Shifting from Industrial Agriculture to Diversified Agroecological Systems in China

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Abstract

In 2016, the International Panel of Experts on Sustainable Food Systems (IPES-Food) published a report entitled "From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems". This report provided a systematic review of existing studies of industrial and ecological systems of agriculture in the global context and offered constructive suggestions to facilitate the shift towards an agroecological system. Yet, its analysis is largely built upon general agriculture development in the world, with limited discussion on China. Meanwhile, after more than thirty years of industrial-oriented development, the agriculture sector in China is in urgent need of an ecological transition. Despite the rapid growth of the organic agriculture sector, the problem of unequal access to healthy foods persists. On the one hand, organic food is only affordable for wealthy, elite consumers; on the other hand, the vast majority of small farmers have limited capacity for conducting organic or ecological farming due to the lack of knowledge and skills and access to the market. By adapting the analytical framework of the IPES-Food report to the Chinese context, this paper examines studies of Chinese agriculture and reviews the outcomes of industrial agriculture and agroecological systems in China, analyzes key factors keeping industrial agriculture in place in China, and proposes suggestions for a paradigm shift in favour of integrated agroecological systems. The paper not only sheds light on the hotspots of future agriculture research in China but also highlights some key actions for the sustainable development of China's agriculture.

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Executive Summary

The IPES 2016 report, “From Uniformity to Diversity”, concludes that merely making incremental improvements to the most egregious aspects of the specialized industrial food system fails to fundamentally address the multiple challenges of soil degradation, water scarcity, social injustice and climate change. By taking a purely scientific approach to food systems issues, we miss the interconnections, power imbalances, political lock-ins and potential levers for change that are only perceived at the systems level. Adapting the systems framework of the IPES-Food Report to the Chinese context provides policy makers, community organizations, academics and other related social groups a road map towards sustaining food systems in China by shedding light on hotspots of future agriculture research and offering recommendations for transition to diverse agroecological systems.

Key Findings

- While productivity gains have been made through the industrialization of agriculture, the environmental, health and socioeconomic outcomes are detrimental.
- The process of agro-industrialization and its inherent mechanization leads to displacement of farmers and farm workers from rural communities to urban centres.
- The loss of power of smallholders is further aggravated by incentives from the state that favour large scale and industrialized producers.
- Modernization of agriculture has forged a dependence on chemicals throughout China. Excessive and inefficient use of synthetic fertilizers contributes to GHG emissions during the production, distribution, and application of synthetic fertilizers. High pesticide use leads to poor health outcomes for Chinese farm workers and local communities.
- The depletion and pollution of soil and groundwater resources are major consequences of agroindustrialization in China. Industrialized agriculture depletes and pollutes soils and aquifers while offering no convincing solutions to the crises the system itself creates.

- Specialized industrial food system in China that focuses on uniformity and profitability of a select few crops and animals and select varieties and breeds within that narrow scope leads to permanent loss of biodiversity, making China's food system vulnerable.

Lock-Ins: The Chinese Exceptions

A key contribution offered through this research paper is our adaptation of the eight lock-ins of industrial food systems within the Chinese context. These eight lock-ins put to rest the naive notion that we can rely on the market to self-correct for sustainability. Forces deeper and more powerful than public purchasing power limit the effectiveness of attempts to simply steer farmer supply through consumer demand.

Lock-in 3: The Expectation of Cheap Food

Rapid urbanization in China has resulted in Chinese consumers becoming accustomed to the abundance of cheap food. The low price of food has made eating out and ordering food from online platforms daily routines for busy urban workers. The demand for cheap food is further enhanced by the rapidly increasing demand for animal products, particularly pork and dairy products in China. Livestock production drives the expanding monoculture of soybeans and imports of animal products.

Lock-in 4: Compartmentalized Thinking

In the compartmentalized mindset, agriculture is treated merely as an activity to produce profitable food commodities rather than people's livelihoods and an inseparable part of the ecosystem. People and Mother Nature involved in agriculture, as a consequence, are reduced to inputs for a linear system. The compartmentalization in policy making also renders China's food policy lacking in systematic and inclusive strategies. Food security policies, for example, are highly biased towards agricultural outputs and the rural context, with limited attention on other key components of food security such as the sustainability issues within food access and food utilization.

Lock-in 6: Feed the World Narratives

The “feed China” narrative, although different from “feed the world” narrative, has become a political mission and a catalyst for China’s agroindustrialization. Governmental agendas on farmland protection sent clear messages of the central focus on quantity of food production. While there is no doubt that producing enough food should be a top priority, this productivity-centred narrative, which defined China’s basic food policies, goes hand in hand with industrial agriculture. It justifies the continuation of the industrial agricultural system, deflects attention from its consequences, and sidelines the discussion of the latent benefits of diversified agroecological systems. It fails to answer the question of how food could be produced and better distributed to everyone, particularly marginalized groups with limited resources, in a way that enhances farmer livelihoods, public health, social well-being, equity and justice.

Key Recommendations for moving toward diversified agroecological systems in China

Today, the Chinese government promotes the standardized industrial farming mode to eliminate smallholders and scale up the agriculture sector. Given the findings of the IEPS-Food Report, it is urgent to strengthen the nascent initiatives outlined in our paper to foster diversified agroecological systems. Besides what has been covered in the IPES-Food report, our research leads to the following China-specific recommendations:

Reconceptualize “modern agriculture” in the policy and educational realms

Agricultural modernization has been a key national development priority in China for decades. The understanding of modern agriculture has long been focused on efficiency and productivity, with limited recognition of agriculture sustainability. With the central government’s promotion of “ecological civilization” as a national strategy since 2007, it is a critical timing to integrate agroecology in the narratives and interpretations of modern agriculture.

Rediscover the value of agroecology in achieving developmental goals in agroecology and rural development studies

The values of agroecology practices, as explained previously, include but are not limit to reducing poverty of remote areas, reducing pollution, enhancing the 'ecological civilization' goal, contributing to social stability by addressing food safety issues, creating jobs and so on. Ecological agriculture should not be confined as a means of safe food production for a niche market.

Promote the diverse ways that agroecological practices are experimenting to overcome the crisis of trust in the food system

Ecological farms are attempting to re-build consumers' trust not only through market mechanisms, such as eco-labels, but (because of low trust in labels) increasingly through relational mechanisms, building personal connections with local government, rural community, local peasants, local suppliers, and with consumers. Given that food safety is the top concern of Chinese residents, promoting these mechanisms beyond small farms will strongly boost the public awareness of agroecology practices, consolidating public support for the transition towards diversified agroecology.

Understand farmers' roles in the agroecology transition

Besides the various studies of consumers in organic food market (e.g. Chen and Scott 2014), farmers' roles in ecological agriculture development also deserve more attention in research and policy making. Little attention has been given to values, ideological challenges, and the roles of farmers' values in agroecology transition.

Explore opportunities for farmer participatory research and participatory plant breeding

The rich experience of farmer participatory research from both China and other countries should be matched with more policy support. Therefore, it is important to explore opportunities for exchanges and visits, such as bringing Chinese stakeholders to attend international events (e.g., organized by Food Secure Canada, the National Farmers' Union, Canadian Organic Growers, and the Guelph Organic Conference) and bringing foreign stakeholders, not only researchers, to share experiences.

Enhance market oversight and credibility of certification systems while increasing farmer training and consumer education for ecological agriculture

It is vital to make certification a viable option for more farmers. That being said, a more fundamental problem is the deterioration of trust in the certification system. It is also important to support farmer training and consumer education for ecological agriculture so that farmers are better complying with the certification requirements and consumers have better knowledge of the meanings of certification.

Support innovative ways to attract farmers and other people back to the land

The urbanization process drained human resources from the countryside and thus created favourable environment for industrial agriculture. It is therefore urgent to make land more accessible for people who are interested in farming. Providing equal support to those new farmers in the ecological agricultural sector will greatly enhance their competency and viability.

1. What are the outcomes of industrial agriculture and diversified agroecological systems in China?

1.1 Outcomes of industrial agriculture

As a vital component of notion of progress and development in contemporary China, the industrialization of agriculture in China can be traced back to as early as the 1950s when it started to adopt agriculture machineries. Mid-size and large machineries were used on collective farmland of communes and more flexible and smaller machineries have been used in agriculture since the establishment of the Household Responsibility System (HRS) in the early 1980s. By 2015, the ploughing, sowing and harvesting process of 63 percent of farmland in China had been mechanized and the Chinese government aimed to achieve the goal of 68 percent in 2020 (Yan 2016). Although the number is still low compared to highly industrialized countries, the increase is stunning compared to the 1950s.

Alongside the growing percentage of mechanized farming is the increasing amount of synthetic fertilizer usage. The total amount increased four-fold from 13 million tonnes in 1980 to 55.6 million tonnes in 2010, with an average annual growth rate of 5 per cent. On average, the amount of synthetic fertilizer applied to each hectare of farmland in China is four times the global average (Luan et al. 2013). Similar to the growth of synthetic fertilizer, the use of chemical pesticides and herbicides is also on the rise. China is the world's largest producer and exporter of pesticides, as well as the second largest consumer (Zolin et al. 2017). Its pesticides use accounts for half of the world's total consumption (Pretty and Bharucha 2015). The total amount of chemicals used has increased annually by 7.4 per cent from 1991 to 2013. The dose of chemicals used in China is 2.5 times of the world average (Chen et al. 2016).

In addition, the development and commercialization of hybrid seeds since late 1970s has also transformed the agriculture sector. The increasing marketization and consolidation of the seed industry in recent years has reduced the number of seed companies from more than 8,600 in 2010 to 5,064 in 2014 (Wu 2016). Together, these 5,064 companies produced 70 per cent of seeds sowed in China.

Although the seed industry is still far more diversified than in most countries of the Global North, there are strong pressures to continue this consolidation. While almost 100 per cent of corn, hybrid rice and canola seeds were commercialized and little space is left for traditional seed saving practices, China has become the world's second largest seed market (Ma 2017). The vegetable seed market, although much more diversified compared to staple grains, is also at the beginning of its commercialization stage (Xu 2017). The commercialized seed market allows more rapid expansion of new crop varieties which leads to "the loss of native seed varieties adapted to local growing conditions and tastes, and the loss of traditional knowledge associated with them" (IPES-Food 2016: 27).

The livestock production in China is no exception in the process of industrialization. Driven by Chinese middle class consumers' growing appetite for meat, or the so-called "eating meat in revenge" against past scarcity (MacDonald and Iyer 2011), the production of meat in China has experienced a dramatic change from small-scale household production to capital and resource intensive factory farming (Schneider 2015). Taking the production of the most widely consumed meat in China – pork – as an example: while pig raising has long been a side project of small-scale farming that not only converts food waste from farm and kitchen to an important source of protein that supplements the grain-based diet but also produces manure for sustainable crop farming, the number of household pig farming has declined rapidly since the early 2000s (Jian 2010, Schneider 2011). Large swine farms are rapidly replacing small-scale household pig raising, consolidating a growing power in both China's food system (Schneider 2015) and the global food market (Sharma 2014). Pigs, previously seen as a valuable, multifunctional asset of rural households were transformed into a commodity that feeds into China's agro-industrialization agenda. Similar situations happen in the poultry and dairy industries, although each of these sectors' developments have unique underlying dynamics. The dairy industry, for instance, has experienced dramatic changes after the melamine milk scandal in 2008, with a sharp decline of consumer trust in domestic dairy producers and a strong push from the state to scale up and consolidate the sector, with the belief that industrialization will solve the food safety challenge (Sharma and Zhang 2014).

1.1.1 Productivity outcomes

The most obvious positive outcome of agriculture industrialization is the significant increase in production. Studies have pointed out that despite the overall decrease of planted area of farmland since early 1990s, the total output has experienced a significant increase, given productivity gains (Huang and Zhu 2014). Figure 1 shows that after 1961, when the great famine ended, China's total grain output has grown almost four-fold. Researchers concluded that the increase of total farmed land is the major contributor, followed by the increase of yield, to the growth of grain output from 2003 to 2011 (Liu et al. 2013b, Sun et al. 2017). The usage of synthetic fertilizer topped other factors and contributed 20.79 per cent of the increase of yield (Fang and Meng 2013, Wang et al. 2015b). It is estimated that in 2012, almost 19 per cent of grain output was saved from pests by using pesticides and other pest control approaches (Chen et al. 2016). It is also estimated that for every round of renewal of seeds in Chinese agriculture sector, which happened roughly every ten years in the past few decades, there has been a more than 10 per cent of increase of yield (Gao et al. 2013). The increase in production driven by industrialization is also reflected in the meat sector. Nowadays, China produces five times the volume of pork the United States produces or half of the world's pork (Schneider 2017). It is also the world's second largest producer of poultry meat and eggs (Horowitz et al. 2014). China's dairy production has also been greatly boosted by scaling up production, vertically integrating small dairy producers and importing foreign breeds and feed (Sharma and Zhang 2014).

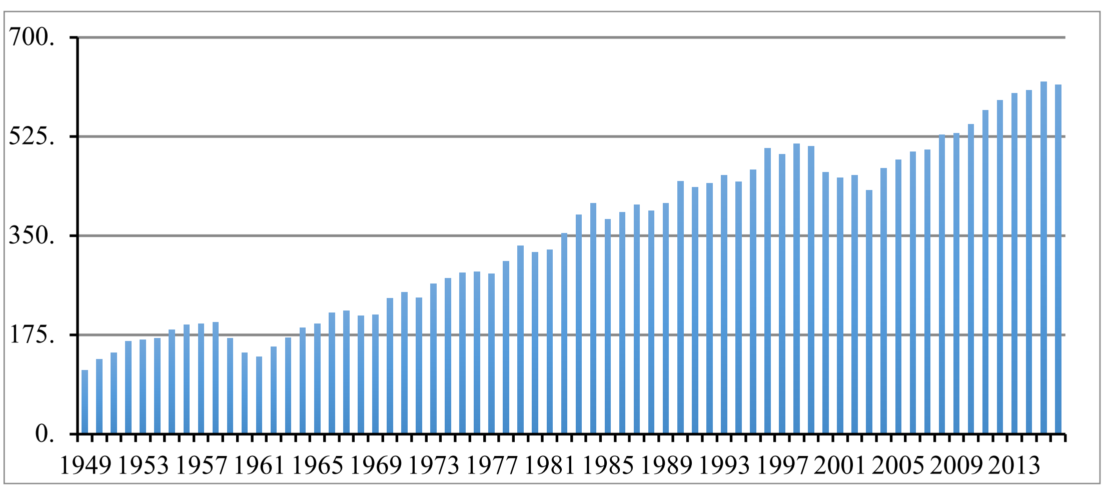

Figure 1. Total grain output in China from 1949 to 2016 (in million tonnes)
Source of data: China National Statistical Reports

Despite the widely reported increase of total output and yield from using more synthetic fertilizer and pesticides, the contribution of chemical fertilizer inputs to yield increase declined in recent years (Fang and Meng 2013, Wang et al. 2015b). Meanwhile, the growth rate of grain output has lagged behind the growth rate of grain-based livestock feeds, driven by China's increasing meat consumption. The growing grain output does not really relax China's heightened food security situation. Instead, just as what is commonly experienced in many other countries, the industrialization of China's agriculture sector has resulted in a series of negative environmental, socioeconomic, nutrition and health outcomes. It is thus of urgent need to balance the food security and sustainability challenges (Lu et al. 2015a).

1.1.2 Environmental outcomes

The great achievement of feeding more than 1.3 billion people has come at an environmental price that can hardly be ignored. The environmental consequences include land degradation and soil erosion, pollution of soil and water resources, greenhouse gas emission from nitrogen fertilizer and livestock, and the destruction of ecological balance (IPES-Food 2016). These consequences result from relying on various unsustainable agricultural inputs that have been widely employed in China since the late 1970s (Han 1989), including the excessive use of synthetic fertilizer and pesticides, the unsustainable intensive exploitation of soil and water resources, as well as the animal waste that pollutes the water system.

One of the major outcomes of the industrialization of China's agriculture sector is its land use and land cover change, which is closely associated with farmland degradation. The expansion of large-scale industrial food production through land reclamation in the corn belt and soybean production base in Northeast China since the 1980s has contributed to the severe soil erosion, decline of soil fertility and black soil layer (Wang et al. 2009, Gong et al. 2013). According to Sun (2010), the alarming rate of soil degradation in this area would destroy the 930,000 ha of cultivated black soil by the year 2058. Soil degradation is not limited to Northeast China, however, as a news report (Patton 2014) suggested, more than 40 per cent of arable land in China was suffering from land degradation. The degradation of farmland associated with intensive farming approach implies high economic costs for the country (Deng and Li 2015). The degradation has casted doubt on the claimed ability of industrial agriculture to sustain China's food self-sufficiency. Industrial systems of agriculture, although responsible for the degradation, fail to provide a convincing solution to the urgent demand to restore these degraded lands (IPES-Food 2016).

The exploitation of natural resources in agro-industrialization is also reflected in the depletion of groundwater resources. Alongside industries and mining, irrigation is the major contributor to the pollution and depletion of unrenewable aquifers in many regions of China, particularly the North China Plain where intensive agriculture activities take place (Feng 2016, Kong et al. 2016). Kong et al. (2016) found that the intensive irrigation in agriculture in the North China Plain has led to a decline of groundwater level at a mean rate of 0.46 ± 0.37 meters per year for the shallow aquifer and 1.14 ± 0.58 meters per year for deep aquifer. Although a national investigation of the condition of groundwater pollution was conducted since 2005 by the central government, the investigation result has been kept a secret. Yet, a separate report found that 41 per cent of monitored groundwater sites were polluted (Li, J. 2013).

The degradation of farmland induced by both natural systems and human interventions might not be as strong a reason as soil and water pollution from industrial agriculture to question the whole industrial system. Scholars have found that the marginal increase of productivity contributed by nitrogen fertilizer has been declining and the usage of nitrogen fertilizer has far surpassed the optimal level (Zhu and Chen 2002). A striking fact is that only 30 per cent of synthetic fertilizer applied to the field in China has been utilized by crops, compared to more than 40 per cent in many developed countries (Yang 2012), and the utilization rate has been declining (Fang and Meng 2013). This nutrient imbalance is a consequence of the excessive usage of nitrogen and phosphorous fertilizer that is common in China. Nitrogen and phosphorous cycles are among the nine planetary boundaries identified by Rockstrom et al. (2009). The other unutilized 70 per cent of fertilizer has evaporated into the atmosphere, infiltrated into the groundwater and flowed to the river system, causing soil acidification (Guo et al. 2010), as well as air and water pollution (Vitousek et al. 2009, Strokal et al. 2016).

The excessive use of synthetic fertilizer, particularly nitrogen fertilizer, also contributed to climate change through releasing greenhouse gas (nitrate and gaseous N species such as NH_3, NOx and N_2O) to the atmosphere. The greenhouse gas emission from the production, transportation and application of nitrogen fertilizer constitutes a major part of total agricultural emissions in China (Zhu and Chen 2002, Kahrl et al. 2010). This is added by the increasing emission from the livestock industry in forms of carbon dioxide, methane and nitrous oxide (Liu and Zhang 2011, Schneider 2011). According to Caro et al. (2014), China was the largest overall emitter of both pig and sheep emissions, which contributed to 30 per cent and 25 per cent of the world's pig and sheep emissions respectively.

The pollution of air, water and soil is worsened by the overuse of pesticides. Since the early 1980s, the use of pesticides in China has increased substantially, leading to a dependence on pesticides in the agriculture sector, particularly in southeast and central China (Li et al. 2014, Zhang et al. 2015). Hu and Rahman (2016) argued that the modernization trajectory of agriculture and rural China forged a dependence on pesticides. This dependence resulted in some widely recognized environmental problems including soil, water and atmospheric pollution, lost soil microbial diversity, ecological imbalance, food safety concerns, and potential health risks (Pimentel and Lehman 1993, Chen et al. 2016, Hu et al. 2015, Jacobsen and Hjelmsø 2014, Lu et al. 2015b, Zhang et al. 2011a,b). Yet, published studies of the environmental impacts of the current usage of pesticides in China is limited, with most studies focusing on legacy pesticides such as DDT and HCH, two highly toxic and persistent pesticides heavily applied in China before they were banned in 1983 (Li et al. 2014, Zhang et al. 2011a). Pesticides use in China is estimated to be twice the global average. As pests develop resistance to pesticides, it stimulates further use of pesticides (Lu et al. 2015b).

Agro-industrialization also significantly reduces agro-biodiversity (loss of traditional and wild animal breeds and crop varieties) through the introduction and commercialized mass production of a limited number of animal breeds and plant varieties. This in turn erodes the potential of sustainable food security (Long et al. 2003). Studies of traditional agricultural practices in various contexts suggested that they effectively conserve agro-biodiversity and nurture a sustainable human-nature relationship (Dorresteijn et al. 2015). For thousands of years, the locally adaptive traditional farming systems in China have successfully managed the rich genetic resources in agriculture (Liu et al. 2013a). Yet, these sustainable models of agriculture have been replaced by mass production of a few select, commercially profitable breeds and crops. As a consequence, China has experienced a significant loss of genetic agro-biodiversity in the past three decades. For example, it was estimated that the varieties of wheat extensively cultivated in China have decreased from more than 10000 in the 1950s to about 400 in the 2000s ((UNDP/GEF and MFPRC 2005). The genetic loss is not only confined to crops and farmed animals. Studies found that the reclamation of wetlands in Northeast China Plain contributes to the degradation of wild genetic pools (Song et al. 2014), which jeopardizes crucial ecosystem services as evidenced in the lack of pollinators in China's farms (Goulson 2012).

1.1.3 Health and nutrition outcomes

One argument leveled in defense of the health impacts of specialized industrial food systems' is the greater selection of fresh food items available year-round. Yet, as the IPES-Food report argues, "the diversity of produce delivered by international trade has mainly benefited wealthy consumers in high-income countries, while poor people in low-income countries continue to be unable to afford the diversity available on these markets (Sibhatu et al., 2015)" (IPES-Food 2016: 27). The IPES-Food Report offers important insights from the literature for governments and for civil society detailing the links between specialized industrial food systems and chronic ailments increasingly associated with affluence and the mass produced, heavily processed foods that characterize contemporary affluent societies: cancer, diabetes, arthritis, heart disease, high blood pressure, depression, obesity, and other conditions that are diet-related.

At the same time, the industrial food system reduces the dietary diversity required to avoid malnutrition resulting in a growing number of people in the U.S. and other regions reliant on heavily processed, meat rich diets suffering simultaneously from the health impacts of both obesity *and* malnutrition. A diverse and balanced traditional diet provides exposure to the anti-oxidant, anti-cancer, and other beneficial properties of various nutrients and non-nutrients, but only if people can access these foods.

This lack of diversity doesn't in any way diminish the role socio-economic conditions play in determining healthy diets. Not only are people with lower incomes likely to eat fewer fresh foods and less produce generally than more affluent fellow citizens, they experience the impacts of food scarcity that are well documented and lead to life long health impacts that effect not only quality and length of life, but the quality of life of future generations.

Numerous studies have demonstrated the correlation between exposure to pesticides and heavy metal residues in food and health problems confronting both farmers and consumers (Li et al. 2008). On the producer side, both long-term and short-term adverse health impacts of pesticides exposure among farmers were found in three provinces of China (Hu et al. 2015). Zhang et al. (2011b) found that 8.8 percent of farmers in China suffered various extents of pesticides poisoning. Exposure to pesticides has also generated significant invisible impacts on farmers' neurological, liver and kidney systems (Qiao et al. 2012).

In addition, the overuse of pesticides residues and veterinary drugs are both cases reflecting food safety risks as side effects of intensive agriculture system. Researchers found that soil degradation resulting from the intensive farming processes make heavy metals more bioavailable to crops (FORHEAD 2014). The accumulation of heavy metal through crop production has resulted in severe health risk such as higher incidence of cancer to residents exposed to heavy metal pollution in many parts of China (e.g. Zhao et al. 2014). "Cancer villages" where cancer morbidity is high due to exposure to carcinogenic chemicals were found across China, particularly in major grain production regions (Lu et al. 2015b). The large scale intensive production of livestock and aquaculture products also fosters the excessive usage of veterinary drugs including antibiotics. This leads to severe long-term health risks because it contributes to the genetic selection of antibiotic resistant bacteria and renders some commonly used drugs to combat diseases in both human and livestock ineffective (FORHEAD 2014).

The expansion of the agro-food industry contributed to the dietary transition in China since the early 1980s, leading to public health problems such as a growing prevalence of overweight and obesity (Garnett and Wilkes 2014, Hawkes 2008). This is partly due to the introduction in China of fast food chains from the west that encourage the over consumption of energy-rich food (Astrup et al. 2008). Studies in many parts of the world suggest that the industrialization of agriculture encourages the over density of energy and the reduction of diversity in people's food intake (IPES-Food 2016: 27-29). Yet, there have not been many studies on the nutritional consequences of the agro-industrialization in China, other than the significant improvement of food security.

1.1.4 Socioeconomic outcomes

The socioeconomic outcomes of agro-industrialization are just as significant as the aforementioned ecological and environmental outcomes. One of the commonly discussed social outcomes is the marginalization of smallholders. The rich but generally negative connotations of the discourses on peasants in modern China, such as their economic underdevelopment, low sociopolitical status and cultural backwardness, justified and shaped the policy trajectories, known as *feinonghua* (非农化), that aim to reduce the number of small peasants and promote the penetration of capital in the agriculture sector (Schneider 2015). Therefore, the process of agro-industrialization in China is accompanied by a marginalization of smallholders in the agriculture sector either through transforming them into urban citizens or supporting vertical integration of them as farm workers. The rise of dragonhead enterprises (*longtou qiye*) in agriculture and contract farming backed by external capitals fosters the dispossession of peasants' own subjectivity of being the sole decision maker of farming. The loss of power of smallholders is further enhanced by the biased supporting schemes from the state that favours large scale and industrialized producers (Scott et al. 2014).

Despite the fact that agro-industrialization resulted in the environmental consequences and food safety crisis, the blame is always cast on smallholders for their "low quality" (*suzhi*) and lack of modern knowledge and skills in farming, as evidenced by Schneider's (2015) study of the pork industry. The marginalization process of smallholders, therefore, is portrayed in developmental discourses as a necessity to modernize the agriculture sector and solve the many crises that plague the current food system and rural China. However, global experiences demonstrate that the outcomes of the requirement of labour input, always considered as a major advantage of industrial agriculture, are debatable (IPES-Food 2016: 24). Just as what has been observed in many other countries, Chinese rural labours pushed out of agriculture could not always find decent alternative employment. Despite a recent surge in labour shortages in cities, the surplus of labour in rural area still persists as a significant socioeconomic problem, due to institutional constraints of living in cities (see Knight et al. 2011). The prosperous informal sector in China in the past two decades also reflects the significance of the problem (Cooke 2011).

Another issue related to industrialized agrifood system is China's increasing reliance upon food imports. This has been particularly obvious since China's integration into the global market after joining the World Trade Organization (WTO) in 2001. Since 2004, China's imports of major cereals have increased sharply alongside its further integration into the global food market. While maintaining a high self-sufficiency rate of 95 per cent has long been a state priority since the announcement at the 1996 World Food Summit, the increase in importation of staple grains (corn, rice and wheat) has outweighed exports since 2010 leading to a continuous decrease in the self-sufficiency rate (ABARES 2014). A news report indicated that China's overall self-sufficiency rate of staple grains, including soybean, has declined to below 87 per cent in 2014 (Li, Y. 2014, see also Figure 2).

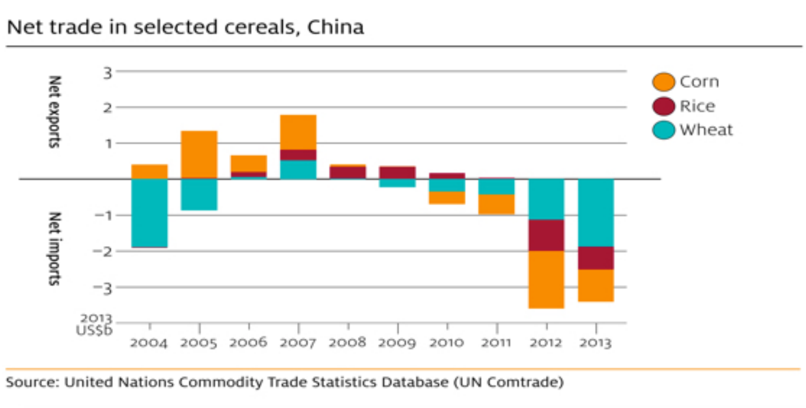

Figure 2. Net trade in selected cereals, China.
Source: ABARES (2014)

In 2016, only 32 per cent of cooking oil consumed, 44 percent of which was soybean oil, was produced domestically (Grain and Cooking Oil Newspaper 2017). The increasing import of food has created pressure on domestic food production, resulting from a dilemma—the increasing imports of foreign grains is not due to the shortage of domestic production but because of the much cheaper price of foreign grains with heavy subsidization (Alpha 2015). This is mirrored in the decline of soybean production in northeast China. Domestic soybean production has continued losing its market share to cheaper imported soybeans since 2004. By 2015, 80 percent of China's consumption of soybean was imported, creating a heightened anxiety of food sovereignty (Jamet and Chaumet 2016).

1.2 Outcomes of diversified agroecological systems

The IPES-Food Report (2016) offers a comprehensive, data rich, interdisciplinary critique of industrial food systems and the costs associated with the industrial model documenting decades of research on the costs and benefits of industrialization. What is of most importance in the report, however, is the detailed discussion on diversified agroecological systems for meeting modern challenges facing Chinese farmers and society more broadly.

Negative population health outcomes increasingly associated with industrial food systems are a key driver towards diverse agroecological systems. Figure 7 from the IPES-Food Report (2016: 28) describes the persistence of malnutrition throughout industrial systems, despite gains made in calorie production resulting from the wide adoption of agrochemical use within farming systems worldwide and of the Green Revolution specifically. Agroecological systems provide opportunities for farming communities and localized food systems to benefit from the co-production of locally valuable nutritionally important crops and commercially valuable financially important crops.

Agroecology offers a pathway forward in an uncertain climate and resource depleted future. Rockström (2009) presented the nine "planetary boundaries" as a way to conceptualize the trans-national nature of our current vulnerabilities for sustaining life. Carbon dioxide and other greenhouse gases (GHGs) are not the only concern industrial agriculture raises. Nitrogen flow, biodiversity loss, phosphorous flow, freshwater consumption, chemical pollution and of course agricultural land use are planetary boundaries identified by Rockström and implicated in our food system. The acceleration towards, and in three cases beyond, the planetary boundaries mirrors the rise of industrialized food systems. In 2014, Kate Raworth added significant value to the Stockholm Resilience Center's modelling to contextualize the nine planetary boundaries in an economics model called "Donut Economics". Raworth updated this mapping of "social foundations" onto Rockström's nine planetary boundaries (renamed ecological ceiling) by identifying indicators—such as access to food, water, and shelter—below which we lack the societal stability to provide the governance and economic capacity needed to address the ecological limits identified as planetary boundaries (see Figure 3).

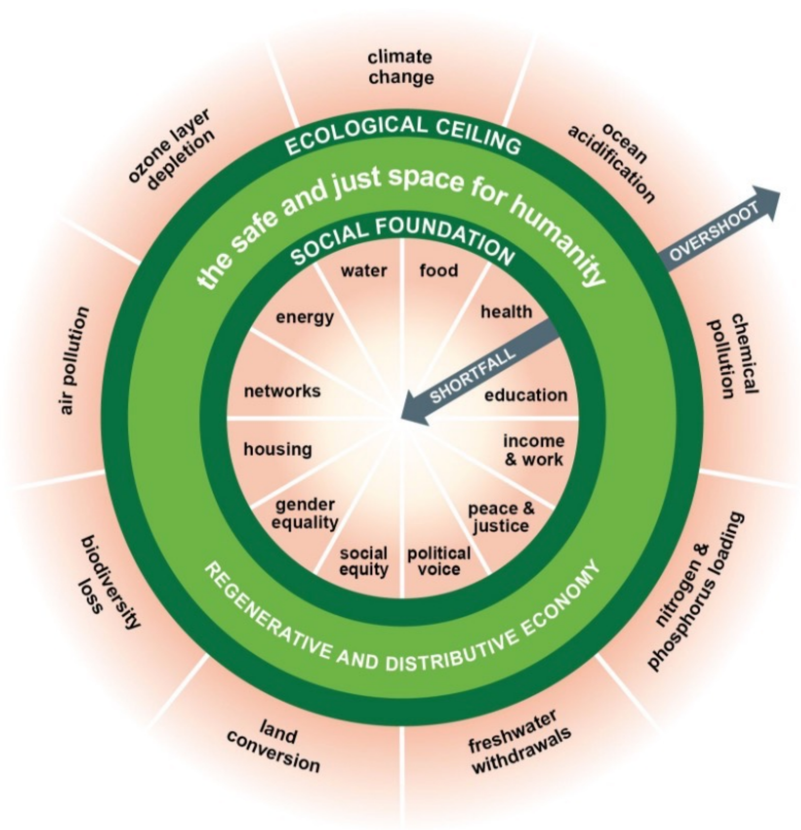

Figure 3. The doughnut of social and planetary boundaries
Source: Raworth (2017)

Diversified agroecological systems mitigate both a) the industrialized agriculture impacts on the ecological ceilings for each of the nine criteria; and b) the social foundation impacted negatively by industrial food systems. The IPES-Food report is contextualized in this view of economics which recognizes social foundations must be intact without exceeding ecological ceilings that ensure the continuation of life if there is to be an economy.

In the agroecological model, lower stocking densities combined with a mixed farm approach ensures that the feces and urine from farm animals can be absorbed in the compost cycle of the farm or region. Using these inputs reduces the need for chemical fertilizers, increases soil organic matter and raises carbon sequestration efficiency. Diverse crops encourage diverse soil micro biome and inter-cropping helps to both reduce pest issues and to reduce the need for irrigation. In addition, greater biodiversity ensures greater resilience for shocks to a crop family. Water and soil are spared contamination by agro-chemicals, and soil building techniques leave the land in better shape than it was found.

1.2.1 Productivity outcomes

Productivity as a measure of commercially viable grain yield per acre misses the important "health per acre" perspective introduced by Shiva and Singh (2011) in which the nutritional value of intercropped species and the input costs are considered when determining how productive a given year was on farm. When total outputs - and not just crop-specific outputs- are considered, diverse agroecological systems outperform industrial agriculture in terms of productivity. The IPES-Food report provides an excellent literature review on productivity. The report includes studies showing total output productivity positively correlated with the number of intercropped species. In particular, the report reviewed studies suggest intercropped plots average 15% higher outputs over monocultures while, in another study, producing 1.7 times more harvested biomass.

In the Chinese context, the productivity of ecological agriculture is a highly controversial issue that generated intensive debates. With the large population size, China is particularly interested in the issue of productivity. Previous studies also found that the skepticism surrounding the productivity of ecological agriculture is a common perception among various stakeholders and, according to some, is one of main reasons that the Chinese government does not fully support the development of organic agriculture (Scott et al. 2014). Despite the controversy, very few researchers study the productivity of ecological agriculture in China. Jiang Gaoming from China Academy of Sciences is one of them. His experimental organic farm, Hongyi Farm, was established in Shandong province in 2006. After three years of restoration of soil fertility with organic compost, he claims that the productivity of corn is 14.5% higher than conventionally farmed field (Jiang 2015).

1.2.2 Environment outcomes

Climate change is expected to have what the IPES describes as “a significant impact” on marginal lands, affecting traditional farmers in particular. Wu et al (2011) show negative impacts on food production in China’s important North China Plain. Ye et al. (2013) identify a literature gap when noting that, despite awareness of China’s particularly vulnerable position relative to climate change impacts, the few studies being done are narrowly looking at agronomic impacts of climate change at the level of production while attention to the links between food security and climate change still require scholarly attention (Ye et al. 2013).

In diverse agroecological systems, synergistic relationships are at the centre of pest management improvements, reducing reliance on and therefore exposure to a host of agrochemicals and undisclosed ingredients found in commercial formulations. The IPES-Food Report highlights the rice-duck systems found throughout Asia as an example of this synergism for pest control. Rice-fish farming is also commonly recognized as a sustainable farming system. In these systems, the ducks or fish eat weeds, weed seeds, insects and pests while their excrement fertilizes the soil. This food chain reduces the need for manual weeding and the usage of chemical fertilizer. Chinese peasants have been practicing rice-fish and rice-duck farming for more than 1000 years. Many studies by Chinese scholars demonstrate the various environmental benefits of the rice-fish and rice-duck farming system. For example, Lu and Xi’s (2006) study shows that the rice-fish farming system significantly reduces the usage of pesticides and chemical fertilizer. It increased the organic matter, total nitrogen and phosphorus in the soil by 15.6–38.5%. Compared to traditional rice farming, the rice-fish farming system also reduces the emission of

CH4 by nearly 30%. Similar results are found in Liu et al.'s (2015) study of GHG emission of an ecological farm in China, which shows that replacing chemical fertilizer with organic manure significantly decreases GHG emission. Zhen et al.'s (2014) study in east China also demonstrates that the application of compost and bacterial fertilizers improves the microbial community structure and diversity of degraded cropland soils.

1.2.3 Health and Nutrition Outcomes

Diversified agroecological systems improve ecological and human health in a number of ways. Shifting away from a handful of species in the diet increases the range and quality of nutrients, assures that seasonality does not effect consistent availability of key nutrients. The IPES-Food Report references several studies linking agricultural diversity and nutrient diversity in various regions, noting that mixed farming systems provide diverse nutrients for producers and consumers and demonstrating that agrobiodiversity leads to positive human health outcomes through both dietary diversity and quality. Aside from improved nutrition through dietary diversity, studies show that health and nutrition outcomes are improved simply through reduced exposure the pesticides and other chemicals used in agriculture. There are also studies demonstrating that specific nutrient densities are improved with organic management, such as the case with omega-3 fatty acids in organic milk and meat, which are around 50% higher in organic than in conventional equivalents (IPES-Food 2016: 39-40).

Due to the high level of anxiety over food safety risks in recent years, the health and nutrition of daily food consumption is becoming an increasingly important issue for Chinese citizens (Lu et al. 2015b). We have seen a growth of popularity of organic and other certified ecologically produced food in Chinese market. Many studies have pointed out that healthfulness is a key factor driving Chinese consumers' purchase of organic food. Si et al.'s (2017) study in Nanjing city shows that the chemical residues in food constitute the major problem of food safety. More than 40% of customers buy organic and ecologically labeled food to combat the food safety challenge. Agroecology therefore has a great potential to become more prominent in China's transitioning food system.

1.2.4 Socio-economic Outcomes

There has been limited study on the socio-economic outcomes of diversified agroecological farming practices in China. From an economic standpoint, crop diversification at the heart of agroecological food systems provide continues production year round. Socio-economic benefits of agroecology also go well beyond the farm gate. Agroecology encourages economic diversity, which the IIED describes as crucial for livelihood resilience (Silici 2014). Diversification is a form of farmer self-insurance.

Not only does this diversity protect against losses- it seems to be good business. The IPES-Food report concludes that despite lower yields, organic agriculture was significantly more profitable (22–35%) than conventional agriculture, and many recent converts to organic are doing so to capture high value markets. Wang et al.'s (2003) study points out that the direct economic benefits of the integrated rice-duck complex system is higher than conventional paddy fields. Studies also identify that diversified agroecological systems can reduce the economic risks associated with natural disasters (IPES-Food 2016: 37-38). For example, a review of the rice-fish farming system in China finds that other than providing food and animal protein for subsistence farmers living in ecologically-fragile mountainous areas, the rice-fish farming system also reduces economic risks that these farmers potentially face (Lu and Li 2006).

Agroecological food systems are also employment strategies. The IPES-Food report references several studies that identify agroecological systems as being more labour-intensive and organic agriculture having the potential to provide 30% more jobs per hectare than conventional farming. Greater employment both on farm and throughout the agroecological system (localized processing, distribution and preparation) can produce cohesive rural communities, install pride in young people engaged in skilled artisanal food production, and improve food security by re-skilling workers in traditional agroecological practices and systems-based science.

2. What is keeping industrial agriculture in place in China?

The comparison of specialized industrial agriculture and diversified agroecological system in the Chinese and global context demonstrates the remarkable potential of the latter system to alter the various negative outcomes of the industrialized system. Yet, the specialized industrial agriculture still prevails nowadays and its dominance overshadows the potential benefits of agroecological system. This puzzle entails a closer examination of the factors that have been keeping industrial agriculture in place in the Chinese context. Building on the IPES-Food report, the following section explores the relevance of the eight major lock-ins of industrial agriculture in China including factors associated with political structures, agriculture markets, and conceptual barriers. It also discusses some other China specific factors in this analysis. It is these factors (lock-ins) that need to be broken if a transition towards diversified agroecological systems in China is to be achieved in the future.

Lock-in 1: Path dependency

Industrial agriculture always demands large investments in high-cost agriculture inputs, machineries and large-scale facilities specifically designed for specialized production. Because farmers are already invested in specialized equipment for their systems, transitioning is unlikely. The rising cost of labour justifies large-scale specialized production in China as temporary migration from rural areas to cities and from agriculture to other sectors gathered pace. This socioeconomic transition led to the reduction of agriculture inputs that has garnered attention among agronomy researchers (Li and Tonts 2014).

Other political and market incentives tailored to industrial farming also function as proponents of industrial mode of food production. This is exemplified by agriculture subsidy programs that favour large-scale agrifood companies, such as the various supports that “dragon-head enterprises” receive from the Chinese government. The bias towards industrial agriculture is also reflected in the foci and results of agriculture research. Chinese Academy of Agriculture Sciences, for example, has conducted research mostly in hybrid seeds cultivation, aiming to overcome the obstacles to agriculture industrialization and modernization.

Subdivisions of chemical based agriculture are also dominating disciplines and curriculums in Chinese agriculture universities. The path dependency is reinforced by the rapid expansion of supermarkets and modern food supply chains in China since the 1990s that often require stable, standardized and large amount of supply of food that is hard for diversified food production to cope (Hu et al. 2004). The synergy between the economic, political and institutional settings enhances the path dependency of industrial agriculture.

Lock-in 2: Export orientation

Food policies in the world are increasingly geared toward global food trade, causing growing supports for specialized food production and the reduction of plurality (IPES-Food 2016: 47). However, the situation in China differs for its relatively high self-sufficiency rate. Despite the growing concerns of the decline of self-sufficiency rate, China is still one of the few countries with a large population to rely mostly on domestic food production to feed itself. Statistics show that more than 95 percent of rice, wheat and corn, the three most consumed staple grains are produced domestically (ABARES 2014). As China's food imports outweigh exports, it is difficult to say that export orientation is a lock-in as other factors to keep industrial agriculture in place.

Lock-in 3: The expectation of cheap food

The changing food retailing and consumption patterns have shaped the agriculture sector in various aspects. On the one hand, the development of mass retailers (wholesale and supermarket chains) that relies upon a stable supply of large amount of cheap uniform food commodities stimulates the expansion of industrial agriculture. This is because the nature of industrial agriculture (i.e. mechanized, standardized, large-scale, mono-cropping) enables it to supply food with uniform quality at low costs, although at high environmental and social expenses that are not fully reflected in the price. While cheap but profitable processed food, with a limited number of staple grains as major ingredients, is widely distributed and marketed at modern food retail chains, it reconfigures the consumption patterns and feeds into the growing demand for the few varieties of grains commonly produced by industrial agriculture (IPES-Food 2016: 49). On the other hand, the demand for cheap food is further enhanced by the rapidly increasing demand for animal products, particularly pork and dairy products in China. Although the growing awareness of healthy eating in recent years cuts down meat consumption of some households, the trend of growing popularity of animal products in general has not been altered. This in turn facilitates the scaling up of meat production because small livestock production could not meet the supply demand. The demand in China also drives the expanding monoculture of soybeans and imports of animal products (Bloomberg News 2017).

Chinese consumers have become accustomed to the abundance of cheap food. The low price of food has made eating out and ordering food from online platforms daily routines for busy urban workers. In recent years, the revenue of China’s restaurant industry has been experiencing double digit growth (Daxue Consulting 2016). In 2016, the gross merchandise volume of China’s online food delivery market reached 166.2 billion yuan (US$24.18 billion), which was almost eight times to the size in 2011 (Tao 2017). While industrial food might be cheap, its price does not incorporate the many externalities generated during its production, processing, distribution and retailing. Yet, consumers rarely recognize these externalities. Instead, the popularity of eating out and food delivery services in Chinese cities further disconnect consumers from the food system, physically, economically and cognitively (IPES-Food 2016: 50). In this way, consumers’ daily food experience that should have been rich and meaningful has been reduced and simplified to just nutrition intake. For many of the farmers already caught up in the industrial food system, there is little choice other than to further specialize their production, in order to continuously supply large volume of cheap food commodities with uniform quality to the food industry.

Lock-in 4: Compartmentalized thinking

The compartmentalized thinking in the global context is reflected in the siloed structures of the agricultural research and education system, the knowledge and technology transmissions to farmers, as well as policy making structures (IPES-Food

2016: 51-52). It prioritizes productivity growth over other increasingly urgent concerns of agriculture. It also ignores the complex dynamics of natural environment and human society interactions that underpins the current food system. It goes hand-in-hand with the marketization of the agriculture sector during which capitalist logics triumph over social ecological rationales. In the compartmentalized mindset, agriculture is treated merely as an activity to produce profitable food commodities rather than people's livelihoods and an inseparable part of the ecosystem. People and Mother Nature involved in agriculture, as a consequence, lost their subjectivities and are reduced to inputs for a linear system.

The compartmentalized thinking's supportive role on the expansion of industrial agriculture in the global context can be traced back to the early 20th century, and was later solidified in the so-called "Green Revolution" in the post-war period. While it is widely recognized that the Green Revolution might not be that green or socially just and inclusive, China's agricultural research, policy and industry structures is largely schemed with the Green Revolution mindset. That is, prioritizing the breeding and dissemination of a limited varieties of input-responsive staple crops, stressing the roles of technological innovation and adopting the value-chain approach (IPES-Food 2016: 51). The Green Revolution thinking in China is deeply rooted in its historical food security challenges, particularly the Great Famine from 1959 to 1961. Producing enough food has been the outset of the earthshaking era of Reform and Opening up since 1978. The capability of continuously increasing food production has always been portrayed as one of Chinese government's greatest achievements and thus, legitimizes its authority.

The agriculture research and education system in China that accords with the general goal of productivity has been major contributors to the country's food productivity growth (Huang et al. 2004). To address the national food security concern, the research focus in the 20th century was mainly on the productivity of staple grains since the 1950s with increasing focus on livestock and other types of food. Agriculture research was largely financed and conducted by the public sector including universities and other institutes. Research expenditure of the private sector was as little as 1.7 percent of the nation's total agriculture research budget in 1999 (Huang et al. 2004). However, researchers have observed a rapid growth in investment in private food and agricultural R&D in China in recent years, particularly conducted by state-owned agri-businesses such as China National Agricultural Development Corporation (CNADC) and China National Cereals, Oils and Foodstuffs Corporation (COFCO). Other privately listed companies also contributed to the privatization of agricultural research (Pardey et al. 2016). This implies an enhancement of focus on market-oriented food commodities that can secure significant returns. In both the public-led and private-led periods of agriculture R&D in China, traditional and minor crop varieties and livestock breeds and farming technologies are marginalized and ignored.

The compartmentalization in policy making also renders China's food policy lacking of systematic and inclusive strategies. Food security policies, for example, are highly biased towards agricultural outputs and the rural context, with limited attention on other key components of food security such as the sustainability of production, food accessibility and food utilization (Scott et al. 2014, Regnier-Davies 2015). Although more policy efforts were spent in recent years on controlling food processing, retailing and consumption due to heightened food safety concerns, there is still a significant lack of food system thinking in the policy making process (Si and Scott 2016a). Concerns of agricultural productivity are often isolated from other priorities and well support industrial agriculture's goal of increasing productivity. Moreover, the development of ecological agriculture is a systematic undertaking, and having only one or two support policies is utterly inadequate. The policy-making structure, reinforced by the compartmentalized agricultural research and education system, constitutes one of the major lock-in factors for industrial agriculture.

Lock-in 5: Short-term thinking

While critiques on short-term thinking in policy-making always originate from its electoral cycles facilitating short-term policy solutions, the short-term thinking in Chinese context is reflected in local government's need for better performance and investor's interest in acquiring quick investment returns. The single-party political system ensures a certain level of policy consistency at the central government level. Yet, the central government has also been emphasizing provincial governments' responsibilities for the “rice Bag” and municipal governments’ responsibilities for the “vegetable basket” since the 1980s (Liu et al. 2004). This results in a strong motivation of local governments to secure short-term grain and vegetable supply in their jurisdictions. Agricultural output therefore has been a key indicator in the performance evaluation of corresponding local government officials. It overshadows other increasingly urgent food issues and facilitates the short-term thinking in local government policies.

The short-term thinking is perhaps more obvious among food production. While transitioning to ecological farming is a gradual process that demands time to build up soil fertility and the farm ecosystem, it also means high cost for farmers, especially smallholders who are the majority of farmers in China. This calls for more supports from the government but ironically most supports go to large-scale (by Chinese standard) industrial agrifood companies (Scott et al. 2014). Dragon-head enterprises, a designation only bestowed upon large-scale industrialized agrifood companies, has enjoyed government supports ranging from financial services, tax reduction, marketing support to land access (China State Council 2012). The majority of Chinese smallholders are left in a disadvantageous position in this competition. Diversified agroecology approaches of farming that do not generate immediate benefits were marginalized in this broad picture.

Lock-in 6: ‘Feed China’ narratives

China has never made any commitment to feed the world. Instead, its perseverance of feeding its own people ever since the establishment of the PRC has led to a series of food policies in the past few decades. Its food policies as a result are to a great extent inward oriented. This “feed China” sentiment was reinforced by the widely debated question “who will feed China” owing much to the report written by Lester Brown, president of the World Watch Institute in 1994 (Brown 1994). It was just in 1995 that China shifted from a net cereal exporter from 1992 to 1994 to a net importer, accompanying a global cereal price spike in 1995-96 (Pinstrup-Anderson et al. 1997). The report not only raised an alarm of China’s Malthusian tragedy among many ordinary Americans but also frenzied the debate on how China will meet its growing food requirement within China (Boland 2000). Various reports on the productivity potential were published to reply to Brown's report (e.g. Cai & Zhou 1999, Liang 1996, Wang 1997). Brown's analysis, despite its errors in his data and analysis, enjoyed authority at global food security meetings such as the 1996 World Food Summit (Boland 2000). In this milestone gathering, the Chinese government made a commitment that it will strive to maintain food self-sufficiency. The "feed China" narrative, although different from "feed-the-world" narrative, has become a political mission and a catalyst for China's agroindustrialization.

Adding to the emphasis on food self-sufficiency is the establishment of "farmland protection" as a basic national policy in the 1998 Land Management Law and the launch of the "1.8 billion mu (1,200 million hectare) farmland protection program" in 2006. These governmental moves on farmland protection sent clear messages of its central focus on the quantity of food production. While there is no doubt that producing enough food should be the top priority, this productivity-centred narrative, which directed China's basic food policies, goes hand in hand with industrial agriculture. It justifies the continuation of the industrial agricultural system, deflects attentions away from its consequences, and sidelines the discussion of the latent benefits of diversified agroecology systems. It fails to answer the question of how food could be produced and better distributed to everyone, particularly marginalized groups with limited resources, in a way that enhances farmers' livelihoods, public health, social well-being, equity and justice.

Lock-in 7: Measures of success

The evaluation of different agriculture systems is always based on productivist indicators such as total yields of specific crops and simplistic cost-benefit analysis, which fails to count in ecological, social, cultural variables and the complexity of the system (Flores and Sarandon 2004). These evaluation approaches, most of which are academic studies underpinned by neoliberal economics, are also obvious in Chinese policies measuring agricultural success. One of the overarching evaluation schemes is the "rice bag and vegetable basket" scheme proposed in the 1980s and emphasized in regulations many times throughout the decades. It specifies the provincial government's responsibility for the production and supply of staple food such as rice, wheat and corn and the municipal government's responsibility for the production and supply of vegetables, meat and agricultural by-products. In 2017, the State Council issued a regulation to clarify the evaluation approach of the “vegetable basket” responsibility (State Council 2017). The major indicators stressed in the regulation are the productivity and safety of vegetables and meat, the spatial distribution of retailers, price volatility and control, construction of storage facilities and information sharing platform, as well as satisfaction degree of citizens. While food access and food safety are clearly indicators incorporated, environmental or social equity and justice indicators are simplistic or absent in the assessment system.

The measuring indicators of sustainable agriculture demonstration areas issued by the Ministry of Agriculture in 2017 (Ministry of Agriculture 2017) convey more environmental concerns by including reporting items such as the recycling rate of agriculture waste and the usage of chemical fertilizer and pesticides. Yet, most of the mandatory reporting items still emphasize the scale of standardized production bases and total output, leaving limited discursive and policy space for diversified agroecology systems. The metrics used by the Chinese government indicates an unquestioning embracement of the standardized uniformed agriculture system and an under valourization of the potential benefits of alternative systems. They overlook the dynamic feature of sustainability, in that the agriculture sector has to recover from shocks and sustain production under stress conditions while diversified agroecological systems can perform well on these fronts (IPES-Food 2016: 56). The concern of working condition of farming labours is also absent in the system. The benefits of agroecological systems, as explained in previous section, should be better incorporated into the assessment systems and reflected in agriculture and development policies.

Lock-in 8: Concentration of power

Rural sociology studies suggest that the concentration of power among transnational agribusiness constituted the third food regime, which promotes the expansion of the industrial agriculture mode at the expenses of the environment and smallholders’ livelihoods (McMichael, 2005). Experiences in many countries reveal various ways that the concentration of power can impact the agriculture sector, such as using the power to frame the problems and solutions, lobbying policy-makers, leveraging influences to secure favourable research focuses, campaigns to discredit crop science, and co-opting the alternatives (IPES-Food 2016: 58).

Unlike the high level of power concentration in the food system in the West (Clapp and Fuchs 2009, Howard 2016), China's agriculture sector is relatively dispersive. This is evidenced in the domestic seed industry, compared with the highly concentrated global seed industry. Multinational corporations only controlled less than one fifth of the grain seed market (Elgion and Zuo, 2014). However, it has also been experiencing growing trend of capitalization in recent years, driven by both domestic and international forces (Zhang and Donaldson 2008). It was estimated that the number of seed businesses dropped from 1,4000 in 2002 to about 5,000 in 2016. Large state owned companies and companies with hybrid ownership such as Longping High Tech, Beidahuang and Shandong Denghai maintain stronger presence in China's grain seed industry (Gaudreau 2017). As the concentration of power is still nascent in China, it is challenging to examine how this will affect China's agriculture sector in the long run.

Other challenges of the transition to agroecology systems in China

The various lock-in factors examined above forge a strong foundation for the continuation of industrial agriculture in China. In recent years, China's agriculture policies have been gradually incorporating more sustainability concerns. Yet, the transition towards agroecology systems in China still has a long way to go also because of the inherent problems within the ecological agriculture sector. The first obstacle is the unequal access to government supports. Our recent visits to ecological farmers in China found that not all ecological farmers can benefit from government supports (both financial and material). Some farmers who have personal relations with local government agencies enjoy preferential access to policy benefits. In addition, local government officials may take a portion of the payments or other resources that should have been allocated to farmers.

What is more challenging is the adaptation to chemical agriculture among Chinese farmers. Despite the fact that Chinese farmers are well known for their rich traditional knowledge and technologies of ecological farming, after decades of promotion of agrochemicals, most Chinese farmers got used to chemical intensive agricultural practices. Knowledge of traditional ecological farming approaches is lost to a great extent. Meanwhile, the marketization of agriculture has led to a preference of high efficiency, high yield and less labour intensive agriculture among farmers. The trajectory towards industrial agriculture therefore is hard to be changed.

Studies on the ecological agriculture sector in China also reveal other hidden problems that jeopardize the transition towards agroecological systems. According to Chen's survey, about 80 percent of bio-pesticides in the Chinese market are adulterated due to intentionally added synthetic chemical contents. A market inspection conducted by the Ministry of Agriculture in 2015 found that 96.2 percent of bio-pesticides sampled were disqualified (Wang 2016). Many of the bio-pesticides tested were found mislabeled, with no indication of the active bio-contents they claimed. This troubled bio-pesticide market renders Chinese ecological farmers afraid of purchasing fake bio-pesticides.

The economic viability of ecological agriculture in China is another major factor that prohibits the ecological transition. According to our interviews in China, although organic and ecological food enjoy a quite high price premium, many ecological farmers are still losing money or hardly making both ends meet, even several years after conversion. This is probably due to the enormous challenge of marketing in a market environment where consumer trust is significantly deteriorated and also the increasing costs of production. The distrust of consumers is further strengthened by instances of fake organic produce revealed by the media.

The policy direction that favours industrial agriculture, despite the recent emphasis on sustainability, also makes transition a difficult task. Sustainability concerns, as reflected in buzzwords of policy documents such as 'ecological civilization', 'circular economy' and 'low carbon economy', needs to be taken more seriously rather than a 'flavour' of the many pro-industrial agriculture policies. The current policy direction mirrors the problematic pursuing of the American model, which is related to the long-standing “learning from the western” mindset in China’s policy realm. While ‘agriculture modernization’ has been emphasized to be the top priority of many agriculture policy documents, the interpretation of modern agriculture is subjected to extensive discussion.

3. Emerging opportunities for a transition to diversified agroecological systems in China

China is in a unique position globally to become a leader in sustaining food systems technology. Diversified agroecological systems contribute to domestic food security and healthy outcomes as illustrated earlier in this report. China can export not only desirable products but desired skills, plant materials, and livestock as a result of investing in the technology. Various state policy objectives are met through the widespread uptake of diverse agroecological systems. China’s capacity to direct public research investments and state-owned agribusiness interests’ investments could place Chinese companies and Chinese scientists in a position of international leadership.

According to agroecologist Steve Gliessman, agroecology is a science, a practice, and also a change process, through which we should bring research, education, actions into changing the sustainability of the whole food system. Gliessman’s research suggests that transitions from industrial agriculture to sustainable food systems can be categorized into five levels: On the first level, we decrease chemical inputs. At the second level, we take out the inputs, followed by the third level in which we redesign the system by considering biodiversity and ecology. These first three levels are production-oriented. Level four requires we build Alternative Food Networks based on human relationships. For the fifth level, Gliessman says we must build on the production levels 1 through 3 and adopt the relationships in level 4 to fully address the social and cultural concerns within the food system. (FAO meeting Agroecology notes day 2 keynote).

The IPES-Food report considered trends within the opportunities to shift from uniformity to diversity, and settled on eight recommendations, which we discuss in the Chinese context below:

3.1 Policy incentives for diversification and agroecology

Globally, governments are creating incentives to move production towards sustaining food systems. The IPES-Food Report speaks of Brazil, where nine ministries have stepped out of their silos to cooperate on the National Plan for Agroecology and Organic Production, a model for other states. Targeting increased consumption of healthy foods in part by encouraging use of traditional plants and animals in the food system. The report also references the EU's 2013 CAP reforms. These changes implemented sustainability targets into the agricultural subsidies, such as automatic recognition for certified farms, and for non-certified farms, adding some crop diversification, permanent grasslands protections, and ecological focus areas. (IPES-Food 2016: 60)

Having recognized the adverse impacts of industrial agriculture, the Chinese government has been sending messages to support the development of ecological agriculture. The Ministry of Agriculture established the Rural Energy and Environment Agency in 2013 to facilitate the policy enforcement and promotion of ecological agriculture across the country. The National Modern Agriculture Planning (2011-2015) calls for more public investment in the restoration of agricultural environment and promotes the multi-functionality of agriculture in urban areas. This indicates an integration of environmental concerns in modern agriculture development agendas, although the integration is quite limited. Another major policy opportunity lies in the establishment of national and provincial ecological agriculture demonstration counties and sites. By 2015, the central government has designated more than 100 national ecological agriculture demonstration counties. Provincial governments also established more than 500 provincial ecological agriculture demonstration counties and more than 2,000 ecological agriculture demonstration sites. These demonstration sites and counties received various subsidies and policy supports from both the central and the provincial government.

The Ministry of Agriculture established the Rural Energy and Environment Agency in 2013 to facilitate the policy enforcement and promotion of ecological agriculture across the country. The National Sustainable Agriculture Development Planning (2015-2030), a guiding document jointly issued by eight central government agencies in May 2015, marked a new beginning of agriculture development in China.

In addition to these national policies, the Chinese government issued various supports for the so-called "three certifications and one symbol" (*san pin yi biao*) agricultural products—"three certifications" refer to hazard-free, green and organic food certifications and "one symbol" refers to geographical indication product. Many food companies get their certification costs covered by the government. In Puji county, Sichuan province, a series of policies support the development of agroecology. For example, specialists help small farmers opening e-stores to link the markets, but only after their production reaching the standards set up by the government.

In a few cases, the government also supports the development of alternative food initiatives that promote diversified agroecological systems. The most prominent CSA farm in China—the Little Donkey Farm—located in Haidian district in Beijing accessed the land and financial resources through the support of the local government. Its sister farm—the Big Buffalo Farm—in Changzhou, Jiangsu province also received supports from the local government. Many other ecological farms also received various supports from the government, although in most cases, these supports are not explicitly for ecological farms. It is also worth to mention that in its "Regulations on the Construction of Ecological and Civilized City" issued in 2009, Guiyang city in southwest China became the first local government that set the development of community supported agriculture (CSA) farms as one of the government's priorities.

China is becoming a world leader in green economy fields such as solar power. Yet, compared to the attention given to the greening of industry, of transportation, and other issues in China, the greening of *agriculture and food* has received less media (and scholarly) consideration, despite considerable developments on the ground in this sector. Even without the creation of new policies, however, China could repeat its solar success in agriculture and food by pursuing diverse agroecological foods systems. Building on the existing policy initiatives, investment in and promotion of agroecology for multiple benefits could improve outcomes and make China a sustainability leader.

3.2 Building joined-up 'food policies'

Governments in countries that have long industrialized their food systems are beginning to recognize that policy silos prevent governments from effectively managing multiple and sometimes competing interests amongst citizens and the business community. As a result, policies can actually operate counter to government's stated objectives.

Joined-up policies in China in support of agroecological systems could begin with recognizing the multiple values in food. Currently, food as a tradable good is the only value, ignoring what Jose Luis Vivero-Pol (2017) characterizes as the other five food values in his Six Food Dimensions concept. While agroecological systems depend on shifting the ways we value food, U.S., Canada and other food exporting nations struggle to monetize food beyond a tradable good.

In China, ensuring that the policy mandates connecting rural development, health, environmental stewardship, and food security are seen as parts of a whole, limiting the impacts of decision-making in isolation that undermine societal goals for short term productivity.

3.3 Integrated landscape thinking

New concepts have emerged from the praxis of food policy councils, regional leadership and other champions of sustaining food systems. A complex array of classifications and conceptualizations over the past 30 years have perhaps muddled the academic conversation around what is at the root called "integrated landscape thinking". Reed et al. (2016) identify three key barriers to increased efficacy for integrated landscape approaches. Too often champions of integrated landscape thinking have simply failed to acknowledge the inevitable trade-offs and promising unrealistic win-win scenarios. While such processes raise the profile of interdisciplinary approaches in words, in practice too often even ardent champions have struggled to overcome disciplinary boundaries. Finally, Reed et al suggest the research community itself is possibly ‘muddying the waters’ when offering solutions to pressing scientific questions, resulting in an endless stream of dense terminology in relation to landscape approaches to developmental and ecological constraints (Reed et al 2016).

The IPES-Food reports on a study of 87 integrated landscape initiatives in 33 African countries, in which 72% of participants reported positive outcomes in at least three domains (IPES-Food 2016: 62). In October 2015, 100 international mayors met in Milan for World Food Day, and committed to the Milan Urban Food Policy Pact. This pact is the first international protocol calling on cities to develop sustainable food systems that grant healthy and accessible food to all, protect biodiversity and reduce food waste. Beijing, Chongqing, Guangzhou and Shanghai are the four Chinese cities among the 171 signatory cities. In 2017 Mayors have committed to unite again to discuss their collaborative efforts, share experiences and document best practices. The FAO’s role is in developing indicators cities can use to assess their progress on these commitments.

Despite the challenges inherent in integrated landscape approaches, municipalities are engaging in efforts to address sociological and ecological realities of our current approach to food. Urban-rural cooperation has helped to support the preservation and regeneration of landscapes. The Chinese government has also been promoting urban-rural coordinated development in recent years. It provides an incentive to rethink some of the land use policies from the perspective of integrated landscape.

3.4 Agroecology on the global governance agenda

Intergovernmental responsiveness to the case that has been made for fundamental food systems transformation is on the rise. As national governments face crises that are global in nature, addressing the underlying causes of inequity and vulnerability within our food systems becomes increasingly necessary. While much remains to be done to achieve the kinds of global governance infrastructure required to transition, a range of intergovernmental assessments and processes have been initiated in recent years. The IPES-Food Report highlights several such processes, including the 2005 “Millennium Ecosystem Assessment” (which calls for shifts to agriculture to reduce its role in the alarming ecosystems degradation the assessment observed), the 2009 “International Assessment of Agricultural Knowledge, Science and Technology org Development (IAASTD)” (a study with 400 collaborators from FAO, World Bank and others calling for a fundamental paradigm shift), and in 2015, the “Sustainable Foods Programme” from FAO and UNEP (which serves to accelerate developing and developed countries’ shifts towards sustaining food systems) (IPES-Food 2016: 62).

Global governance moves at a glacial pace, however assessments like the IAASTD give governments evidence-based recommendations for moving forward and provide a road map that each region will need to fill in relative to their own socio-ecological realities and political will. By prioritizing the indicators developed in these assessments and building principles from these reports into national policy, nation states can make steps in a common direction. As we highlighted earlier in the paper, the eight lock ins identified by the IPES-Food report require addressing flaws in our global trade agreements and building accountability for industry relative to these lock ins. As climate change continues to dominate global governance discussions, it is an opportunity to raise agroecology as a good news story within global governance arenas.

3.5 Integrated food systems science and education

In the global context, agriculture related educational structures and programmes are witnessing an evolution to systems analysis, and agroecology is garnering supports in the international scientific community (IPES-Food 2016: 63). In China, agroecology has been established as a discipline since its introduction in 1975 (Luo 2016). Research and practices of ecological agriculture has also accumulated rich experience in the 1980s and the 1990s, with the strong supports from the central government (Ye et al. 2002). In this period, what is known as “Chinese ecological agriculture” was promoted to address the environmental impacts of conventional agriculture and the limited productivity of traditional agriculture (Ye et al. 2002, Shi 2002).

The research focus of agroecology has experienced several shifts in the past three decades. The research started from analyses of the energy and material flows of traditional agroecological systems in the 1980s. In the 1990s, climate change, biodiversity and sustainable development became hot topics in agroecology studies and this was later joined by circular economy, low carbon economy and clean agriculture production in the late 1990s. With the introduction of landscape ecology and molecular biology methods in the 2000s, agroecology research has extended to both macro and micro scales (Luo 2016). While the original agroecology studies in China are explicitly focused on the functionalities of the agroecosystem from scientific perspectives (e.g., crop science, soil science, animal science), since the 2000s, the content of agroecology research and education has gradually recognized the roles of socioeconomic factors in the development of sustainable agriculture and incorporated more analysis of social economic dimensions (Luo 2016). Substitution of chemical inputs with organic inputs, water saving techniques, no-tillage methods, and pollution control in agriculture are hot topics in agroecology studies.

Besides agroecology programs in many agriculture universities which are the major players in agroecology education (see Luo 2016), academics in several Chinese universities have been proactively advocating the potential and rights of small farmers in sustainable agriculture development. Liang Shuming Rural Reconstruction Centre affiliated with China Renmin University for example has been facilitating ecological farmers' cooperatives and organizing training for youth to participate in sustainable rural development across the country. The Institute of Rural Reconstruction of China in China Southwest University was established in 2012 to advance the education of holistic and sustainable rural development knowledge and experience including ecological agriculture modes and practices.

Emerging initiatives of integrated public food education are also found in several leading community supported agriculture (CSA) farms such as the Little Donkey Farm and the Shared Harvest Farm. The CSA model became popular in the past eight years and has been a viable model for conducting ecological agriculture on small and family farms. The Little Donkey Farm as the most well-known CSA farm in China has been promoting the CSA model through organizing training workshops for farmers to learn about CSA operation and management. It has also been cohosting the annual national CSA symposium to facilitate peer learning among farmers. The Shared Harvest farm, established in 2013, launched the "Children of the Earth" (*dadi zhi zi*) program in 2014, an educational program on its production base in Shunyi district providing food education to children and primary and secondary school students and their parents. Lectures on rooftop gardening are also being offered. These learning opportunities not only enable children to engage closely with agriculture and nature but also raise public awareness of sustainability. In addition, both the Little Donkey Farm and Shared Harvest and many other ecological farms in China provide internships for aspiring new farmers, often university graduates.

3.6 Peer-to-peer action research

Agroecology research has witnessed an emergence of participatory approaches, enabling the development of locally adaptive techniques and knowledge. In contrast to the one solution-fits-all goals of industrial-oriented research, the agroecology paradigm demands participatory research that generates meaningful results for specific local ecological and socioeconomic conditions. To answer this call, researchers in China have conducted successful peer-to-peer action research in China, particularly around seed breeding, the promotion of ecological farming approaches, and the conservation of agricultural heritage systems.

The Center for Chinese Agricultural Policy (CCAP), the country's leading public agricultural policy research organization, facilitated the participatory seed breeding projects. As China's public funded agriculture research is increasingly disjointed from local demands (in terms of its exclusive experimental conditions, disconnection from farmers and local practitioners, disregard for local biodiversity), a group of "action researchers" including plant breeders, extensionists, farmers and policy researchers have started a participatory research in villages in five counties in Guangxi province. By working with local farmers and other stakeholders, this initiative bridged formal plant breeding (R&D) system with farmers, adapted innovations to local conditions, increased maize yield and farmers' income, and also facilitated policy changes (Song and Vernooy 2010).

Researchers from Chinese Academy of Sciences have been working on the conservation of traditional agroecology systems designated by the FAO as the Globally Important Agricultural Heritage Systems (GIAHS). Their research aims to better understand the ecology, indigenous knowledge, tradition and culture associated with the GIAHS, and explore their potential in meeting the contemporary challenges in agriculture and rural development. The research also formulated a more holistic approach to go beyond scientific studies of the GIAHS to study the GIAHS as a whole, with equal emphasis on their history, culture and customs (Fuller et al. 2015).

3.7 Sustainable and healthy sourcing

A range of responses to the increasing public concerns about the health impacts of the industrial food system are emerging around the world. Organic food sales are growing steadily. The market share of sustainability-compliant and Fairtrade certified food is increasing. Home-grown school feeding programmes and public procurement programmes are developing in growing number of cities and countries. Some under-utilized crops are being recognized from their nutritional benefits (IPES-Food 2016: 64).

In China, similar opportunities for agroecology transition are emerging. The sale of organic food has been rising steadily in recent years, with an increasing number of certified products. According to the Chinese Certification and Accreditation Administration, the governmental agency in charge of setting organic certification standards and accrediting certification agencies, in 2016, 1.74 billion packages of organic produce, valued 36 billion yuan (5.3 billion USD) in total, were sold nationwide, a rise of 16 percent from 2015 (Wang 2017). About one percent of China's farmland was certified organic in 2016. In addition to the growth of domestic sales of organic food, some private schools and companies start to source organic food for their canteens. The Waldorf School in Chengdu for example periodically organizes organic farmers' markets to promote organic food and organic farming lifestyle (Wu 2013).

3.8 Short supply chains

Significant attention has been given to the impressive grassroots development of various short food supply chains around the world in recent years. Driven by food safety concerns and the lack of trust in conventional food sources, short supply chains, particularly CSA farms and ecological farmers' markets, have also been proliferating in China in the past eight years (Wang et al. 2015a). It was estimated that by the year 2016, there were more than 300 CSA farms across the country, mainly located at the peripheries of cities. The Hong Kong based NGO Partnership for Community Development (PCD) has been proactively working with local NGOs, farmers and other stakeholders to promote the community supported agriculture model and other short food chain initiatives in China (Si et al. 2015). They have developed training programs to support young rural returnees to start ecological farms in their home villages, such as their imperative role in fostering the development of China's first CSA farms located in Anlong village. The New Rural Reconstruction Movement in China has also been facilitating the convergence of various initiatives on many fronts (Si and Scott 2016b).

Accompanying the development of CSA farms is the emergence of ecological farmers' markets in some Chinese cities. These markets, significantly different from conventional wet markets in various dimensions, offer venues for direct communication between small ecological farmers and concerned consumers who are willing to pay extra for safe and healthy food. Although often facing social political constraints, these markets have garnered tremendous momentum in some cities (Si 2015; Zhang et al. 2016). The Beijing Farmers' Market as the first and most influential ecological market in China managed to expand to three markets a week operating at multiple locations in Beijing. These markets not only provide an alternative venue for safe food but also make small-scale ecological farms economically viable, thus offer a notable opportunity for the agroecology transition in China.

Direct purchase from ethnic minority groups in remote areas are also facilitated by consumer groups such as "nested market" project established by scholars (van der Ploeg et al. 2012) and buying clubs in major cities. One example is the organic restaurant called Tusheng Liangpin in Nanning city that sources high quality food directly from the province's ethnic minority villages (Song et al. 2015). The initiative transformed agricultural production in the village has from a maize-based system to an integrated crop-livestock system. The Hong Kong based PCD also has projects to support the development of short food supply chains that connected ethnic minority groups with urban consumers. These initiatives provide livelihood opportunities to marginalized communities and disseminate food and agriculture knowledge to urban consumers.

4. Recommendations for moving toward diversified agroecological systems in China

The various opportunities we identified in the previous section are challenging the industrial food system and its supportive policy system in multiple ways. However, as the Chinese government are still promoting the standardized industrial farming mode to eliminate smallholders and scale up the agriculture sector, there has been a significant problem jeopardizing the continuous growth of the ecological agriculture sector. On the one hand, the current high price of organic food and other non-certified quality food is unaffordable for most consumers who are eager to access quality food; on the other hand, the vast majority of small farmers do not have the capacity needed to convert to ecological farming. This is a problem we call "the two 'dead-ends'".

To foster the paradigm shift towards diversified agroecological systems is to solve the two 'dead-ends'. This is because rather than eliminating smallholders, agroecological systems transition demands the participation of small farmers not only because of their dominance in the agriculture sector but also because of their rich knowledge of local conditions. Thus, capacity building among smallholders is critical. With more farmers participating in the transition and the expansion of the ecological agriculture sector, quality food will become more affordable for consumers. That being said, the transition is far beyond converting more small farmers to ecological farming. This is reflected in the recommendations identified in the IPES-Food report.

The IPES-Food report (2016: 65) identified seven key recommendations that specify actions to be taken for supporting the paradigm shift. These recommendations are proposed to break the key lock-in factors that keep industrial agriculture in place (see Figure 14, IPES-Food 2016: 67). The report summarizes many inspirational cases from around the world. Each of them merits more careful analysis in terms of its feasibility and adaption in the Chinese context.

These recommendations include,

a) Develop new indicators for sustainable food systems;
b) Shift public support towards diversified agroecological production systems, this entails policy support to cooperatives and establish organic sector support organizations;
c) Support short supply chains & alternative retail infrastructures;
d) Use public procurement to support local agroecological produce;
e) Strengthen movements that unify diverse constituencies around agroecology;
f) Mainstream agroecology and holistic food systems approaches into education and research agendas;
g) Develop food planning processes and 'joined-up food policies' at multiple levels, this entails adopting a 'food systems' approach to planning and integrated policy.

While these recommendations are extremely relevant to China, we do not want to repeat them in detail here. Instead, we would like to highlight a few China specific recommendations here.

The first recommendation is to **reconceptualize "modern agriculture" in the policy and educational realms**. Agricultural modernization has been a key national development priority in China for decades. The understanding of modern agriculture has long been focused on efficiency and productivity, with limited recognition of agriculture sustainability. In this sense, what is considered "modern agriculture” is subject to reconsideration. With the central government’s promotion of “ecological civilization” as a national strategy since 2007, it is a critical timing to integrate agroecology in the narratives and interpretations of modern agriculture. Moreover, most government interventions to promote ecological agriculture in China tend to focus on farming techniques or marketing skills, rather than considering the issues from the perspective of a social movement or community organizing. Therefore, it is vital to reconfigure the elaborations of agriculture policies and the content of agricultural educational system through collaborative efforts between multiple stakeholders. In this process, traditional agro-ecological practices should be treated as an asset.

The second recommendation is to **rediscover the value of agroecology in achieving developmental goals** in agroecology and rural development studies. The values of agroecology practices, as explained previously, include but are not limit to reducing poverty of remote areas, reducing pollution, enhancing the ‘ecological civilization’ goal, contributing to social stability by addressing food safety issues, creating jobs and so on. These are all important objectives of China’s development agendas. To rediscover the true value of agroecology in rural development demands a change of the current status of ecological agriculture in China. Ecological agriculture should not be confined as a means of safe food production for a niche market. Rather, it bears much richer socioeconomic contributions (Qiao et al. 2016). That being said, even on the productivity front, it is also important to recognize the yield potential of organic agriculture under certain conditions (see Seufert et al. 2012).

The third recommendation is to **promote the diverse ways that agroecological practices are experimenting to overcome the crisis of trust in the food system**. Ecological farms are attempting to re-build consumers' trust not only through *market mechanisms*, such as eco-labels, but (because of low trust in labels) increasingly through *relational mechanisms*, building personal connections with local government, rural community, local peasants, local suppliers, and with consumers (Chen 2017, personal communication). Although these approaches are expanding quickly among small ecological farms, they are hardly recognized as feasible solutions to the food safety problem. Given that food safety is the top concern of

Chinese residents, promoting these mechanisms beyond small farms will strongly boost the public awareness of agroecology practices, consolidating public support for the transition towards diversified agroecology.

The fourth recommendation is to **understand farmers' roles in the agroecology transition**. Besides the various studies of consumers in organic food market (e.g, Chen and Scott 2014), farmers' roles in ecological agriculture development also deserve more attention in research and policy making. For example, previous studies mainly highlight technology, market-orientation and economic benefit as the key factors influencing the transformation of farmers' production. Chen (forthcoming) noted that little attention has been given to *values* or (ideological challenges) linked to this transition. Therefore, more emphasis should be given to the roles of farmers' values in agroecology transition. Understanding farmers' role in this transition also demands better resources for ecological agriculture research (Cook and Buckley 2015).

The fifth recommendation is to **explore opportunities for farmer participatory research and participatory plant breeding** (e.g., Canada has valuable experience with this through the Ecological Farmers' Association of Ontario, and University of Guelph professor Sally Humphries, working with the Canadian NGO, USC, has done great work on participatory plant breeding in Central America). The rich experience of farmer participatory research from both China and other countries should be matched with more policy support. Therefore, it is important to explore opportunities for exchanges and visits, such as bringing Chinese stakeholders to attend international events (e.g., organized by Food Secure Canada, the National Farmers' Union, Canadian Organic Growers, and the Guelph Organic Conference) and bringing foreign stakeholders, not only researchers, to share experiences.

The sixth recommendation is to **enhance market oversight and credibility of certification systems while increasing farmer training and consumer education for ecological agriculture**. The current certification system could be made more accessible and relevant for small ecological producers through a simplification of certification procedures (Cook and Buckley 2005) and the incorporation of stakeholder inputs on the revision of organic standards. It is vital to make certification a viable option for more farmers. That being said, a more fundamental problem is the deterioration of trust in the certification system. If the credibility of the certification system is not rebuilt, making certification more accessible will make no big difference. This underlines the importance of ensuring that there is no unqualified organic or green food in the market through enhancing the current monitoring system of the organic and green food market. It is also important to support farmer training and consumer education for ecological agriculture so that farmers are better complying with the certification requirements and consumers have better knowledge of the meanings of certification and the food system.

The seventh recommendation that is specific to China’s situation is to **support innovative ways to attract farmers and other people back to the land**. The urbanization process drained human resources from the countryside and thus created favourable environment for industrial agriculture. It is therefore urgent to make land more accessible for people who are interested in farming. Making land accessible to not only farmers but also people who are interested in gardening will boost the development of ecological agriculture. Recreational gardening around major cities for example should have more supports in terms of accessing land. Our research also found that most small-scale new farmers found themselves in an awkward position—their urban background makes farming a new challenging career path, yet their small scales prevent them from enjoying various agriculture supports that are designated to large farms. Provide equal support to those new farmers in the ecological agricultural sector therefore will greatly enhance their competency and viability.

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