

**FEEDING THE WORLD'S RAPIDLY GROWING URBAN POPULATION
SAI PLATFORM CONFERENCE
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***Technology and Innovation for Small Holders in
China***

**Background paper for the working session co-organized by GIZ
and SAI**

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Summary

This background paper has been written as an input to discussions at the SAI Platform Conference in Beijing, on April 24-26 2017. It introduces sustainability issues in China's agri-food sector, and presents case studies of how supply chain actors are promoting innovation for sustainability among their small holder suppliers, including through public-private partnerships.

Transformations in China's agri-food sector: China's agri-food sector has developed rapidly in recent decades. The value of agricultural production accounts for about 25% of the total value of the sector. Input supply, food and drink manufacture and wholesale and retail trade are growing rapidly. With rapid urbanization and rising incomes, consumers' diets have changed, driving growth of cash crops (e.g. fruit and vegetables) and livestock production. Although agricultural production is still dominated by small holder farmers, agribusinesses and modern supply chains have emerged. Changes in farming practices, adoption of new technologies and improved farming infrastructure have played important roles in continued agricultural growth. Government policies, backed by strong fiscal support, have also promoted growth in productivity and changes in supply chains.

Sustainability challenges: With a large population but limited land and water resources, increasing productivity and yields, increasing the efficiency of resource use, and reducing environmental impacts of food production are high priority concerns in China. Widespread environmental challenges include the need to maintain productive arable land area, improve soil fertility, increase water and nutrient use efficiency, and prevent pollution of soil and water resources. More intensive production practices, longer supply chains, increased food trade, transport and processing have also increased the food safety risks, and food safety is now a priority concern of both government and citizens alike. Large-scale migration to the cities has changed the structure of the rural labour force, with women and elderly people playing ever greater roles in agricultural production. Both technological and institutional innovation are relevant to addressing China's sustainability challenges.

Government policies: Many of these sustainability challenges are addressed in a recently issued *National Plan for Sustainable Development of Agriculture (2015-2030)*. Major reforms of food safety regulations have also been underway. Government policies strongly support continued technological innovation in the agriculture sector, while also promoting institutional reforms. Two important policies are the promotion of markets for arable land use rights, and the promotion of agricultural cooperatives. Markets for arable land use enable more efficient producers to engage in production. Rights to use about 30% of China's arable land have been transferred, about 10% of which has been to agribusinesses. There are now more than 1 million farmer cooperatives, providing a range of technical and marketing services to their members. More recently, government policies have promoted public-private partnerships to leverage private investment in the agriculture sector.

Innovation for sustainability in China's agriculture sector: This report presents ten case studies of how agri-businesses are addressing sustainability issues in their supply chains, and ten case studies of public-private partnerships to address sustainability challenges. The examples cover a range of products and services, and involve international and domestic agri-businesses, small and medium enterprises and farmer cooperatives, all of which work source from farmers. The sustainability dimensions addressed in the case studies include inclusive growth (expanding

market access for smallholders, and increasing productivity and profitability); addressing ecological challenges relating to land, water, nutrients and resource flows; and improving product quality and safety. Examples of public-private partnerships address sustainability through knowledge exchange and technology innovation; testing and demonstration of existing technologies; and the deployment of technologies and know-how with public goods benefits possessed by the private sector. Together, the cases exemplify international and domestic input producers whose core products have sustainability benefits; agri-food companies whose business model depends on enhancing sustainable practices within their own supply chains; and companies promoting public goods benefits in partnership with public sector and in pre-competitive partnerships with other private firms. The case studies highlight the following key points:

- Innovation for sustainability often depends on partnerships, whether between public and private sectors, with input, advisory service or technology providers, or between suppliers and buyers in the supply chain.
- Innovations have stronger potential for uptake when there are synergies between environmental benefits and productivity, quality and profitability. Improvements in economic outcomes may be essential for incentivizing adoption of practices with benefits for the environment and food safety.
- In China's rapidly changing economic context, appropriate and effective strategies for promoting sustainability will change over time and vary from place to place. This suggests that there will be no single approach that meets diverse and changing needs.
- Recent government PPP policies primarily frame partnerships as a mechanism to leverage private investment for public goods provision, but addressing sustainability challenges is also knowledge-intensive. Development of pre-competitive partnerships involving the public sector and private firms, who may compete in other respects, may require strategic planning and patient support.

1. Introduction

This background paper has been written as an input to discussions at the SAI Platform Conference in Beijing, on April 24-26 2017.¹ The paper introduces sustainability issues in China's agri-food sector, and presents case studies of how supply chain actors are promoting innovation for sustainability among their small holder suppliers, including through public-private partnerships.

Following this introduction, Section 1 describes key changes in China's rapidly evolving agri-food sector, and the main drivers of change. It highlights a range of sustainability challenges faced. It also introduces government policies on agricultural sustainability, technology and innovation, and recent policies on public-private partnerships in the agriculture sector.

Section 2 presents ten short case studies of how international and Chinese companies and farmer cooperatives are addressing different dimensions of sustainability, including: inclusive growth (market access, productivity and profitability), environmental sustainability (land, water and nutrient management) and food quality and safety.

Section 3 presents ten short case studies of public-private partnerships involving international and Chinese companies to address sustainability challenges. These partnerships focus on knowledge exchange and technology innovation; testing and demonstration of existing technologies; and the deployment of technologies and know-how possessed by the private sector.

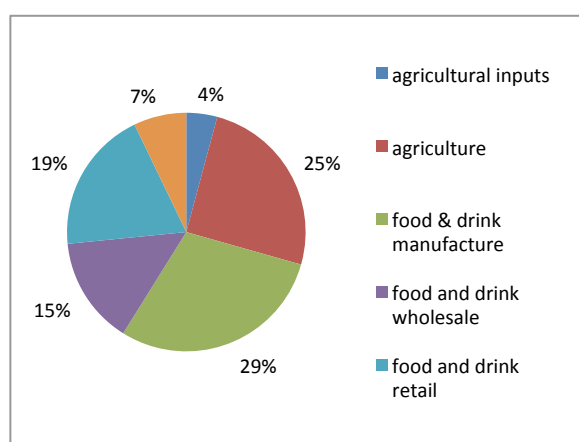
Section 4 summarizes some key findings from this brief survey of sustainability initiatives and public-private partnerships in China's agri-food sector.

¹ <http://saiplatformconference.org/>

1.1 Transformations in China's agri-food sector

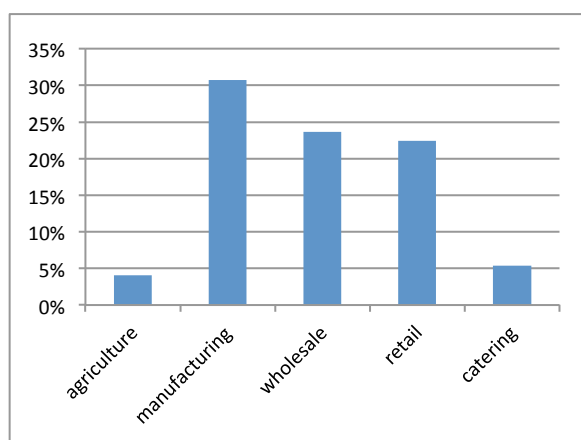
China's agri-food sector has developed rapidly in recent decades and is no longer solely dominated by agricultural production. The total value of the sector is estimated at about CNY 39 trillion (ca. US\$ 5.7 trillion) in 2015.² The value of agricultural production and food and drink manufacture accounted for about 55% of the total, while wholesale and retail trade combined accounted for about a third of total value (Figure 1). This sectoral structure is the result of rapid change in recent years. While the value of agricultural production has grown at an average annual rate of about 4%, manufacturing, retail and wholesale have grown at much faster rates (Figure 2). The following sections describe the major transformations that have been taking place in recent decades and their main driving forces.

Figure 1: Estimated contribution of agri-food sub-sectors to total agri-food production value (2015)



Note: Agricultural inputs include seeds, fertilizer, pesticide and agricultural machinery. See fn 1 for sources.

Figure 2: Average annual real growth rates of agri-food subsectors 2006-2015



1.1.1 Key transformations in China's agri-food sector³

Dietary change: In the last 10 years, the number of urban residents in China has increased by 188 million and disposable incomes have more than doubled. The composition of urban and rural residents' diets has also changed. Chinese consumers purchase less rice than before, but more animal products, vegetable oils, sugar, processed foods, confectionary and alcohol. These trends are most marked among urban consumers, but are also apparent in rural areas. Dietary change is reflected in the changing structure of the agricultural sector: livestock production now contributes almost a third of the value of agricultural output compared to a

² This estimate, developed by this study, includes the gross value of output of agriculture, livestock and fisheries; the sales value of agri-product, food, drink and tobacco industries; the sales value of food, drink, tobacco, livestock product, grain and oil wholesale; sales value of supermarkets and food, drink and tobacco specialty retail stores; revenue of catering enterprises and hotel catering revenue; and total sales value of seed, fertilizer, pesticide and machinery industries. All data are from the National Bureau of Statistics (<http://data.stats.gov.cn/>), except estimates for agricultural inputs, which derive from industry and media reports.

³ For more detail on the trends in this section, see Garnett & Wilkes (2014).

quarter just 20 years ago, and about 36% of annual grain output is used as livestock feed. The proportion of arable land sown to cash crops (e.g. fruit, oil seed, vegetable) has increased from 17 to 29% over the same period. Greenhouse production now covers more than 4.1 million hectares.⁴

Emergence of modern supply chains: China's food and beverage market is the largest in the world. In urban areas, supermarkets now account for a significant proportion of food sales, and supermarket sales are growing faster than the retail sector as a whole. Growth in sales of processed foods, dairy products, bakery products and health foods has been particularly rapid. Agricultural production is still mainly done by small farmers, and small enterprises still dominate food processing. But large and medium sized food processing enterprises now account for more than 40% of total sales of processed foods. Driven by food safety concerns and profitability, product supply chains linked to food processors and supermarkets have become more regulated through integration of supply chain functions, traceability schemes and regulation of production methods. Products certified as 'Hazard Free' and 'Green Food' – China's two most widely used domestic assurance standards – are grown on about 36 million hectares, or 29% of China's arable land area.⁵ Logistics systems, refrigeration and other supporting infrastructure are developing rapidly, but remain key development constraints.

Changing labour, land and input markets: Although there are still more than 200 million farmers, large-scale migration from rural areas to towns and cities and increased rural off-farm employment have reduced the dependence of the rural population on agricultural income. Recent reforms of rural land tenure allow not only land rental but also investment of land as a share in agri-business partnerships, which facilitate consolidation of land plots and mechanization. Nationwide, almost one third of arable land has been rented out, often for vegetable and cash crop production by specialized farmers, cooperatives or agribusiness. Markets for other production inputs (e.g. agrochemicals, seeds) are well developed, with a combined output value of more than CNY 1 trillion (ca. US\$ 145 billion). Commercial provision of specialized agricultural services (e.g. harvesting, crop residue management) is beginning to emerge in some regions, and the market for commercially produced organic fertilizers is also developing rapidly.⁶

Growth in agricultural production: Total food output has grown continually in the last 20 years. Grain production has increased by more than 1% per year over this period, and output of vegetables, fruit and other cash crops have grown even faster, as a result of both increasing share of sown area and yield increases. Improvements in technology have been a major driver of yield increases. The irrigated area has increased by about 15 million ha in the last 20 years. High yielding seed varieties are widely used and agrochemical input use is intensive, in both grain and cash crops. Public (and more recently private) investment in agricultural research and development (R&D) has been a key driver of long-term growth. In livestock production, increasing proportions of poultry (>80%), pigs (>60%) and dairy and beef cattle (>40%) are being raised in intensive production systems, although the efficiency of these larger-scale livestock operations can still be improved.

⁴ Yue (2015).

⁵ Wilkes and Zhang (2016).

⁶ Xinhuanet (2017).

1.1.2 Drivers of change

Several inter-related factors emerge as systemic drivers of change in China's agri-food system:

Urbanization and rising incomes: The pace and scale of both urbanization and income increases in China in recent decades has been unprecedented in modern history. In 1980, just 20% of the population were urban residents. Today the figure has passed 55%. Both urban and rural per capita incomes have grown more than four fold since 1990. These trends are associated with significant change in food consumption patterns as well as changes in consumer preferences and purchasing habits. In addition to changes in dietary preferences, there is also growing demand for processed and convenience foods. With limited time and higher demand for convenience, urban consumers are buying more products from supermarkets, convenience stores and online. Increasing spending on dining out has been a major driver of growth in the catering sector, though restrictions on government spending on entertainment have contributed to slow growth of the sector in the last few years. Dining out has been a major contributor to increasing meat consumption. Wealthier consumers, particularly in urban areas, are increasingly paying attention to food safety issues in their purchasing, and supply chain management measures to ensure food safety are now critical for food product and food retail brand management.

Growth in consumption and production of livestock products: The growth in demand for animal products in China has had major impacts throughout the agri-food sector, as well as on consumers' health and the agri-environment. Demand for livestock feed accounts for an increasing proportion of cereal (especially maize) production and has driven large increases in imports of soy products and maize. Concerns with zoonosis risks and environmental pollution from animal waste have spurred policies that support the production of pigs, poultry and cattle in large-scale confined animal feeding operations. The shift to confined production systems has itself brought about challenges in addressing animal health and environmental risks. Animal disease prevention and control is a high priority, and from both an economic and resource use perspective, increasing the efficiency of feed conversion into livestock products remains a priority for realizing the potential benefits of larger scale livestock farms. International firms are actively involved in supplying animal genetics to intensive livestock operations, but production practices to maximize the potential benefits can often still be improved. On the consumption side, increasing consumption of meat, in particular, has been associated with a significant rise in obesity and chronic diseases among urban consumers and wealthier rural consumers. Both meat and dairy products have often been implicated in food safety incidents.

Rising food safety concerns:⁷ In recent years, food safety has become one of the top concerns of urban consumers. Major food safety incidents have occurred due to practices in all stages of food supply chains, from production through to retail at the point of consumption. The types of risk involved include contamination from the production environment (e.g. heavy metals) and production process (e.g. pesticides, veterinary drugs), excessive use of both legal and illegal additives, sale of fake food products, and sale of unhygienic products. Some of the drivers of food safety risks are those that have also affected developed countries – intensification of production methods, lengthening supply chains, increased food trade and transport, increase in food processing – but are exacerbated by the scale and pace

⁷ For an overview of food safety issues in China, see FORHEAD (2014).

of change in China. Other drivers are specific to the Chinese context, such as the legacy of industrial pollution in rural areas, disparities between more and less developed areas, and the challenges that rapid change places on regulatory agencies.

Government policies: With the goal of meeting the food needs of a fifth of the world's population, food security has long been a government priority. Earlier policies focused on food production. More recent policies also emphasise nutrition (including malnutrition, diet-related chronic disease and meeting consumers' needs for diverse nutrition), food quality and food safety. Since the 1990s, China's overall policy has been to ensure basic self-sufficiency in key food grains and other key food products. Current policy continues this stance, while recognizing that imports will make important contributions to livestock feed supply, but there is increased policy emphasis on the quality and safety of food.⁸ Since tax reforms in 1994, total fiscal revenue has grown twice as fast as GDP, and central government revenue has increased to about half of total fiscal revenue, enabling the government to implement a large number of policies addressing development needs throughout supply chains. Government investments in agriculture in 2011 were about US\$87 billion, equal to roughly 11% of the value of agricultural output.⁹ Thus, government policy priorities translate rapidly into implemented programmes, and government investments often influence corporate investment decisions.

1.2 Sustainability challenges¹⁰

Increasing productivity and yields, increasing the efficiency of resource use, and reducing environmental impacts of food production are high priority concerns in China. This is in part because of China's limited natural endowment of land and water resources, and in part because of increasing awareness of the environmental impacts of food production and the importance of resource use efficiency in sustainable competitiveness. With one fifth of the world's population but just 8% of global arable land and 10% of global average per capita water availability, efficient use of land and water resources are major drivers of policies and practices to increase the efficiency of food production. The adverse impacts of intensive nutrient application, in particular, have recently become a focal issue.

Land resources: China has limited arable land area, and a large area of arable land has been lost to urban and industrial construction. Of the remaining 135 million ha of land, 67% have moderate or poor quality soils. Thus, maintaining arable land area and increasing the productivity of arable land are key national objectives. Maintaining arable land area above 120 million ha is a key national strategy. Increased productivity of arable land is largely pursued by intensification of production, though use of high yielding varieties and application of modern farm inputs, such as fertilizers, pesticides and machinery. Increasing the area under irrigation and the efficiency of water use are also key strategies to improve production. A mechanism has been established whereby payments for urban and industrial land appropriation are used to invest in improving infrastructure and consolidating land plots in farming areas.¹¹

⁸ State Council of the P.R. China (2014a).

⁹ Garnett and Wilkes (2014).

¹⁰ See Wilkes and Zhang (2016).

¹¹ See Wilkes et al. (2016).

Water resources: Agriculture accounts for more than 60% of total water use. The proportion of arable land under irrigation increased from 32% in 1980 to about 48% in 2015.¹² Irrigated land now accounts for about 70% of the area sown to grain and 80% of grain production.¹³ While irrigation can increase yields, it may also bring new challenges. Throughout northern China, where groundwater is an important source of irrigation, ground tables have been falling. Water use efficiency in the country as a whole is low, with more than half of irrigation water lost to evaporation and leakage. Investment in improving irrigation infrastructure and the efficiency of irrigation operations has been a consistent priority for government funding in recent years. Furthermore, water quality is poor in almost 40% of China's rivers and 57% of its freshwater lakes, and agriculture is also the main source of water pollution, mainly due to livestock waste discharge and excess nitrogen fertilizer. Manure management regulations have recently been introduced for large-scale livestock operations,¹⁴ but the majority of livestock are raised on smaller-scale farms, so waste management is less easily regulated.

Nutrient use: Increased application of nitrogen fertilizer has been a driver of increased crop yields over the years, but the gains from extra fertilizer application have almost disappeared. Low nutrient use efficiency and over-application of inorganic fertilizers are common. It is estimated that 30-50% of nitrogen fertilizer is now surplus to plant growth requirements.¹⁵ Excess nutrient loads from both fertilizer and manure are major sources of water pollution, and considerable attention has been given in recent years to addressing both environmental impacts and nutrient use efficiency in production. A policy of zero growth in nitrogen fertilizer application was recently announced, and preferential policies for fertilizer manufacturers have been scaled back.¹⁶

Food quality and safety: Alongside resource-use efficiency, ensuring the quality and safety of agricultural produce and food products is a key dimension of sustainable intensification in China's agriculture sector. Agricultural input quality management, standardized production processes, supply chain traceability systems, and quality testing systems in wholesale and retail markets are all under development, processes that will drive further change in the technologies, techniques and relations of agricultural production.

Social issues:¹⁷ Large-scale migration has changed the structure of the agricultural labour force. In many areas, farm workers tend to be older than the average worker. The proportion of farms on which women do all the farm work has increased. There have been concerns that these changes in the farm workforce have affected the welfare of those remaining behind to work on the farm. Time use in both farm work and domestic duties has increased for the elderly (especially women) and for children. Children whose parents are absent for longer and who visit less regularly are likely to have lower health-related quality of life, and elderly parents of migrants may also be at higher risk of poverty. There have also been concerns that transfers of land use rights may not always be voluntary and that the development of larger-scale farming may increase inequality within villages. While the number of farm

¹² www.stats.gov.cn

¹³ Wang, J. *et al.* (2012).

¹⁴ State Council of the P.R. China (2013).

¹⁵ Ju, X. *et al.* (2009).

¹⁶ Ministry of Agriculture of the P.R. China (2015a); Tax Policy Department of the Ministry of Finance of the P.R. China (2015).

¹⁷ See Wilkes and Zhang (2016).

workers employed by agribusinesses is increasing, very little is known about issues related to labour conditions.

1.3 Government policies for sustainability and innovation

The following sections describe government policies on sustainable agriculture, technology and innovation, and recent new policies on public-private partnerships in the agriculture sector.

1.3.1 Government policies on sustainable agriculture

In 2015 a *National Plan for Sustainable Development of Agriculture (2015-2030)* was issued, which will guide the development of legislation, government policy and funding programmes for the agriculture sector in the coming years. The plan addresses several of the environmental challenges mentioned above, setting out key tasks and targets, including:

- to protect and improve the quality grading of existing arable land, and to control pollutants from other sectors (e.g. industry, urban waste);
- to increase water-use efficiency in agriculture;
- to promote ecological and circular agriculture models that reuse and recycle agricultural waste in the supply chain;
- to reduce agricultural non-point pollution by promoting soil nutrient testing and improved nutrient and pest management practices, with a goal of achieving zero increase in pesticide use by 2020, and promoting recycling of plastic mulch sheeting and pesticide packaging; and
- to support large-scale livestock production farms to improve waste management so that 75% of livestock waste is reused by 2020 and 90% by 2030;

Links with food safety are also made through initiatives to monitor the agri-production environment and regulate agricultural production in locations where environmental parameters do not meet standards. The priorities set out in this plan have been reflected in subsequent specific action plans at national and provincial levels.

Food safety has also been the focus of new legislation and policies. The 2009 Food Safety Law was revised in April 2015, and new institutional arrangements for cross-sectoral coordination put in place. The China Food and Drug Administration (CFDA) is now the lead food safety regulatory agency, responsible also for manufacture, distribution and catering processes. The Ministry of Agriculture is responsible for food safety in agricultural production processes, while other agencies are responsible for export and import and packaging, and for risk surveillance. A national surveillance system has been established, and the number of monitored food products is being expanded as local capacities for inspection and enforcement are strengthened. A thorough revision of food safety standards has been undertaken and new standards and codes of practice in food manufacture and marketing have been elaborated.

These food safety reforms have several implications throughout food supply chains. Concerted efforts have been made to develop 'farm to table' food traceability systems for key food products, and to further promote Good Agricultural Practices (GAP), Good Management Practices (GMP), HACCP, and ISO or other enterprise quality and safety management systems. Systems for clarifying the distribution of proportionate responsibility across the supply chain are also under development. To

address risks at the production level, the Ministry of Agriculture is supporting counties and enterprises to pilot integrated food quality and safety risk management systems, demonstrations of standard compliance, promoting product quality labelling and certification, developing risk management and traceability systems, and developing systems to link post-harvest distribution with market entry regulation. More generally, food safety concerns are increasingly driving policy support for standardization of production practices. This is sometimes achieved through horizontal integration – for example where producer cooperatives provide support to their member farmers – but more often it is being done through vertical integration – where producers conform to the standard requirements of their buyers. In 2017, the Ministry of Agriculture issued a 5-year plan to support all main agri-food producing enterprises to implement traceability systems by 2020, alongside further development of agricultural production standards and government capacities for food safety testing.¹⁸

1.3.2 Government policies on technology and innovation in agriculture

Innovation has driven China's agricultural reforms since the late 1970s. Initially, institutional reforms, such as contracting production to households and the liberalization of markets, played key roles in providing farmers with incentives for production. Subsequently, technology played a significant role, and increasing application of modern inputs, such as high yielding crop varieties, fertilizer and pesticides, have been responsible for considerable growth in output over a long period.¹⁹

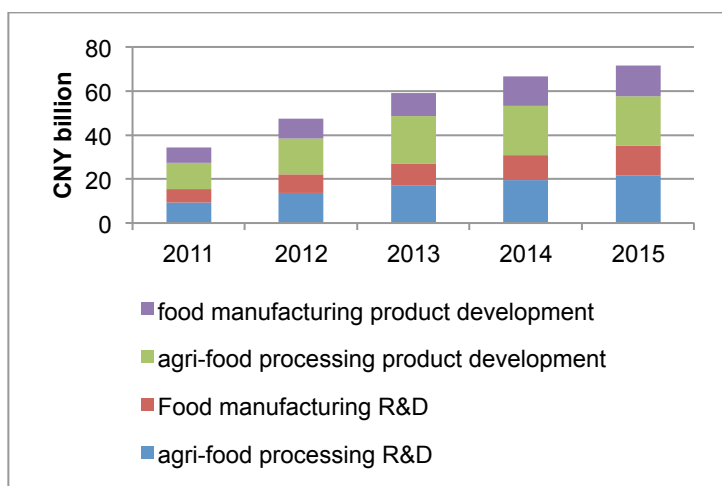
Both institutional and technological innovation are relevant in the current, rapidly evolving context. The *National Plan for Sustainable Development of Agriculture (2015-2030)* recognizes the importance of science and technology to agricultural growth, including new innovations as well as expanded deployment of proven technologies and infrastructure. Agricultural innovation is also supported by the *National Medium and Long-term Masterplan for Development of Science and Technology (2006-2020)*, implemented by the Ministry of Science and Technology. That plan emphasizes (i) use of new technologies to increase agricultural productivity, (ii) promoting efficiency through development of commercial agri-food supply chains, (iii) developing technologies to protect the agri-environment, and (iv) promoting industrial agriculture to increase labour productivity. Research and development (R&D) in key technologies, such as crop genetic resources, animal health, agricultural product processing, and ecologically friendly pesticides and fertilizers, will be critical to achieving these goals. A range of technology needs are also highlighted to improve food safety throughout supply chains, including food safety testing technologies, hard and software for supply chain monitoring, control and traceability systems, and ICT-based solutions for provision of marketing and other information. These priorities are also reflected in recent 5-year plans for agriculture and aquaculture technology development, agricultural ICT development, agricultural mechanization and agri-product processing.²⁰

Figure 3: R&D and product development expenditures by medium and large food manufacturing and processing enterprises (2011-2015)

¹⁸ Ministry of Agriculture of the P.R. China (2017a).

¹⁹ Huang and Rozelle (1996); Fan (1991); Fan and Pardey (1997).

²⁰ Ministry of Agriculture of the P.R. China (2016a and b; 2017b, c, d,).



Source: Data from <http://data.stats.gov.cn/>

Public and private R&D both make critical contributions to technology development. Public investment in agricultural R&D tripled between 1990 and 2010, and today China has one of the largest public agricultural R&D budgets of all developing countries.²¹ In 2012, public research institute expenditures on agricultural research totalled about CNY 30 billion.²² Public funding for agricultural research has increasingly focused on basic research, and research institutes have been encouraged to generate their own funding for research with commercial potential. In the early 2000s, a national fund was established to support the application of agricultural research results, which has now been replicated in many provinces, and a 2016 national action plan explicitly supports research institutions to establish technology transfer units and will support commercial exchange of agricultural intellectual property rights.²³

Private investment in research has also grown significantly. In 2006 (the latest year for which data are available), private investment in agricultural research and development (R&D) was about 17% of total investment in agricultural R&D.²⁴ Reportedly, about 500 seed enterprises spend about 10-12% of their annual turnover on R&D.²⁵ More recent official data on from processing and manufacturing enterprise suggests that the scale of private investment in research in these supply chain stages is of the same order magnitude as public investment in agriculture (see Figure 3), and has been increasing rapidly in recent years.

In addition to technological innovation, institutional innovations continue to be important in enabling the application of improved technologies and agricultural techniques. Agricultural land use rights transfers and the development of agricultural cooperatives are two noteworthy institutional innovations. Widespread application of these innovations has been driven by a combination of demand and policy support:

Agricultural land use rights transfers:²⁶ With the majority of rural people employed off-farm and working in cities, agricultural labour shortages are widespread. Beginning as a local innovation, regulations providing a supportive environment for

²¹ Beintema and Stads (2010); Pardey and Pingali (2010); Hu *et al.* (2011).

²² Babu *et al.* (2015).

²³ Office of the State Council of the P.R. China (2016).

²⁴ Hu *et al.* (2011).

²⁵ Babu *et al.* (2015).

²⁶ Wilkes and Zhang (2016).

land use rights transfers were issued in the early 2000's. Government policies have also promoted land transfers to enable mechanization and increase the economic and resource use efficiency of agricultural production. Land use rights over one-third of arable land have now been transferred, either to specialised households, cooperatives or companies. Land rights transfers are one of the main ways in which private agri-businesses access land for production, with about 3 million hectares (ca. 10% of the total transferred area) transferred to companies.²⁷ Significantly, however, rural people who rent out their land retain other rights, ensuring that they do not become landless. Studies have found that resource use efficiency and a range of environmental outcomes are better on larger farms than on small, fragmented plots, suggesting that consolidation of land plots can be an enabler of more sustainable practices.²⁸

Agricultural cooperatives: Cooperatives have emerged as an institution to enable cooperation among farmers, bolstered by farmer cooperative legislation issued in 2007. There are now almost 1.29 million farmer cooperatives, with 92 million member households (about 35% of the total number of farming households).²⁹ Cooperatives often provide technology or information services to their members and help members link with input and product markets.³⁰ A significant proportion of cooperatives have signed supply contracts with wholesalers or downstream processors, with contracts often specifying quality or safety requirements.³¹ Cooperative involvement in providing information and technical support to farming practices, and their role in transmitting buyers' product requirements to producers, suggests that they can sometimes play a key intermediary role in agricultural innovation.³²

1.3.3 Government policies on public private partnerships in agriculture

Public-private partnerships (PPPs) are a particular form of institutional innovation that is now being brought into play in agricultural development in China. PPPs have been widely used in other sectors in China since the 1990s. Their importance in policy circles has grown as macro-economic policies emphasize the need to increasingly rely on private sector investment and growth. New PPP policies and regulations were introduced in 2014, and in late 2016 a policy was issued supporting the use of PPP mechanisms in the agriculture sector.

In 2014, the State Council issued a *Guiding Opinion on Financing Mechanisms to Encourage Private Capital in Key Sectors*³³ which encourages the use of business concessions and equity investment in construction and operation of water infrastructure, including irrigation. Private investors are allowed to receive water fees as operational revenues and benefit from public subsidies for what were previously public tasks, such as construction, maintenance and management of water infrastructure. Policies have also been issued encouraging the participation of private investment in the development of rural and agricultural tourism facilities and in pilot activities to increase the collection, treatment and reuse of agricultural waste,

²⁷ Ministry of Agriculture of the P.R. China (2016c).

²⁸ See Wilkes and Zhang (2016).

²⁹ Research Network for China Farmer Cooperatives (2015).

³⁰ Deng et al (2010).

³¹ Jia and Huang (2011).

³² Yang et al. (2014).

³³ State Council of the P.R. China (2014b); and Ministry of Finance (2014).

such as livestock manure and crop residues.³⁴ A further policy initiated pilots in innovative finance mechanisms for land improvements, with state farms or agribusinesses making initial investments supported by concessional loans, to be partially reimbursed through a government subsidy paid upon completion of each project.³⁵ At the end of 2016, The National Development and Reform Commission and Ministry of Agriculture issued a *Guiding Opinion on Promotion of Government and Private Finance Cooperation in the Agriculture Sector*.³⁶ The policy explicitly encourages public-private partnerships, with a focus on facilities and public services in several areas, including: land improvement, seed reproduction, port modernization, agri-product quality and safety inspection and traceability systems, genetic resources conservation, utilization of agricultural waste productions, prevention of non-point source pollution, large-scale biogas plants and other environmental and sustainable development projects, agricultural demonstration zones, agri-product logistics IT systems, wholesale markets and rural tourism. The policy encourages a range of innovations in financing, including subsidies, equity investment in the form of finance or land, and leveraging of financial instruments such as bonds, shares and other assets. From the policy perspective, two key motivations for encouraging PPPs are to leverage private investment in agricultural public goods and to shift the functions of government from a provider of public goods to that of a regulator of public goods provision.

In accordance with the regulations, local governments can propose PPP projects, which are listed in a national project pool, while companies may also propose PPP investments for approval by government.³⁷ Although few projects are explicitly marked as agriculture projects, the current project pool (as of March 2017) includes more than 100 projects related to the agri-food sector. Examples of these projects are summarized in Annex 1. They include investments in irrigation infrastructure, land improvement, agricultural production facilities, logistics, storage and marketing infrastructure, tourism facilities and waste recycling facilities. This illustrates the broad range of projects for which local government perceives a need and potential for private investment.

³⁴ Ministry of Agriculture of the P.R. China (2015b, 2016d).

³⁵ Ministry of Finance and China Development Bank (2015).

³⁶ National Development and Reform Commission and Ministry of Agriculture (2016).

³⁷ The pool is accessible at <http://tzs.ndrc.gov.cn/zttp/PPPxm/xmk/>

2. Sustainable sourcing and smallholder initiatives by the private sector

This section presents ten examples of how agri-businesses in China are addressing sustainability issues in their operations involving small holders. These examples cover a range of products, including cash crops and livestock products, as well as drinking water. The actors involved are also diverse, involving international and domestic agri-businesses, small and medium enterprises and farmer cooperatives, all of which work source from farmers. The sustainability dimensions addressed in the case studies include inclusive growth (expanding market access for smallholders, and increasing productivity and profitability); addressing ecological challenges relating to land, water, nutrients and resource flows; and improving product quality and safety. Table 1 indicates the sustainability dimensions addressed by each case study.

Table 1: Selected case studies on agricultural sustainability initiatives by the private sector

	Product, province	Inclusive growth		Environmental sustainability				Quality & safety	
		Market access	Productivity & profitability	Land degradation	Water scarcity & quality	Nutrient management	Waste and resource re-use	Product quality	Food safety
1	Lamb, Inner Mongolia								
2	Dairy, Heilongjiang								
3	Grapes, Ningxia								
4	Gouji, Qinghai								
5	Water, Guangdong								
6	Yam, Shandong								
7	Apples & grapes, Shandong								
8	Fruit & pigs, Guangdong								
9	Vegetables, Shandong								
10	Coffee, Yunnan								

Each of the case studies illustrates responses to challenges faced in a specific context shaped by geographical factors, production systems, prevailing agricultural practices, and regional specialization in products. Although only a small number of examples are illustrated, the case studies also point to some commonalities:

- Almost all the case studies show that cooperatives' or companies' innovation for sustainability depends on partnership with other companies, such as providers of production inputs or advisory services, or partnerships between suppliers and buyers.
- Several case studies relate to environmental sustainability, and show that the practices promoted often address more than one environmental challenge at the same time. For example, installation of drip irrigation (case study #3) improves both water and nutrient use efficiency, and integration of crop and livestock systems

within an enterprise (case study #8) improves nutrient management while also promoting the cycling and re-use of resources.

- The examples highlight the potential for synergies between environmental benefits and productivity, quality and profitability to form a basis for shared value outcomes in sustainability interventions. Improvements in economic outcomes may be essential for incentivizing adoption of improved practices. In several cases (case studies #3, 6, 7 and 8), reductions in production costs and increased profitability for farmers were driven by reduction or substitution of chemical fertilizer costs, which has environmental benefits. Similarly, product traceability initiatives (e.g. case study #9) may increase consumer trust in products, ensuring access to consumer markets and maintaining brand value.

CASE STUDY 1	Business partnerships for sustainable grazing management in Inner Mongolia
<p>Sustainability dimensions: Land degradation, product quality, market access, profitability</p> <p>Context: Siziwang Banner, in central Inner Mongolia, is a typical desert steppe, with annual rainfall of only 300 mm, most of which falls in the summer months. Low rainfall only supports sparse vegetation on the steppe. For centuries, the steppe has been used for sheep herding, with the Mongolian fat-tailed sheep as the traditional breed. Herders are heavily dependent on income from livestock raising, and face economic pressure to increase the number of animals raised. This is one factor driving degradation of rangelands in the area. Over half the grassland in Siziwang is now degraded to some degree.</p> <p>Innovative solution: Some years ago, a local businessman and some experienced herders experimented with cross-breeding local sheep breeds and the Dorper breed introduced from South Africa. Their work – corroborated by studies by Inner Mongolia Agriculture University – found that the Mongolian-Dorper cross-breeds are typically slightly heavier than traditional breeds, and – most importantly – grow much faster. Lambing occurs in February and March, but with local breeds it takes 7 months to raise a lamb to about 25 kg – a weight at which it can be sold. By contrast, the Mongolian-Dorper cross-breeds can reach 25 kg in 3 months. The herders and businessmen realized that this presents unprecedented opportunities. With faster growing lambs, households can maintain and even increase their incomes while keeping fewer animals on the pastures in summer, as the lambs can be sold off at 3 months of age before the move to summer pastures.</p> <p>Sainuo Co. Ltd. and the herders went on to establish a jointly invested cooperative in 2011, dedicated to promoting adoption of the new cross-breeds and limiting the density of animals grazing on the degrading grasslands. The cooperative now has almost 2000 members in twenty-one villages in the area. The company and cooperative jointly operate a breeding farm, producing about 250 breeding rams per year. Herders joining the cooperative are given 2 breeding rams, and can buy feed and hay at subsidized prices, but in return they have to sell their lambs to the cooperative and promise to restrict the density of sheep grazing on their grasslands. The cooperative will only purchase lambs that fall within a certain age and weight range, and pays a small premium over the market price. The lambs are then sold on to Sainuo's fattening farm, where the lambs are fattened before slaughtering.</p>	

Sainuo has signed supply contracts with high-end catering firms in Beijing and elsewhere, where the quality of meat from young animals is highly valued. In this way, the company benefits from a secure source of quality-assured, standardized cross-breed meat, while the herders benefit from an assured purchaser of lambs, and a higher income. While each traditional sheep realizes an annual income of about CNY 420-450, each cross-bred sheep raised realizes an income of almost CNY 600 per year. Studies have also shown that herders raising the cross-breeds have a lower grazing intensity on their pastures, which gives hope for sustainable management of the vulnerable steppe environment.

Source: Beijing Environmental Asset Management Consulting Centre (2011)

CASE STUDY 2 **The Dairy Farming Institute: a platform for professionalization of the dairy industry**

Sustainability dimensions: Productivity, profitability and product quality

Context: Nestlé began its operations in Shuangcheng, Heilongjiang province, in 1987. Following 150 years of Nestlé tradition, it began by implementing its milk districts model of support to farmers in its milk collection area and procurement of their milk. Over time, it built up a supplier base of about 30,000 farmers, each of whom commonly had small herds of up to 10 dairy cows. Technical advice was provided to the farmers on issues such as breeding, and milk quality and hygiene. Village collection centres were established at which samples were tested from each milk delivery. This established a system of traceability that enabled Nestlé to ensure the quality and safety of its products.

Following the milk adulteration scandals in other parts of China in 2008, government policy underwent a dramatic transformation to ensure the safety of milk. Larger-scale farms implementing standardized procedures were encouraged. Today, Nestlé procures milk in Shuangcheng from about 500 farms, each of which have a about 150 dairy cows. The vast majority of the current suppliers were former smallholder suppliers, who moved with the times and increased the scale of their dairy operations, investing their own resources as well as benefitting from government subsidies for infrastructure and other investments. Many other farmers left the sector, seeking off-farm employment or switching to other agricultural enterprises.

These new, larger farms are operated as specialized dairy enterprises, employing intensive dairy production methods and a much higher level of professionalization in farm and dairy management. The focus of today's dairy farmers is on producing quality milk with fewer inputs and less waste. These farmers rely on specialized input providers and business partners, and need professional solutions from commercial companies.

Innovative solution: In response, Nestlé's support to its suppliers has also evolved. In 2014, Nestlé invested CNY 250 million in establishing a Dairy Farming Institute (DFI) in Shuangcheng. The DFI provides professional knowledge and skills on dairy farming and pasture management to technicians, supervisors and managers in the dairy industry. DFI also serves as a platform for dairy farmers to learn about the solutions available from a range of businesses. Nestlé has partnered with academic and business partners specializing in areas such as nutrition, milking and reproduction, animal health, facilities and equipment, each of whom takes the lead in their area of competence. DFI also has two demonstration farms that play key roles in both

training and demonstration of business solutions. More than 1000 people have attended courses on various aspects of dairy farming. The courses also provide a valuable opportunity for dairy farmers to exchange experiences with other professionals. After the courses, they stay in contact with each other through social media chat groups, which shows the value of DFI as a platform bringing professionals together.

Sources: Nestlé (2016), with additional information provided by Juerg Zaugg.

CASE STUDY 3 **Drip irrigation tackles water scarcity, nutrient use efficiency and greenhouse gas emission reduction in viticulture**

Sustainability dimensions: water and nutrient management, product quality and profitability

Context: People living in arid areas, such as Ningxia Autonomous Region in northwestern China, face challenges in generating a livelihood and achieving food security in a context of land degradation, water scarcity and increasingly unpredictable rainfall and temperature patterns. Adoption of water-saving irrigation methods is one key technological approach to addressing agricultural development needs in water scarce environments. In 2011, only 22% of the irrigated area in Ningxia was using efficient forms of irrigation such as drip or sprinkle irrigation. Adjustments in the structure of agricultural production can also increase the economic returns to water use in the agricultural sector, providing an economic incentive for farmers to invest in sustainable land management practices. In recent years, viticulture has been widely promoted on the east flanks of the Helan Mountain range in northern Ningxia. By the end of 2010, a total of 25,000 ha had been planted, supporting a wine industry with an annual output value of CNY 1.15 billion. Compared to maize production, which realizes net income of less than CNY 1 per m³ of water used, net returns to grape production can be three times higher. However, viticulture can be water-intensive, so reducing water consumption remains a priority.

Innovative solution: Ningxia State Farm Group (NSFG), a state-owned agri-business with several thousand grape farmer suppliers, has invested in converting vineyards from conventional flood irrigation to drip irrigation. Under flood irrigation, much water evaporates, while drip irrigation is able to target water to grapevine roots where it is used more effectively. In addition, nitrogen fertilizers can be applied through the irrigation tubes – a practice known as ‘fertigation’ – so nutrients are taken up by the plant, whereas under flood irrigation a significant proportion of nitrogen leaches into the soil or volatilizes into the atmosphere. NSFG’s initial testing of drip irrigation with fertigation, using special fertilizers produced by the local university, found that annual water consumption is reduced by 60%, and fertilizer use is also reduced from 2625 kg/ha to 540 kg/ha. Lower water use means less use of energy in pumping irrigation water, and less fertilizer use significantly reduces emissions of nitrous oxide, a potential greenhouse gas. Primarily due to reduced fertilizer costs, net revenue per hectare increases by more than 80%. In addition, the sugar content of grapes produced under drip irrigation was found to increase by 1-2 Brix, indicating a higher quality product for wine production, for which farmers can receive a higher purchasing price. NSFG has partnered with local government financial institutions to install drip irrigation on more than 1600 hectares, bringing financial benefits to thousands of its farmer suppliers, increasing resource use efficiency in grape production, and reducing the environmental impact of grape production.

Source: Beijing Environmental Asset Management Consulting Centre (2015)

CASE STUDY 4

Greening desertified lands with cash crops

Sustainability dimension: land degradation

Context: Desertification is a widespread threat in arid and semi-arid areas of western China. Cash crops that increase the value of agricultural production are a key way to incentivize farmers to invest in sustainable land management practices.

Innovative solution: In Dulan county, Qinghai province, Damohong Co. has developed a large-scale gouji (wolfberry) industry on the sandy soils. Since its initial investments in 2012, Damohong has invested CNY 400 million, planting gouji shrubs on more than 1300 hectares of nearly bare, sandy soils, as well as 500,000 of poplar saplings, which serve as a windbreak. The harvest is processed into gouji drink and other products.

Damohong took advice on organic production methods, training staff and farmers in soil and water management, cultivation and pest control. Subsequently, organic certification was obtained. Water for irrigation is obtained from a 120 meter well, which provides drinking water quality water. All cultivation is done by staff, many of whom are local villagers. Cultivation follows international organic standards, using only organic fertilizers and organic pest and fungicides. It has established processing facilities on the site, investing in basic infrastructure, irrigation, nurseries, and has 219 greenhouses for saplings, and planted more than 10 million cuttings of gouji. Damohong is now the largest wolfberry drink producer in China.

Source: QDCDA (2014).

CASE STUDY 5

Watershed protection secures both private and public benefits

Sustainability dimensions: Water quality and land degradation

“Social and business context: The quality and volume of water in the Jiaquan Watershed in Guangdong Province, South China, is currently at risk. The water is seriously polluted with chemicals and general household waste. In addition, the environment and long-term livelihoods are under threat from large and expanding tree plantations which are insufficiently managed so there is little protection and restoration of the spring core area and secondary forests. Mineral water has to meet very strict quality standards for purity, composition, stability and nitrate levels. Danone needs to safeguard water quality at its Longmen plant.

Solution: With the support of the Danone Ecosystem Fund, Danone Waters China and the International Union for Conservation of Nature co-created the “Longmen” pilot project on a total of 10 hectares of green mandarin and alternate crops. The project aims to restore 43 hectares of secondary forest while setting up a water training school for waste water and drinking water management. All these initiatives can be delivered through farmers’ self-help groups and community associations.

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school for waste water and drinking water management. All these initiatives can be delivered through farmers' self-help groups and community associations.

Social and business impacts: The project improves farmers' incomes through alternative sustainable livelihood opportunities and creates an infrastructure for building capacity among farmers in the skills of sustainable agriculture techniques and water use for both agricultural and household use. Danone Waters China strengthens its credibility and reputation by contributing to watershed conservation and environmental protection. Environmental protection and water safety are two important subjects in China and the project raises awareness about these issues."

Source: Danone Ecosysteme (n.d.)

<http://ecosysteme.danone.com/project/longmen/>

CASE STUDY 6

A farmer cooperative leads farmers in ecologically friendly production

Sustainability dimensions: Market access, productivity, nutrient management, product quality

Context: Since about the turn of the century, falling prices and a decline in the labour force led to a decline in production of Chinese yam in Huantai county, Shandong province. Since 2008, Xingcheng Chinese Yam Cooperative has been supporting farmers to improve yam cultivation methods, and to market their products. The cooperative promotes ecological nutrient management practices, substituting for inorganic fertilizers that had become common in the area.

Innovative solution: The cooperative began with 5 households in one village in 2008, but has since grown to include 286 member households throughout Xincheng township, and the area under yam cultivation has increased from 66 hectares to 200 hectares. The cooperative trains members in ecological cultivation methods and purchases inputs in bulk, and members sell their produce to the cooperative for marketing through the cooperative's branded products. These branded products obtain higher prices, which have enabled increases in farmers' incomes.

The cooperative encourages members to produce biogas from pig manure, and to use the biogas slurry as fertilizer instead of inorganic fertilizers. This provides nutrients as well as controlling pests and diseases, requiring less application of fungicides and other inorganic chemical inputs. Some organic pesticides are also used.

Using organic fertilizer, yam yields are 50-100% higher than under conventional methods, and the yam quality is higher. Although labour inputs in yam production are high, profit per hectare is up to 5 times higher than for grain crops commonly grown in the area, and yam prices have been increasing in recent years. As a result, cooperative members' incomes have increased significantly. The cooperative has branded its products, and in 2012 the cooperative registered a brand trademark. A technical specification for the promoted ecological production methods has been registered with the government, which it is hoped will also support the growing reputation of the cooperative's products in the local market.

Source: Qiao et al. (2016)

Sustainability-led marketing restores soil fertility in orchards and

CASE STUDY 7**vineyards**

Sustainability dimensions: Land degradation, nutrient management, profitability

Context: Soil fertility is low across a large proportion of China's arable land. This is a particular problem in perennial crops. Since 2016, Syngenta has partnered with local government agriculture institutes and agribusinesses to promote cover cropping in apple orchards and vineyards in Yantai, Shandong province, an area with poor quality soils. Adoption of cover cropping has been limited by farmers' perception that the seed, labour and other input costs involved make it unprofitable.

Innovative solution: Syngenta partnered with COFCO Yantai winery to establish a 3.33 hectare demonstration site that combines green cover cropping to restore soil fertility with application of a Syngenta product, ISABION®, a bio-stimulant that increases plant nutrient uptake. With the results of the demonstration plot, farmers owning more than 6,600 hectares were trained in cover cropping. As a result, farmers who planted green cover and used the bio-stimulant saw a significant improvement in the yield and quality of their crops. With these new techniques, farmers were able to reduce chemical fertilizer inputs, which made planting cover crops more profitable than their previous practices. Soil fertility improvements are now being implemented on more than 2000 hectares of arable land.

The success of this sustainability-led marketing initiative depends on bringing benefits to all stakeholders involved. Farmers benefit from increased net incomes in the short-term as well as improved soil fertility in the longer-term. Local agribusinesses benefit from increased supply of higher quality crops. For Syngenta, not only has it identified potential markets for its products, but the marketing contributes to its global commitment to improve soil fertility on 10 million hectares of degraded farmland.

Source: Information provided by Sun Jinan, Syngenta.

CASE STUDY 8**Circular agriculture links livestock and fruit production in a virtuous circle**

Sustainability dimensions: Livestock waste, nutrient management, market access

Innovative solution: Tianzhou Green Island Ecological Agricultural Co. Ltd. has developed a series of resource reuse cycles in its core agricultural business. The company began by establishing olive, lychee and longyan orchards in a degraded hilly area, interspersing the orchards with other trees on slopes and other areas not suitable for fruit production. It developed its own nurseries and fruit processing facilities, and used organic pest control methods. In 1997, the company then set up a large-scale pig farm. The animal waste is all treated in an anaerobic digester, and is fully used to fertilize the orchards, reducing the need to apply chemical fertilizers. The pig farm itself focuses on breeding, with piglets being sold on contract to the surrounding farmers, who then re-sell them to the company when fully grown, thus contributing to poverty alleviation among the surrounding farmers. In the early 2000s, the company developed tourism activities in its orchards and surrounding forest, which further diversified the company's revenues from its agricultural base.

Source: Xiao and Lin (2006).

Traceability systems linking farmers to consumers

CASE STUDY 9

Sustainability dimensions: Product quality and food safety

Context: Tianyuan Fruit and Vegetable Co. Ltd. was established in 2000 in Shouguang City, a major centre of vegetable production in Shandong province. The company focuses on producing and marketing Hazard Free and Green Food products. It has its own production base of 13 hectares, and also procures from nearby farmers who work more than 650 hectares of land, mostly in greenhouses. Annual sales are about 20,000 tonnes. Farmers follow technical requirements set by the company, which sends its technicians to the farms to provide guidance, training and monitoring.

Innovative solution: In 2004, the company was selected to pilot a traceability system, becoming the first vegetable company in China to provide fully traceable products. The traceability system uses a GS1 barcode system to trace products through the supply chain. The system was designed by Shandong Province Standardization Institute, and is also used by inspection agencies and retailers in the province. The system has three components. The enterprise component traces product inputs from source, and also provides packaging and logistics information, enabling control of the whole production and processing stage, supporting not only management by also food safety information. The information is transmitted to the food safety platform, which also contains information from inspection and certification agencies. The retailer component enables consumers to scan the barcodes, which provides information on the production process, such as use of fertilizers and pesticides, information on the processor and production processing date and inspections undertaken. For Tianyuan, the system uses a single barcode for Tianyuan's branded products, and unique identifiers for each producer, enabling traceability from the company's suppliers through to retail. The pilot showed that traceability is welcomed by consumers, and can play a key role in establishing brand reputation and market development.

Sources: Wang and Wang (2010)

Nestlé grows together with coffee farmers in Pu'er

CASE STUDY 10

Sustainability dimensions: market access, productivity, profitability

Context: Yunnan Province, in southwest China, is one of the most northerly coffee growing areas. Yields of Arabica coffee in the area are high, due to intensive management by farmers, and the coffee is of high quality. Significantly, the area has not faced the same disease pressures as many other coffee producing regions. The coffee sector in Yunnan is recent, and Nestlé has been consistently working closely with coffee farmers in the area for the past 25 years.

Innovative solution: Seeing the high potential of the area for coffee production, Nestlé began providing agronomic advice to farmers in what is now Pu'er district in 1994. International agronomists based on the area have trained local technicians, who then reach out to farmers, providing advice on selection and planting of the right varieties, appropriate agronomic methods and quality control. Later, an experimental and demonstration farm was established. Nestlé now works with 30,000 farmers through more than 300 technicians. Since 2002, Nestlé has procured directly from farmers through its own buying stations, enabling farmers to access a reliable

market and obtain better prices, which are pegged to international prices.

In 2011, Nestlé extended its support to local farmers by implementing the Nescafé Plan, which aims to promote efficient and sustainable coffee production in line with the internationally recognized Common Code for the Coffee Community (“4C”). The Code sets out basic requirements for ensuring economic, social and environmental benefits in the production of green coffee. By 2015, more than 30,000 farmers and workers in Nestlé’s supply chain in China were engaged in the 4C initiative, and 11,000 tonnes of 4C verified coffee were procured – representing a significant proportion of the total harvest in Pu’er. This has been the result of Nestlé’s long-term commitment to farmers in Pu’er district.

Source: Nestlé (2016) with additional information provided by Juerg Zaugg

3. Public private partnerships for sustainability

While government policy for PPPs focuses on leveraging private financial investment, addressing sustainability challenges often requires more than investment alone. This section presents ten examples of PPPs that address different sustainability challenges. Inevitably, the examples presented here are not exhaustive of the range of existing PPPs in China's agriculture sector. The case studies do, however, illustrate the range of purposes to which PPPs are being applied and a variety of partnership modalities. The partnerships illustrated address sustainability through **knowledge exchange and technology innovation; testing and demonstration of existing technologies;** and the **deployment of technologies and know-how** with public goods benefits possessed by the private sector. They cover different aspects of agricultural development, including value chain development, innovation and technology transfer, and development of market infrastructure (see Table 2).³⁸ In some cases, the partnerships aim to improve government service provision (case #15), while in others the partnership facilitates service provision by the private sector (case #19) or public-private collaboration, such as knowledge exchange (case #13). The types of partnerships also vary by funding mechanism, including government as a purchaser of services (case #11), government providing co-financing (cases #12, 13, 15, 16) and public and private equity investment (case #14). Among the case studies selected, one (case #13) illustrates a pre-competitive partnership involving more than one company, which is a relatively new approach in China. Reportedly, commercial partners took time to recognize the value added of the pre-competitive platform, suggesting that pre-competitive partnerships for sustainability in China needs to strategically make best use of each partner's strengths and develop over time.

Table 2: Selected case studies of public-private partnerships for sustainability

Intervention area	Inclusive growth		Environmental sustainability				Quality & safety	
	Market access	Productivity & profitability	Land degradation	Water scarcity & quality	Nutrient management †	Waste and resource re-use	Product quality	Food safety
Value chain development	Case 11	Case 12			Case 11	Case 11		
Innovation and technology transfer		Cases 13, 16, 17, 18, 20			Case 17			Cases 15, 20
Market infrastructure	Case 19							

³⁸ FAO (2013)

CASE STUDY 11**Enabling livestock waste reutilization through a PPP mechanism****Sustainability dimension: market development, nutrient management**

Context: China is the world No. 1 pork producer, with a herd of about 450 million head. Limited utilization of livestock waste and poor treatment practices have contributed to pollution of soils and water resources in many parts of the country. Areas of intensive pig production, such as Sichuan, are particularly affected. Pork production is a key industry in the province, so restricting growth is not an option. Nevertheless, the resulting waste needs to be addressed for longer-term sustainability. Since 2015, Chengdu has been experimenting with PPP mechanisms to address livestock waste, and one pilot mechanism has been developed in Pujiang county. Pujiang is also a major producer of kiwi, tangerines and tea, with a total of more than 33,000 ha under perennial crop production. With annual production of about 600,000 head of pigs, some 328 million m³ of livestock waste is created.

Innovative solution: In this pilot mechanism, Chengdu city provided CNY 2 million and Pujiang county government invested CNY 3.3 million, putting out a tender for specialized services to collect, treat and enable reuse of pig slurry. The winning bids were selected by a committee consisting of township officials, the county agriculture bureau and farmer representatives. Winners of the bids purchased slurry transport vehicles, with a subsidy of CNY 50,000 per truck, and constructed slurry storage pits with a further subsidy per pit constructed. For each m³ of slurry collected, the transporter receives a subsidy of CNY 15, a payment from the pig farmer of CNY 5, and a payment of CNY 17.50 from the fruit cultivator. This has led to the development of numerous slurry collection teams, employing thousands of rural people to provide professional slurry collection and fertilization services. The plan is that after 2 years, the government will withdraw its subsidy, and the market for slurry reutilization services will have been stimulated.

On the demand side, it helps that farmers have a high awareness of the importance of fruit quality and the beneficial effects of organic manure on quality. It has also reversed a long-term declining trend in inputs of organic fertilizer in the region, and exclusive reliance on inorganic fertilizers had resulted in widespread soil hardening and low soil fertility.

Source: Zhang (2017)

CASE STUDY 12**PPP mechanism for value chain development**

Sustainability dimension: market development, productivity and profitability

Context: In the early 1980s, meat was still not in plentiful supply in Beijing, so in 1982 the state established the Beijing Huadu Broiler Co., which came to dominate supply to Beijing in the late 1980s.

Innovative solution: To make full use of the expertise of the company, in 2006 with support from the Poverty Alleviation Office (PAO) of the State Council, the Huadu Luanping Broiler Industry Poverty Alleviation project began. This was initiated through a PPP arrangement, whereby the PAO, China Development Bank and Luanping County Government provided a mix of grants and loans, while Huadu Broiler Co. and Guantang Investment Holding Company established Hebei Luanping Huadu Food Co. The total investment was CNY 560 million, of which 40% was public and

60% was private. This was used to establish facilities for poultry breeding, feed processing, broiler incubation, chicken breeding, slaughter and processing, and deep processing of manufactured food products. It also supported preferential loans to farmers to engage in chicken raising. Since completion of the investment project in 2010, each year the company provides 70,000 birds to the market, and has an annual sales value of CNY 1.3 billion. It has created more than 9100 local jobs, and greatly benefited thousands of farmers who raise chickens from and sell chickens to the factory.

Sources: FAO (2013) and Baidu (n.d.)

CASE STUDY 13

PPP establishes a pre-competitive platform for knowledge sharing and transfer

Sustainability dimensions: Productivity, profitability, product quality and food safety

Innovative solution: The Sino-Dutch Dairy Development Centre (SDDDC) was launched in November 2013. Based in Beijing, the SDDDC was initially established through a partnership between Royal FrieslandCampina (a Dutch dairy cooperative), China Agricultural University and Wageningen University and Research Centre. China's dairy sector is developing rapidly, and a range of issues are faced at all stages of the supply chain, from feed production, through dairy farm operations to milk collection, processing and retail. Several challenges, such as governance of quality and food safety throughout supply chains, affect all participants in the sector, and cannot be addressed by individual companies working alone.

The SDDDC was established to improve dairy productivity, safety, quality and sustainability throughout the dairy chain in China by bringing together all relevant stakeholders to share knowledge and collaborate in innovation. The SDDC is a pre-competitive platform for collaboration between industry, universities and government and between companies within the supply chain. The centre involves these stakeholders in research and innovation, training and education, demonstrations, and networking and exposure activities. To date, 22 research projects have been conducted; about 250 people have completed training courses, including train the trainer courses and knowledge transfer to farmers; and a demonstration farm established near Beijing in partnership with Zhongdi Dairy, a Chinese dairy company.

There are now 10 partners in the SDDDC, including 8 Chinese and international companies working at different stages of the supply chain, as well as universities from the public sector. The corporate partners have all directly invested in the activities of the centre, while the academic partners have generated funding from the Chinese and Dutch governments to support research and knowledge transfer activities. Pre-competitive collaboration between companies is a relatively new approach in China. Over time, the partners have come to recognize the importance of combining their relative strengths, and the value added of the pre-competitive platform is increasingly appreciated.

Sources: http://www.sdddc.org/index_en.aspx, with additional information provided by Atze Schaapp.

CASE STUDY 14

PPP for agri-tech display park

Sustainability dimensions: transfer of knowledge

Context: Changsha county, Hunan Province, is a major center of vegetable and horticultural production.

Innovative solution: In 2015, a government plan was approved to establish a Modern Agriculture Demonstration Park in Changsha. The planned area of the park is about 180 hectares, consisting of wetland and rice paddy features, and a core area providing visitor services, an organic certification centre, the farm office, a media centre, and an agro-meteorological station. Tourism oriented components are also envisaged. The investments are structured in three stages: stage 1 will involve construction of an innovation display area, and a modern agriculture service centre; stage 2 will construct an international agricultural science product display and trade centre; and stage 3 will expand the tourism related facilities, such as an agricultural culture centre and other visitor facilities. Thus, the project involves both public goods and economic activities, which provides some basis for private investors expecting a return.

The investment contents include the design, financing, investment, construction, operation and maintenance of the proposed park and its facilities. The PPP model proposed is based on a build-operate-transfer (BOT) model during which the private partner has an exclusive license during the operation period, and will be responsible for the operation and maintenance of public buildings and other infrastructure in the park. Total investment is estimated at CNY 875 million. A company representing local government will provide 30% of the investment needed, and take 30% of shares in the park, while the private investor is invited to take 70% of shares in the park. The private partner was chosen by competitive bidding in 2017.

Sources: *Chunhuanet (2015)*

CASE STUDY 15

PPP stimulates development of IT applications in animal health monitoring

Sustainability dimensions: Product quality and food safety

Context: Animal health monitoring is a key aspect of ensuring food chain safety and public health. This initiative was a response to the lack of complete and reliable data on animal production, and constraints in linking data between different production stages and producers, all of which hampered inspection and regulation as well as response zoonotic emergencies.

Innovative solution: Shanxi Animal Health Monitoring Institute – a public agency responsible for inspection of animals and animal products – has developed a new PPP mechanism involving IT applications (modern computing technology, mobile networks and mobile smart information collection) to facilitate animal health monitoring, process monitoring and traceability. Focusing on the main livestock products in the province, full traceability systems have been set up covering all factors of production and the whole supply chain. This system links electronic ear tags and production documentation (e.g. vaccination documentation, livestock numbers) to the inspection process (e.g. issuance of electronic certifications, waste disposal and slaughter monitoring). The system has several specific functions, including: (1) smart phone reading of ear tags, which lowers costs and facilitates direct links with other information systems; (2) inspectors can carry out their work through PCs, PADs and smart phones, which increases mobility and service convenience to animal producers; (3) ear tag barcodes and radio-frequency

identification are used to enable traceability through the whole supply chain; (4) remote, high resolution visual monitoring is facilitated, enabling provision of remote guidance on inspection activities. Digitization of inspection work also facilitates quality control and traceability in the inspection work conducted. The system also provides access to all relevant laws, regulations and standards, enabling on-line training and guidance for vets and inspectors. It is intended that through the transparency provided by the system, producers and slaughter companies can also benefit from strengthening traceability and brand value.

To develop the system Shanxi Animal Health Monitoring Institute jointly partnered with Beijing Baoxun Chaoyuan Science and Technology Co. and China Telecom Shanxi Co. to plan and design the IT system. The PPP model adopted involved government providing guidance on service standards and purchasing the services, with an investment of CNY 7.2 million in equipment purchase. The companies invested CNY 6.7 million to develop the IT platform and applications. A strategic cooperation agreement was signed in March 2016, and in July 2016 the Smart Animal Health Monitoring platform was initiated. More than 1000 government vets in 60 counties have been provided with mobile data collection units, and distance learning has been provided to all vets in the province. The system is now functioning to provide real time data, traceability of livestock products, and information necessary for management of zoonotic outbreaks.

Source: Market and Economic Information Department of the Ministry of Agriculture (2016).

CASE STUDY 16	PPP finances uptake of modern machinery
<p>Sustainability dimensions: Productivity and profitability</p> <p>Context: Mechanization is one of the key technological strategies for continued productivity growth and profitability in Chinese agriculture. John Deere, a US-based machinery manufacturer, has been active in China since the 1970s, and has been manufacturing in China since the late 1990s. In Xinjiang, less than 20% of the region's cotton is harvested using machines. Rising wage labour costs has put pressure on cotton profitability in recent years. Labour costs now account for more than a third of total production costs. Mechanization will increase production efficiency and profitability in Xinjiang's cotton sector.</p> <p>Innovative solution: In 2015, John Deere Finance Lease Co. Ltd. signed an agreement with Xinjiang Autonomous Region Agriculture Department and Xingye Agricultural Machinery Service Cooperative to enable the cooperative and its users to purchase 200 large-scale cotton harvesting machines through concessional credit. Under this agreement, the Ministry of Agriculture will provide CNY 8 million of credit with subsidized interest rates, and John Deere will provide CNY 12 million of credit at a preferential interest rate. In addition, when the cooperative purchases cotton harvesting machinery, it will only need to make a down payment of 30% of the total price of each machine, which eases access to the machinery and facilitates payment of interest on the loans, which should be repayable within 3-4 years. This agreement represents an innovation in the Chinese context, particularly in the linking of public finance to financing and leasing services from the private sector. The arrangements will help overcome barriers to financing agricultural development and access to credit by farmers, while leveraging private finance to</p>	

supplement public finance.

Source: John Deere (2015)

CASE STUDY 17

PPP demonstrates the relevance of new fertilizers

Sustainability dimensions: productivity, nutrient management

Context: Research has estimated that about 100 million people in China suffer from zinc deficiency. Moreover, a large proportion of China's croplands have low plant-available zinc, which both depresses yields and limits zinc micronutrient composition in food products.

Innovative solution: Since 2012, Teck – a Canadian firm that is one of the world's largest producers of mined zinc – has been partnering with the National Agricultural Technology Extension Service Center of the Ministry of Agriculture of China (NATESC) and the International Zinc Association (IZA) to promote the production and use of zinc fertilizer in China.

The partnership made use of NATESC's nationwide network of trial and demonstration plots to demonstrate the benefits of zinc fertilizer. Crop trials showed that zinc fertilizer can improve nitrogen fertilizer uptake and can increase maize yields by 6-15% and wheat and potato yields by about 10%, while also increasing zinc content in food crops by 20%. On the basis of these trials, zinc fertilizer was included in the national fertilizer recommendation guidelines, which lays the basis for more widespread use of zinc fertilizer. In 2014, 40,000 tonnes of zinc fertilizer were used. By 2015, this increased by a further 20,000 tonnes, which is enough for 2 million hectares of cropland, and could indicate production of more than 8 million tonnes of zinc-enriched food grains. The partnership therefore has the potential to improve the micronutrient availability for millions of people.

Sources: Teck Resources Limited (2012) and Scaling Up Nutrition Business Network (n.d.)

CASE STUDY 18

PPP supports R&D by China's seed industry

Sustainability dimension: productivity

Context: Hainan – China's most southerly province – has a tropical climate, which enables plant growth all year round, providing ideal conditions for plant breeding and research. Because multiplication can occur in winter, the duration required to breed new varieties is shortened.

Innovative solution: The Southern Seed Reproduction Base, in Hainan Province, is a key national base for seed research and reproduction in China. It was established by the government and serves as a public platform for innovation by public and private seed companies. The Southern Seed Reproduction Base now has several hundred research institutes and both public and private seed companies undertaking seed research and multiplication. About 80% of China's crop varieties have been selected or multiplied there. In addition to resources for research and breeding, the base also has facilities for suitability trials, testing and certification, as well as seed production and sales. Given the importance of the base to national seed production, the government also provides quarantine inspection services. Companies using the base rent land from farmers in the surrounding counties, and

local management agencies assist companies to organize land, water, electricity and telecommunications infrastructure. Currently, there are plans to expand the multiplication and varietal conservation area to more than 17,850 hectares, including 3,500 hectares of a core breeding zone, involving land improvement, breeding and other services, and a seed processing centre to encourage enterprises to bring their seed R&D activities to Hainan. In addition, a cloud-computing public service platform is under development, to provide information and services to support research and application in seed research, production, extension and post-harvest stages.

Source: Southern Seed Reproduction Base website:
<http://219.141.234.66:50005/?topnav=1>

CASE STUDY 19 **PPP develops market information services**

Sustainability dimension: market access, productivity, profitability

Innovative solution: In 2012, Shanxi province began to pilot new modes of providing services in rural areas. Partnering with several research institutes in the province and Jinman Agricultural Science & Technology Co. Ltd., the government explored how to improve farmers' access to technical information, advice on farming (e.g. pest and disease control) and market information. In the project process, CNY 5.5 million were invested by the government and CNY 53.45 million by private partners to establish the extension platform.

After 3 years, a platform has been created. There are 702 Jinman Agricultural Service Stations, covering 80% of the main grain producing areas in the province. The company has provide obtain training on agricultural topics as well as vocational training to 30,000 information technicians, and supported 100,000 demonstration households.

For example, the stations have a soil nutrient testing kit and microscopes for pest identification. The stations have become a key source of diagnostic services for farmers. They also support local government in promoting integrated technologies, such as fertilization and seeding methods. By providing access to information on marketing opportunities, the stations help farmers realize increased income from their on-farm investments. Some stations also take on the role of harvesting neighbouring farmers' produce. At least one supermarket has also joined the Jinman service platform, and is trialing procurement from dedicated sites where appropriate pesticide use and other agronomic practices can be guaranteed. Plans are underway to further link the platform with agricultural commodity exchanges and financial services.

Source: Xinhua News Agency (2015)

CASE STUDY 20 **PPP for safe and responsible use of pesticides**

Sustainability dimensions: productivity, health and safety

Innovative solution: Syngenta is best known as a provider of agrochemicals, but is also a provider of integrated crop solutions. Its Good Growth Plan aims to increase the efficiency of crop production, protect and restore soil fertility and biodiversity, and support smallholders to increase productivity and ensure safe production

practices on farm. Since 2002, it has worked with the National Agro-tech Extension and Service Center of the Ministry of Agriculture to promote safe and responsible use of pesticides. NATESC leads the nationwide system of agricultural extension agencies.

Knowledge of safe practices have been shared through a cascade training programme, involving training of master trainers, training of trainers and training to farmers. Since 2002, more than 8950 trainings in safe and responsible use have been provided in all the major rice producing provinces, with more than 450,000 people trained. Independent evaluations by agriculture universities show that the training significantly improved farmers' awareness about pesticide safe use, including reading product labels, use of protection during application, protection of pollinators, and disposal of empty containers. NATESC has also used its nationwide platform of test plots to demonstrate methods for reduced use of pesticides, replacement of highly toxic pesticides, and integrated solutions covering seed care, herbicide, insecticide and fungicide use. These new techniques increase yields and incomes while reducing the frequency and volume of pesticide application. Syngenta also partners with national agencies from the health sector, providing training to rural doctors on dealing with pesticide related health risks.

The importance of environmentally friendly crop protection techniques has gradually risen in the national policy agenda in recent years, and national policy is now to achieve zero growth in pesticide use by 2020 through controlling use, replacing inorganic products, improving precision and promoting integrated solutions. NATESC is leading the provision of training and organization of 'green crop protection' demonstration sites nationwide.

Sources: Information provided by Sun Jinan, Syngenta

4. Conclusions

Agricultural sustainability is high on the Chinese government's policy agenda. Sustainable agricultural development needs to address a range of environmental challenges, while supporting inclusive growth, and ensuring that consumers' demands for quality and safe foods are met. Both technological and institutional innovations are required to address the multi-dimensional sustainability challenges in China's rapidly developing agri-food sector.

While not based on a comprehensive survey of ongoing innovations in China, this paper shows that private actors are active in innovation for sustainability in China. The cases exemplify international and domestic input producers whose core products have sustainability benefits; agri-food companies whose business model depends on enhancing sustainable practices within their own supply chains; and companies promoting public goods benefits in partnership with public sector and in pre-competitive partnerships with other private firms. The case studies presented highlight the following key points:

- Innovation for sustainability often depends on partnerships, whether between public and private sectors, with input, advisory service or technology providers, or between suppliers and buyers in the supply chain.
- Innovations have stronger potential for uptake when there are synergies between environmental benefits and productivity, quality and profitability. Improvements in economic outcomes may be essential for incentivizing adoption of practices with benefits for the environment and food safety.
- In China's rapidly changing economic context, appropriate and effective strategies for promoting sustainability will change over time and vary from place to place. This suggests that there will be no single approach that meets diverse and changing needs.
- Recent government PPP policies primarily frame partnerships as a mechanism to leverage private investment for public goods provision, but addressing sustainability challenges is also knowledge-intensive. Development of pre-competitive partnerships involving the public sector and private firms, who may compete in other respects, may require strategic planning and patient support.

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Annex 1: Selected agri-food related PPP projects listed in the government-approved project pool (as of March 2017)

Project name	Province	Industry	Contents	Investment (CNY 100 million)	Government participation	PPP model
Tiemenguan city farm	Xinjiang	Agriculture	10,000 m ² greenhouse, 200 greenhouses, canteen	3.6	Concession	BOO
Jinyinchuan agricultural market	Xinjiang	Agriculture	12,700 m ² agricultural market	0.32	Concession	BOT
Tianrun dairy farm	Xinjiang	Agriculture	Renovation of 10 1000-head dairy farms and provision of facilities for slurry drainage and cleaning, milking, feed mixing and feeding	1	Equity investment	BOT
Alaer logistics centre	Xinjiang	Agriculture	Logistics platform and 100,000 tonne warehouse and wholesale market for date harvest	1.8	Equity investment	BOT
Yanglin agri-product processing park	Shaanxi	Other	27 ha park with office, experimental centre, display centre and other facilities	2.666	Not yet confirmed	BOT
Yuanmo irrigation system	Yunnan	Water	7600 ha irrigation area, using 4.42 million m ³ water p.a., and inter-field canals and ditches for 5000 ha	3.05	Fiscal subsidy	BOT
Nanjiang county reservoir	Sichuan	Water	Irrigation with drinking water supply; 11 million m ³ reservoir for irrigation of 3600 ha and drinking water for 110,000 people	5.7	Equity investment	BOT

Xichong agri-park	Sichuan	Other	Land improvement on 733 ha, of which 533 has already been consolidated, to create a cropping-aquaculture production area	6	Concession	BOO
Guilin City catering waste treatment	Guangxi	Urban mgt.	Design & construction of 2 ha facility for pre-treatment + anaerobic fermentation for catering waste (100t/d)	1	User pays + fiscal subsidy	BOT
Xixian agri-science park	Sichuan	Agriculture	Construct a demonstration park for poverty alleviation through commercial development, including an agriculture development park and ecological agriculture recreation park	2	Equity investment	BOO
Huludao food industry park water treatment system	Liaoning	Urban mgt.	Construct a water treatment plant for a food industry park	0.4	Other	BOT
Qinhuangdao port	Hebei	Agriculture	Port expansion and facilities include land and water based services, e.g. dock, dyke, roads, customs building, aquatic products wholesale market, refrigeration and processing centre, boat repair facilities etc	11	Equity investment	BOT
Wuqiao circular economy park	Shandong	other	30 ha centre for treatment, processing and reuse of residential, livestock and crop, and urban waste, to produce biogas, organic fertilizer and bioenergy	1.5	Government purchases services	BOT

Notes: BOT: build-operate-transfer; BOO: build-own-operate

Source: <http://tzs.ndrc.gov.cn/zttpp/PPPxm/xmk/>