's negative impacts on the environment are minimized. The Foresight Report makes no specific comments about China's ability to meet these two challenges, but this independent review of the report's implications for China has identified a number of areas of uncertainty and limited consensus among Chinese scientists about the actions needed to overcome these challenges. These areas relate primarily to:

- safeguarding the resource base
- improving resource use efficiency, particularly fertilizer nutrients and water
- reducing non-point pollution and other environmental impacts
- mainstream agricultural climate change mitigation in low-carbon management through innovative mechanisms such as clean development mechanism (CDM) and ecosystem service payments
- reducing food waste in all stages of the food chain and promoting sustainable food consumption
- integrated approaches to catchment management and manure management.

Safeguarding the resource base

The 12th Five-Year Plan re-affirms the goal of stopping the loss of cropland to urban and industrial development and of not breaching the so-called 'redline' of 120 Mha. However, it can be questioned whether this is feasible. Land laws have been progressively strengthened since the 1990s, but the loss of some of China's best cropland has continued. Moreover, some recent projections suggest that the redline will be breached by 2015 and the area of cropland may even decline to 110 Mha by 2030. Although some of the losses are being compensated by opening up new cropland, much of this is in the north-east of China where the growing season is short and multiple cropping is impossible.

The land loss issue is being compounded by a deterioration in certain aspects of soil quality, notably acidification, which has doubled over the past 30 years (Guo et al, 2010) and is difficult and expensive to overcome. Increased use and misuse of nitrogen fertilizer accounts for about 60% of the acidification, and ammonia emissions from the expansion of livestock production seems likely to add to this problem. This acidification threatens food security by lowering crop yields by suppressing microbial activity and reducing the availability of micronutrients. The new

targets in the 12th Five-Year Plan for the reduction of ammonia emissions will help to reduce acidification, but it is likely to take many years to overcome the problem.

Resource use efficiency

Resource use efficiency in China is low by global standards. It is particularly low for irrigation water, fertilizer, and livestock feed. This reduces the competitiveness of agricultural production, lowers farmers' income, and threatens the long-term sustainability of food production and ecosystem services.

China has implemented a range of programmes over the past 10 years to raise fertilizer use efficiency and nutrient management, e.g. the national soil test and fertilization recommendation programme (since 2005) and the improved fertilizer quality and labelling programmes. Nonetheless, overuse and misuse of synthetic fertilizers and manure are still widespread, and the adoption of improved nutrients management (INM) practices by farmers remains a challenge. Even following special programmes whereby farmers have received intensive training on INM, only a small fraction of them have adopted these practices permanently. New approaches are needed to match technical recommendations and farmers' socioeconomic situation, particularly the labour constraints that many farmers face because they spend most of their time and gain most of their income from non-farm employment. There is no clear consensus on what these approaches should be, but there is increasing agreement that past programmes have been insufficient to achieve the required improvements in fertilizer use efficiency, and that farm labour constraints need to be overcome by appropriate mechanization and land consolidation.

Furthermore, with China's grain basket shifting to the north where water resources are more limited and the soils tend to be less fertile, the complexity of the challenge increases because more integrated approaches are needed to address nutrient and water use efficiency simultaneously. Meeting the challenge will involve facing up to serious institutional difficulties because of the complex national and local governance structures for water management (see Table 1; Zhong & Jones, 2011).

Advanced biotechnologies, including genetic modification, should be an important component of increasing productivity and reducing reliance on synthetic agro-chemicals.

Reducing non-point and point source pollution and other environmental impacts

Agriculture has become the major source of water pollution. Much of it is the result of the poor fertilizer and manure use efficiency discussed above. The 10th and 11th Five-Year Plans contained measures to reduce it, but progress has been slow. It is now being increased by point source pollution from the rapid expansion of intensive livestock production, which requires forms of policy integration that might be difficult to achieve in China in the short to medium term. For example, pollution from livestock wastes needs to be tackled by a range of measures that are the responsibility of many government departments and agencies:

- planning controls on location of confined animal feeding operations
- building regulations regarding drainage and waste storage requirements
- discharge standards for effluents
- limits on stocking rates and manure or slurry disposal
- support for anaerobic digestion and organic fertilizer production.

Mainstream agricultural climate change mitigation

China is to embark on a low-carbon development plan to cut carbon intensity by 45% by 2020. The NDRC has initiated low-carbon development pilot zones to identify and test policies and technical measures to achieve this reduction, but agriculture does not generally feature in these plans. However, China's agricultural sector is the source of 20% of the nation's total GHG, 92% of its nitrous oxide and 50% of its methane emissions, and these can be reduced substantially through improved farm management. The China–UK Sustainable Agriculture Innovation Network (SAIN) project on GHG mitigation in China confirms the existence of a range of cost-effective measures, but, as with the above discussions on improving resource use efficiency and reducing non-point and point source pollution, it can be questioned whether the changes needed to meet the NDRC targets set for 2015 and 2020 can be implemented quickly enough. For example, the 12th Five-Year Plan has for the first time set a target for a 10% reduction in ammonia emissions by 2015, and these come largely from agriculture. This target seems very ambitious given the continued growth in fertilizer use and expansion of livestock production. It took the UK 30 years to reduce ammonia emissions by about 20%, and much of this decline came from lower cattle numbers, an option that is not feasible for China.

Reducing food waste

The Foresight Report raises concerns that developing countries may experience an increase in food wastes as incomes rise. Recent estimates show that food wastes along the food chain in China are in the range 6–40% (Xu 2005). Storage wastes are the highest at 24 Mt, but some of these are used for livestock feed or bio-ethanol production so are not wastes per se. Harvesting, processing and transportation wastes are 19, 4.5 and 3.5 Mt respectively. Restaurants wastes are 2.2 Mt, assuming that 10% of people eat in restaurants, and this might increase with rising incomes in both rural and urban areas, so food wastes from restaurants could grow, although cultural factors may limit this. Hence, the food waste issue in China may be less important than in other countries considered by the Foresight study. Nonetheless, there is the wider issue of waste, low resource use efficiency and high GHG emissions along the livestock chain. This issue has two components: first, the structure and technology of livestock production, which is evolving rapidly from traditional systems to intensive confined feeding operations that could be made much more sustainable within 10–20 years if stronger policies were adopted; second, food consumption preferences, which could lead to high wastage if Chinese people adopt the high meat and milk diets of North America. This seems unlikely. Most recent food modelling suggests that Chinese people will adopt a modified Japanese diet. Nonetheless, there is a growing problem of obesity in young people, and guiding corrective

changes in consumption behaviour to achieve a well-balanced sustainable diet is a complex and slow process.

Conclusions

The main implications of the Foresight Report are positive for China in that it raises no issues that are not already being addressed at least in part by the GOC's development strategy. Moreover, the Report's 12 key priorities for action are mirrored by GOC policies formulated in the context of the 12th Five-Year Plan, which are less generic in nature than those suggested by the Report. However, this independent review highlights a number of areas of uncertainty about the challenges facing sustainable food production in China and how they can be overcome. In particular, it questions whether China can meet some of the demanding targets it has set for 2015 and 2020. A number of these targets are technically feasible but may be difficult to implement in the short to medium term because of institutional and socioeconomic constraints. For example, the 10th and 11th Five-Year Plans addressed the problems of non-point pollution from agriculture and the overuse and misuse of fertilizer, but progress has been limited. Consequently, there may be a case for launching a China Foresight Analysis, which, like the UK Foresight Report, seeks to break away from the conventional policy and technical responses of the past decade and forge new alliances between government departments and pay greater attention to the socioeconomic determinants of sustainable agriculture.

Finally, and to place this independent review in a more global and bilateral context, it should be acknowledged that there is much to be positive about. First, much of China's past work on agricultural sustainability has had substantial global benefits, for example it's development of improved rice cultivars. The actions in the 12th Five-Year Plan are likely to continue such benefits and even widen them because of the massive investment that is going into biotechnology and the extensive support being given to national agricultural research systems in Africa. Second, China and the UK have been developing strong research and development partnerships, through SAIN, the Food Security Action Plan, and numerous small collaborations, that could provide an effective framework for joint follow-up activities relating to the findings of the Foresight Report.

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Annexes on the Legislative Framework for China's Agriculture and Food Policy System

Annex I Medium- and Long-term Plan for National Food Security (2008–2020)

This Plan was released on 13 November 2011, prepared by the National Development and Reform Committee, together with other more than 10 ministries. The Plan outlines the objectives, tasks, and specific programmes for food security and provides the strategic framework for all actions on food security.

Objectives

- (i) Stabilize grain-sown areas. By 2020, maintain arable land area at not less than 1.2 billion hectares.
- (ii) Ensure grain and other major food basically self-sufficient. Maintain grain self-sufficiency over 95%.
- (iii) Maintain a reasonable level of grain storage and the proportion of wheat and rice not less than 70% of the storage.
- (iv) Establish a modern grain logistic system; reduce grain distribution costs.

The key tasks

- (i) Increase food production capability.
- (ii) Utilize non-grain food resources.
- (iii) Strengthen international cooperation on grain and edible oil.
- (iv) Perfect grain distribution system.
- (v) Perfect grain storage system.
- (vi) Further improve grain processing system.

Policies and measures to safeguard food security

- (i) Strengthen government's food security responsibility; provincial government is responsible for the region's arable and water resource protection, grain production, distribution, storage and marketing regulation.
- (ii) Strongly protect production resources, including arable land and grassland.
- (iii) Strengthen scientific and technological support to agriculture, establish the government-led multiple founding system and encourage business sectors and farmer associations to disseminate agricultural technologies.
- (iv) Increase agriculture input for infrastructure, finance service and production subsidies.
- (v) Perfect grain macro control mechanism, improve grain statistic system, emergency response system, grain distribution policies, and strengthen grain administration system.
- (vi) Promote healthy food consumption and reduce food chain waste.
- (vii) Push forward food legislation.
- (viii) Implement specific programmes and plans regarding grain production, distribution, storage, process and consumption.

The 10 specific programme and plans proposed, include

- (i) The plan to increase grain production capability by 50 Mt (2009–2020).
- (ii) Arable land protection and land reclaim development plan.
- (iii) Water resource protection and development plan.
- (iv) Agricultural and food science and technology development plan.
- (v) Grain saving livestock development plan.
- (vi) Edible vegetable oil development plan.
- (vii) Modern grain logistic development plan.
- (viii) Grain storage system development plan.
- (ix) Grain processing industry development plan.
- (x) Policies and measurements for healthy food consumption.

Annex 2 12th Five-Year Plan for National Economic and Social Development (2011–2015)

This is China's most comprehensive development plan which covers all the important sectors of social and economic development. The Plan covers two important aspects of the food system – food production and resource/environmental protection. The section on agricultural development, with the title of 'Strengthen Agriculture and Benefit Farmers, Speed Up the Development of the Socialist New Countryside', outlines objectives of major aspects of agricultural development in the period of 2011–2015, including:

Chapter 5 *Develop Modern Agriculture More Rapidly*

- Become More Capable of Ensuring Food Security
- Carry Out Strategic Agricultural Restructuring
- Accelerate Scientific and Technological Innovation in Agriculture
- Improve the Agricultural Social Service System

Chapter 6 *Expand the Ways in Which Farmers Can Increase Their Incomes*

- Solidify and Raise Household Production Income
- Strive to Increase Wage Incomes
- Energetically Increase Transfer Income

Chapter 7 *Improve Living and Working Conditions in the Countryside*

- Improve Planning and Management of Towns, Townships and Villages
- Strengthen Rural Infrastructure
- Strengthen Public Services in Rural Areas
- Comprehensively Clean Up the Rural Environment

Chapter *Improve Systems and Mechanisms for Rural Development*

- Uphold and Improve the Basic Rural Management System
- Develop a Sound System for Integrated Urban and Rural Development
- Enhance the Vitality of Economic Development in Counties

Chapter 21 *Actively Respond to Global Climate Change*

- Control Emissions of Greenhouse Gases
- Enhance the Ability to Adapt to Climate Change
- Extensively Develop International Cooperation

Chapter 22 *Strengthen Resource Conservation and Management*

- Save Energy and Resource Consumption
- Strengthen Water Resource Conservation
- Use Land Economically and Intensively
- Intensify the Surveying, Protection and Rational Exploitation of Mineral Resources

Chapter 23 *Vigorously Develop a Circular Economy*

- Promote Cyclic Production
- Improve the Resource Recycling System

- Spread Green Consumption
- Enhance Policy and Technological Support

Chapter 24 Intensify Environmental Protection

- Reduce and Control Emissions
- Guard Against Environmental Risks
- Strengthen Environmental Monitoring

Chapter 25 Promote Ecological Protection and Remediation

- Construct Ecological Safety Barriers
- Strengthen Ecological Protection and Governance
- Establish an Ecological Compensation Mechanism

Chapter 26 Intensify the Development of Systems for Water Conservancy and Disaster Prevention and Mitigation

- Improve Capabilities to Guarantee Supply of Water
- Enhance Flood Control Capabilities
- Strengthen the Prevention and Control of Mountain Torrents, Geological Disasters, Meteorological Disasters and Earthquakes

Chapter 27 Increase Scientific and Technological Innovation Capabilities

- Promote Major Scientific and Technological Breakthroughs
- Accelerate the Establishment of a Technological Innovation System Led by Enterprises
- Accelerate the Construction of Science and Technology Infrastructure
- Strengthen Support Policies for Scientific and Technological Innovation

Chapter 49 Deepen Reform of the Prices for Resource Products and Environmental Protection Charges

- Improve the Price Formation Mechanism for Resource Products
- Reform of the System of Environmental Protection Charges
- Establish a Sound Mechanism for Trading in Resources and Environmental Property Rights

The main targets for economic and social development in the 12th Five-Year Plan period

Item	2010	2015	Average annual increase (%)	Nature
Economic development				
Gross domestic product (GDP) (trillion RMB yuan)	39.8	55.8	7	Anticipated
Share of services in GDP (%)	43	47	[4]*	Anticipated
Urbanization level (%)	47.5	51.5	[4]	Anticipated

Science, technology and education					
Nine-year compulsory education retention rate (%)	89.7	93	[3.3]	Obligatory	
Senior secondary school gross enrolment rate (%)	82.5	87	[4.5]	Anticipated	
Ratio of R&D expenditure to GDP (%)	1.75	2.2	[0.45]	Anticipated	
Number of patents granted per 10,000 people	1.7	3.3	[1.6]	Anticipated	
Resources and environment					
Total cultivated land (billion hectares)	1.818	1.818	[0]	Obligatory	
Reduction of water use per unit of industry Value Added (%)			[30]	Obligatory	
Efficiency coefficient of irrigation water	0.5	0.53	[0.03]	Anticipated	
Percentage of non-fossil fuels in primary energy resource consumption	8.3	11.4	[3.1]	Obligatory	
Reduction of energy per unit of GDP (%)			[16]	Obligatory	
Reduction in carbon dioxide (CO ₂) emissions per unit of GDP (%)			[17]	Obligatory	
Reduction of major pollutant emission (%)	Chemical oxygen demand (COD)		[8]	Obligatory	
	Sulphur dioxide (SO ₂)		[8]		
	Ammonia-N		[10]		
	Nitrogen oxide/dioxide (NO _x)		[10]		
Forest growth	Forest coverage (%)	20.36	21.66	[1.3]	Obligatory
	Forest volume (billion cubic metres)	13.7	14.3	[6]	
People's life					
Urban per capita disposable income (RMB yuan)	19,109	>26810	>7	Anticipated	
Rural per capita net income	5,919	>8310	>7	Anticipated	

(RMB yuan)				
Registered urban unemployment rate (%)	4.1	<5		Anticipated
Increase in urban employment (million)			[45]	Anticipated
Urban residents covered by basic pension insurance (million)	257	357	[1]	Obligatory
Urban and rural residents covered by one of the three basic medical insurance systems (%)**			[3]	Obligatory
Low-income housing units built (million)			[36]	Obligatory
Total population (billion)	1.341	<1.39	<7.2 ‰	Obligatory
Life expectancy	73.5	74.5	[1]	Anticipated
<p>* '[...]' indicates 5-year cumulative amount</p> <p>** The three basic medical insurance refers: basic medical insurance for urban workers; basic medical insurance for non-working urban residents; new rural cooperative medical insurance scheme.</p>				

Annex 3 Foresight priority actions for policy makers and relevant components in 12th Five-Year National Plan

Foresight priority actions for policy makers	Relevant components in 12th Five-Year National Plan
1. Spread best practice	<ul style="list-style-type: none"> • Strengthen the ability to provide public services to agriculture • Foster pluralistic agricultural social service institutes to provide diverse services • Establish a marketing network for agricultural products <p><i>(Chapter 5, section 4)</i></p>
2. Invest in new knowledge	<p>Speed up the pace of modern agriculture development</p> <ul style="list-style-type: none"> • Promote technology integration, mechanization, and application of information technologies in agricultural production • Speed up innovation, extension and application of biotechnologies • Develop technologies for highly efficient cultivation, epidemic disease prevention and control and water conservation agriculture <p>Increase innovation capability</p> <p>Advance breakthroughs in major science and technology (S&T) areas include:</p> <ul style="list-style-type: none"> • Establish enterprise-led technology innovation system • Accelerate the construction of S&T infrastructure • Strengthen policy support to S&T innovation • Accelerate education reform and development • Foster high-quality innovative workforce <p><i>(Chapters 5, 27, 28, 29)</i></p>
3. Make sustainable food production central in development	<p>Take nation's food security as top priority, change agriculture development mode and improve agriculture's comprehensive capacity of production, risk resistance ability and market competitiveness</p> <p><i>(Chapter 5)</i></p>
4. Work on the assumption that there is little new land for agriculture	<ul style="list-style-type: none"> • Stabilize arable land area, optimize variety composition, increase per unit yield and quality • Speed up rural land reclamation • Delimit permanent prime farmland • Balance requisition–compensation of arable land,

	<p>ensure the total arable land reserve is not reduced</p> <ul style="list-style-type: none"> • Tightly control construction land use (<i>Chapters 5, 22</i>)
5. Ensure long-term sustainability of fish stocks	<p>Promote the healthy development of aquaculture and develop distant fishing</p> <p>Scientifically plan for the development of maritime economy, rationally develop and utilize maritime resources (<i>Chapter 5, section 2; Chapter 14, section 1</i>)</p>
6. Promote sustainable intensification	<p>Speed up the pace of modern agriculture development</p> <ul style="list-style-type: none"> • Strengthen the capacity to safeguard food security • Implement agricultural structure strategic readjustment • Accelerate innovation in agricultural S&T • Strengthen agricultural social service system <p>Expand farmers' income sources</p> <ul style="list-style-type: none"> • Maintain and increase household operating income • Increase wage income • Increase transfer income <p>Improve agricultural production and rural living conditions</p> <ul style="list-style-type: none"> • Improve village and township planning • Improve rural basic infrastructure • Strengthen rural public services • Improve rural environmental protection and management <p>(<i>Chapter 5, 6, 7</i>)</p>
7. Include the environment in food system economics	<p>Improve rural environmental protection and management</p> <ul style="list-style-type: none"> • Control the non-point pollution from pesticides, chemical fertilizers, and plastic films, etc., and comprehensively promote the prevention of pollution from livestock and poultry farming • Enhance the protection of the drinking water sources in rural areas and comprehensive management of rivers and of treatment of waste water in rural areas • Strengthen supervision and management on the prevention of soil pollution. Measures on rural cleaning project will be implemented

	<p>Actively respond to global climate change</p> <ul style="list-style-type: none"> • Control GHG emissions • Strengthen climate change adaptation capacity • Implement broad international cooperation <p>Strengthen resource saving and management</p> <ul style="list-style-type: none"> • Promote energy saving and consumption reduction • Save water resources • Intensify land use <p>Promote circular economy</p> <ul style="list-style-type: none"> • Promote circular production mode • Improve resource recycle system • Initiate green consumption • <p>Boost effort in environmental protection</p> <ul style="list-style-type: none"> • Reduce pollutant discharge • Manage environmental risk • Strengthen environmental monitoring <p>Promote ecosystem protection and restoration</p> <ul style="list-style-type: none"> • Establish ecological security defence • Strengthen ecosystem protection and management • Establish ecosystem compensation mechanism <p>Reform the resource price and environmental protection payment</p> <ul style="list-style-type: none"> • Refine resource price mechanism • Advance environmental protection payment system reform • Establish environment and resource property right trading system <p><i>(Chapters 7, 21, 22, 23,24, 25, 49)</i></p>
8. Reduce waste	<p>Reduce food waste was not directly mentioned in the 12th Plan. However, the State Grain Administration, in 2010, published a document 'Implementation</p>

	<p>Suggestion for the Work on Food Saving and Combating Food Waste'. The Suggestion calls all levels of grain administrations and grain enterprises to take effective actions to strengthen grain saving, combat waste, raise grain utilization efficiency, constrain unreasonable consumption and safeguard the country's food security. The suggested actions include:</p> <ul style="list-style-type: none"> • Widely campaign on grain saving, increase grain saving awareness • Perform good practice in grain purchasing and storage management <ul style="list-style-type: none"> ○ Timely purchase of grain from farmers ○ Improve infrastructure of grain storage facilities ○ Improve storage technologies and prevent accidents • Improve grain logistic facilities, reduce grain loss in transportation • Establish rational standards for grain and edible oil products, raise the utilization rate • Reinforce R&D and dissemination of new technologies for grain saving • Push forward grain and oil quality programme and guidelines
<p>9. Improve the evidence base upon which decisions are made and develop metrics to assess progress</p>	
<p>10. Anticipate major issues with water availability for food production</p>	<p>Enhance water resource conservation</p> <ul style="list-style-type: none"> • Apply the most strict water resource management system, strengthen control over the total volume of water utilization and quota management • Enforce measures on protecting water resources • Accelerate the formulation of plans on the allocation of the water volume at various rivers • Enhance the establishment of the water rights system, and build a water conservation type society <p>(Chapter 22)</p>
<p>11. Work to change consumption patterns.</p>	<p>Promote Green Consumption Model</p> <ul style="list-style-type: none"> • Advocate civilized, thrift, green, and low-carbon

	<p>consumption concept</p> <ul style="list-style-type: none">• Promote the formation of a green lifestyle and consumption model• Encourage consumers to buy energy-saving and water-saving products,• Reduce the utilization of disposable products• Restrict excessive packing,• Control irrational consumption <p><i>(Chapter 23 This is general green consumption, not specifically on food)</i></p>
12. Empower citizens	

Annex 4

Annex 4.1 Ministry of Agriculture's 12th Five-Year Plan for Agricultural and Rural Economy (2011–2015)

The overall objective of agricultural and rural development in the 12th Five-Year Plan period are (i) steadily increase production capacity of grain and other agricultural products; (ii) significantly increase farmers' income; and (iii) make significant progress in new countryside development. To achieve the objectives, the Ministry of Agriculture will take actions on the following seven aspects:

Steadily Increase the Grain Production Capacity

- Stabilize grain planting area
- Optimize grain variety structure
- Strengthen the redevelopment of main grain production areas
- Increase per unit area yield

Substantially Improve the Level of Agricultural Material and Equipment

- Strengthen science and technology innovation and professional training
- Strengthen infrastructure development
- Accelerate agricultural mechanization and development of facility agriculture
- Build up the capacity for disaster prevention and reduction

Adjust and Optimize the Structure of Agricultural and Rural Economy

- Deepen agricultural structure adjustment
- Accelerate the development of the agricultural product processing industry
- Enhance township enterprise development
- Promote agricultural services
- Foster emerging rural industries

Increase Farmer Income

- Steadily increase incomes from household business operations
- Strive to increase wage incomes
- Effectively increase transfer income

Enhance Agricultural and Rural Public Services

- Strengthen the development of the agricultural public service system

- Enhance rural infrastructure construction
- Strengthen rural social services

Perfect and Innovate Rural and Agricultural Development Mechanism

- Perfect rural land administration system
- Develop multiple types of operations
- Further develop farmer technical associations
- Raise the quality of agricultural industry development
- Strengthen the establishment of modern agricultural demonstration zones

Protect Rural Ecological Environment

- Strictly protect arable land
- Strengthen grassland protection
- Strengthen water resource and agricultural biological resource protection
- Push forward agricultural energy saving and emission reduction and rural environmental management (see Annex 4.2)

The main targets for agriculture and rural economic development in the 12th Five-Year Plan period

Item	2010	2015	Average annual increase (%)
Agricultural products supply capacity			
Grain crop sown area (100 million ha)	1.099	>1.067	
Grain production capacity (100 Mt)	>5.0	>5.4	
Cotton, total production (10,000 t)	596	>700	>3.27
Yield of oil-bearing crops (10,000 t)	3230	3500	1.62
Yield of sugar crop (10,000 t)	12008	>14000	>3.12
Total meat (10,000 t)	7925	8500	1.41
Eggs (10,000 t)	2765	2900	0.96
Milk (10,000 t)	3780	5000	5.75
Total output of aquatic products (10,000 t)	5373	>6000	>2.23
Pass rate for regular quality test of agricultural products (%)	94.8	>96	>[1.2]
Agricultural production structure			
Proportion of livestock production value to total agricultural production value (%)	30	36	[6]
Proportion of fishery output value to total agricultural output value (%)	9.3	10	[0.7]

Ratio of the value of agricultural products processing industry to the total value of agricultural output	1.7	2.2	[0.5]
Average annual growth rate of added value of township enterprises (%)			10
Agricultural technology and equipment			
Contribution rate of technical progress (%)	52	>55	> [3]
Total mechanical power (100 million kW)	9.2	10	1.68
Level of mechanization in ploughing, sowing and harvesting (%)	52	60	[8]
Increase in irrigated area (100 million ha)			[0.027]
Irrigation water use efficiency	0.5	0.53	[0.03]
Number of rural skilled population (10,000)	820	1300	6.8
Agricultural production operation and management			
Number of households associated to production association (100 million)	1.07	1.3	3.97
Proportion of large-scale dairy cattle farms (%) (annual in stock number over 100 heads)	28	>38	> [10]
Proportion of large-scale pig farms (%) (annual slaughter number over 500 heads)	35	50	[15]
Agricultural benefits and farmer income			
Annual growth rate in added value of agricultural, forestry and livestock output			5
Rural labour transfer (10,000 people)			[4000]
Rural per person income (RMB yuan)	5919	>8310	>7
Resource utilization and environmental protection			
Utilization rate of crop residues (%)	69	>80	>[11]
Percentage of biogas pits installed in suitable households (%)	33	>50	>[17]
Release various aquatic species for stock enhancement (100 million heads)	289		[1500]
[...] 5-year cumulative number			

The Ministry of Agriculture has also prepared five-year plans for specific sectors including:

- 12th Five-Year Plan of Crop Production (2011–2015)
- 12th Five-Year Plan of Livestock Development (2011–2015)
- 12th Five-Year Plan of Fishery Development (2011–2015)
- 12th Five-Year Plan of Feed Industry (2011–2015)

Annex 4.1 Suggestions on Agricultural and Rural Energy Saving and Emission Reduction (ESER)

Released on 14 December 2011 by the Ministry of Agriculture as a sectoral response to the national action plan

Targets

By 2015, compared with 2010, total agricultural chemical oxygen demand (COD) emissions reduced by 8%, ammonia nitrogen emission reduced by 10%; coverage of soil test programme reaches 60%, fertilizer use efficiency increased by 3%; promote unified pest and disease prevention and control programme 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-poison, high-residue pesticides; promote ESER planting system and reduce high-energy consumption procedures; over 50% of intensive livestock farm or livestock-raising community equipped with waste treatment facilities; households with biogas reach 55 million and annual biogas consumption reaches 21.6 billion m³; phase out high-energy consumption and high-pollution machines and fishing boats; update township enterprises for energy saving and increase rural production energy efficiency.

Actions

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

Actively Prevent and Control Agricultural Non-point Pollution

- Disseminate technologies for fertilizers, pesticides and water saving
- Disseminate technologies for ecological livestock raising
- Disseminate technologies for healthy aquaculture

Step Up the Efforts to Promote Reuse of Rural Waste

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

Provide Effective Enabling Measures to Rural and Agricultural ESER

- Strengthen the leadership and consensus
- Design and improve relevant policies and regulations
- Increase financial input
- Strengthen technical support
- Initiate extensive training and dissemination

Annex 4.2 Circular Economy Promotion Law

The Circular Economy Promotion Law was passed at the 4th meeting of the Standing Committee of the 11th National People's Congress of the People's Republic of China on 29 August 2008. It entered into force on 1 January 2009.

The Law was formulated for the purpose of facilitating a circular economy, raising the resource utilization rate, protecting and improving the environment and realizing sustained development.

The term *Circular Economy* in the Law refers the general term for the activities of decrement, recycling and resource recovery in production, circulation and consumption.

The Law contains 7 chapters and 58 articles. The titles of the 7 chapters are as follows:

Chapter 1 General Provisions

Chapter 2 Basic Administrative System

Chapter 3 Decrement

Chapter 4 Recycling and Resource Recovery

Chapter 5 Incentive Measures

Chapter 6 Legal Responsibilities

Chapter 7 Supplementary Provision

There are two Articles particularly relevant to agricultural sector:

Article 24 The people's governments above county level as well as their agricultural departments shall promote the intensive use of land, encourage and support agricultural producers to adopt advanced planting, breeding and irrigating technologies that reduce the use of water, fertilizer and pesticide, promote the energy saving of agricultural machinery, and give priority to developing ecological agriculture.

In areas where water is insufficient, efforts shall be made to adjust planting structure, give priority to develop water-saving agriculture, promote the collection and utilization of rain water and build and manage water-efficient irrigating facilities to raise water use efficiency and reduce the vaporization and loss of water.

Article 34 The State encourages and supports agricultural producers and relevant enterprises to employ advanced or applicable technologies to make comprehensive utilization of the straw of crops, the excrement of poultry and livestock, by-products from the processing of agricultural products, and waste agricultural films, and develop and use marsh gas and other biomass energies.

Annex 5 Grain Law (draft, 2012)

On 21 February 2012, the Legislative Affairs Office of the State Council released a draft of a new Grain Law to solicit public opinion. The draft law was jointly prepared by the National Development and Reform Commission and the State Administration of Grain. According to the explanatory notice, safeguarding national grain security is the fundamental purpose of the Grain Law. It aims to ensure grain security by stabilizing grain output and intensifying control and supervision over the market.

The draft law applies to grains, edible vegetable oil, and oilseeds, as well as the production, distribution, and consumption of these commodities. It also defines the roles and responsibilities for different administrative departments in managing grain production, processing, trade, reserves, and market information dissemination.

The draft law contains 10 chapters and 97 articles. The 10 chapters are listed as below:

- Chapter 1 General Provisions
- Chapter 2 Grain Production
- Chapter 3 Grain Distribution and Processing
- Chapter 4 Grain Consumption and Conservation
- Chapter 5 Grain Quality Safety
- Chapter 6 Grain Macro Regulation and Reserve
- Chapter 7 Support to and Development of the Grain Industry
- Chapter 8 Supervision and Inspection
- Chapter 9 Legal Liability
- Chapter 10 Supplementary Provisions

Annex 6 Laws and guidelines regarding food safety and food consumption

Annex 6.1 Food Safety Law (2009)

Food Safety Law (FSL) was approved by China's National People's Congress (NPC) Standing Committee on 28 February 2009. The FSL went into effect on 1 June 2009. The FSL aims to enhance monitoring and supervision, toughen safety standards, recall substandard products and severely punish offenders. To reinforce the implementation of FSL, the State Council issued the implementing regulation on 20 July 2009, and set up the Food Safety Committee on 6 February 2010. The Committee is responsible for the coordination of food safety work, making major policies and measurements on food safety, and supervising the fulfilment of food safety responsibilities.

The FSL covers the following 10 chapters:

- Chapter 1 General Provisions
- Chapter 2 Surveillance and Assessment of Food Safety Risks
- Chapter 3 Food Safety Standards
- Chapter 4 Food Production and Trade
- Chapter 5 Food Inspection and Testing
- Chapter 6 Food Import and Export
- Chapter 7 Response to Food Safety Incidents
- Chapter 8 Supervision and Administration
- Chapter 9 Legal Liabilities
- Chapter 10 Supplementary Provisions

Annex 6.2 Food and Nutrition Development Guideline (2011–2020)

Led by MOA and MOH, the State Food and Nutrition Consultant Committee (SFNCC) is preparing the Food and Nutrition Development Guideline (2010–2020). The Guideline will cover the aspects of food supply, food consumption, nutrient intake, balanced diet, and disease control. The Guideline will also set out the goal of food and nutrition development in 2015 and 2020, as well as enabling policies, technology and investment to achieve the goal.

Annex 6.3 State Grain Administration Suggestion to Combat Food Waste

On 12 April 2010, the State Grain Administration issued Suggestion to Combat Food Waste. The Suggestion outlined the following actions to combat food waste in China:

- A broad publicity campaign to raise awareness on food saving
- Enhance grain purchase and storage and reduce grain waste in storage
- Accelerate grain logistic infrastructure development and reduce grain waste in transportation
- Improve the standard of grain and oil products and enhance the efficiency of grain and oil process
- Develop and disseminate new technologies for grain waste reduction
- Push forward the trusted grain and oil programme, encourage grain and oil business to combat grain waste, and provide services to help the public combat food waste

Annex 7 Research and Extension

Annex 7.1 National 12th Five-Year Plan on Science and Technology Development

The objectives

On 13 July 2011, the National 12th Five-Year Plan on Science and Technology Development was released by MOST. The Plan aims to push China forward towards becoming an innovative nation by significantly boosting the nation's innovation capacity and international competitiveness in high-tech sectors and achieving breakthroughs in priority and key technical fields.

Some other targets under the 12th Five-Year Plan on scientific and technological development are included in the table below:

Targets	2010	2015
R&D expenditure as percentage of gross domestic product	1.75%	2.20%
R&D personnel per 10,000 workers	33/man-year	43/man-year
Ranking of citations in international science papers	8th	5th
Invention patent ownership per 10,000 persons	1.7 pieces	3.3 pieces
R&D personnel's invention patent applications	10 pieces/100 man-years	12 pieces/100 man-years
Total contract deals in domestic technology market	RMB 390.6 billion yuan	RMB 800 billion yuan
High-tech value added as percentage of manufacturing sector value added	13%	18%
Percentage of civic scientific literacy in the population	3.27%	5%

The contents

1. Situations and demands
2. Overall ideas, targets and strategies
3. Accelerate the implementation of major projects of national science and technology

4. Make great efforts to nurture and develop emerging industries of strategic importance
5. Forge ahead with breakthroughs in key technologies in major areas
6. Forward deploy basic research and frontier technology research
7. Strengthen the construction of scientific and technological innovation bases and platforms
8. Vigorously cultivate innovative technology talents
9. Enhance the level of opportunity and cooperation in science and technology
10. Deepen the reform of the science and technology system, and comprehensively promote the establishment of a national innovation system
11. Strengthen the implementation and development of science and technology policies, and optimize the environment for whole social innovation
12. Effectively guarantee the implementation of the plan

Relevant elements on agriculture and food system

1. Raise the capability of transferring science and technology into practice
 - Strengthen the agricultural science and technology transfer system.
 - Continue to implement various dissemination programmes.
 - Make full play of the leading and demonstration role of leading enterprises, cooperatives, and large-scale livestock and crop farms.
 - Actively nurture small and medium-scale technically intensive agricultural enterprises and cooperatives.
 - Develop technical service platform and support farmers' entrepreneurship.
2. Carry out rural technical entrepreneurship initiatives and establish a new type of rural technology service system
 - Boost the initiative of specially appointed technical agents (*Keji Tepaiyuan*).
 - Support the development of national agricultural technical parks and zones.
 - Strengthen the integration and demonstration of rural information technology.

- Establish a nationwide rural public service system which integrates extension services, entrepreneurship services and diversified technical services.
- Establish a novel rural science and technology service system which is centred on leading agricultural enterprises, affiliated to farmers' professional organizations.
- Continue to perfect various forms of rural technical services, which include extension services provided by universities and research institutes, Court of Agricultural Experts, rural technology cooperation organizations, Spark programme, etc.
- Continue to push forward science popularization in rural areas.

3. Create new crop varieties using gene transfer technology

- Achieve breakthroughs in key techniques on gene cloning and functional verification and large-scale gene transfer and bio-safety on major crops and livestock production.
- Improve gene transfer biological cultivation and security assessment system, gain an array of functional genes with high application values and self-owned intellectual property rights.
- Create a number of important gene transfer varieties with high disease and pest resistance, high stress tolerance, high quality, high yield and high efficiency.
- Commercialize genetically modified cotton and maize and raise the overall level of biobreeding.
- Strengthen the capacity for agricultural innovation and enhance agricultural efficiency and farmers' income.

4. Foster emerging industries of strategic importance

- Bio-seed industry – priority will be on modern bio-breeding techniques and commercialization of varieties and accelerating wide uptake of new plant and livestock varieties.
- Agricultural biomedicine – focuses on leading-edge technologies of target discovery and drug molecular design, high throughput screening and nano-scale agricultural biomedicine.
- Bioenergy – emphasis on production of vehicle fuel from biogas, cellulosic liquid fuel, liquid fuel using agricultural waste through gasification and pyrolysis, biodiesel and non-grain bioethanol.

5. Strengthen agricultural technology innovation

- Capture key technologies for agriculture and rural development.

- Increase technology transformation.
- Carry out rural technical entrepreneurship initiatives and establish new types of rural technology service system.

6. The priorities of agricultural technical innovation

- Technologies for high grain yield .
- Multi-functional agricultural equipment.
- Green and safe food processes.
- Marine agriculture.
- Water-saving agriculture.
- Rural information.
- Rural community and residence.

7. Future basic and cutting-edge research in agriculture

- Research on high-yielding, high-stress tolerance, high-quality and high-efficiency crops.
- Research on high productivity, high quality and high disease resistance in agricultural animals.
- Efficient utilization of farm land
- Sustainable farming systems.
- Bio-safety of agricultural produces.

8. Water pollution control and management.

9. Promote circular economy and recycle agricultural and urban wastes.

Annex 7.2 Natural Science Foundation of China priority areas to support in 12th Five-Year Plan period

The Natural Science Foundation of China (NSFC) is an organization directly affiliated to the State Council for the management of the National Natural Science Fund. It is equivalent to the UK Research Council. The funds of NSFC mainly come from the State financial allocations. NSFC supports basic research and some applied research, identifies and fosters talented

researchers in the realm of science and technology, accelerates the progress of science and technology, and promotes the socioeconomic development in China. The budget for the NSFC was RMB 10.4 billion yuan in 2010.

The following are the agricultural- and food-related areas NSFC aims to support in the 12th Five-Year Plan period.

Biodiversity and conservation mechanism

Research themes: relationship between biological evolution and diversity; formation and distribution of biodiversity patterns and conservation mechanism at different scales; relationship between biodiversity and ecosystem function; restoration of biodiversity to degraded ecosystems.

Assessment and explore biological germplasm resources

Research theme: theory and strategy for biological genetic resource protection; genetic diversity and differentiation of agricultural biological wild relatives and wild populations; variation and evolution of biological resources; identification and assessment of good gene resources; new methods of bio-resource preservation.

Water and nutrient demand and pathways for efficient use of major crops

Research theme: water and nutrient demand by high-yielding and high-quality crops; mechanism and regulation of water and nutrient efficient use; moisture movement in the field and crop response; ecological interactions in the rhizome; mechanism of nutrient and moisture synergies.

Disease and pest epidemiological characteristics and control mechanisms for major crops

Research theme: mechanism of major crop disease and pest occurrence; interaction among pathogens, insects and crops and co-evolution; regional occurrence of agricultural diseases and pests and control.

Epidemiology and control of major agricultural animal diseases

Research theme: pathology and pathogen ecology of major animal diseases; interaction between pathogen and host; molecular mechanism of interspecies pathogen transmission.

Biochemical mechanism of food storage and process

Research theme: mechanism of food quality change and maintenance; change in bioactive substances and nutritional elements in food processing and storage; formation and transmission of toxic substances; methods for toxic substance and harmful microbe inspection and risk assessment.

