PART THREE

A NEW FRAMEWORK FOR CHINA'S GRAIN (FOOD) SECURITY

China's agricultural and rural development in the early 21st century
Edited by: Bernard H. Sonntag, Jikun Huang, Scott Rozelle and John H. Skerritt
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CHAPTER 9

FOOD SECURITY

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9.1 FOOD SECURITY SUCCESSES AND DEFINING A NEW APPROACH

CCICED ARD Task Force members

The importance of food security in China's development strategy is well-recognised, but it also has significant cost. The task force believes that, if China redefines its national food security goal and shifts its focus to household food security for the poor, the nation's development targets and poverty-reduction objectives can be met without compromising the nation's food security.

China is one of the most food-secure developing countries in the world, a status achieved through many decades of hard work. China's success in increasing food and fibre supply in the past 50 years to satisfy its growing population has been widely recognised. From a nation that could not meet minimal nutrition needs of its population in the early 1950s, per-capita food availability reached 3040 kcal per day in 2000, a level that is 14% higher than the average of developing countries and 8% higher than the world average. Since the early 1980s, China has shifted from being a net food importer to a major net food exporter to world markets. The improvement in food security both in terms of national aggregate supply and in relation to average household living standards creates a healthy social and political environment and lays a sound foundation for economic development. Furthermore, China has a foreign exchange reserve ranked second in the world. These financial reserves could assure food purchasing power if the nation were to experience short-term grain shortages.

Despite the record of recent years, as in previous episodes of price increases (e.g. 1988–89 and 1994–95), there has been a resurgence of concern about China's grain security by national leaders after prices rose between late 2003 and the first six

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months of 2004. In response, the government launched several policies to promote grain production. For example, a 10 billion yuan direct subsidisation program was implemented in 2004 that is supposed to distribute cash payments to farmers in areas that are major grain producers. Leaders are planning to expand this subsidy program. Perceiving part of the problem to be a fall in cultivated land area, leaders imposed strict controls on the conversion of cultivated land to non-agricultural uses. The nation's Grain for Green program, one of the largest land set-aside programs in the developing world, was also drastically scaled down.

The actions taken by the government in 2004 raise several critical questions. Is China's food and grain supply security a serious problem? What will the situation likely be in the future? What priority commodities should be covered by a food security plan? Should China shift its focus from aggregate supply of food to household food accessibility? What is the impact of the conversion of land to industrial and infrastructure use? Has the Grain for Green program contributed to the recent price rises? Can China rely on long-term productivity growth for grain security?

FOOD AND GRAIN SECURITY

Because of the tremendous progress that China has made toward ensuring its national food security over the past five decades, the task force suggests that *there are currently no serious threats to national food and grain security in China*. In 2003, both exports and net exports (export less import) of food and grain reached historic highs. Beginning in the mid 1990s, China's grain production and grain stocks were so high that they led to more than five years of falling grain prices. As a natural consequence of the laws of supply and demand, production gradually fell during this time. By early 2003, the excess supplies of grain in storage (in government stocks and in household reserves) that had hung over China's grain markets for the previous several years gradually disappeared and grain prices began to stabilise. The increase in grain prices at the end of 2003 and throughout the early months of 2004 should be viewed as a normal and expected market reaction resulting from many years of low prices. All modern, market-oriented agricultural economies operate this way.

The rising grain prices in late 2003, far from signalling a problem in the grain sector, should be interpreted as a return to a normal market environment, providing leaders with an opportunity to meet other policy objectives. China's grain prices in May

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2004, when measured in real terms, were about the same as average grain prices during the mid 1980s and early 1990s and lower than those in the late 1980s and the mid 1990s. The increases in grain prices should be welcomed and be seen as a victory for China's policies that were seeking to raise farm incomes. When China's farmers have faced high grain prices in the past, they have responded. High prices provide farmers with incentives to produce. In fact, they have already led to significantly higher production of wheat and early rice in 2004. Many believe that grain production in 2004–2005 will rise. Hence, high prices play a role in national food security. Finally, grain price increases provide a good opportunity for deepening grain-market reform.

While China appears to have attained a high degree of food security in terms of national aggregate supply, there are still households that do not always have access to enough food, part of China's remaining poverty problem. Despite the rapid reduction of poverty in China over the past two decades, there are still more than 100 million people in both rural and urban areas below the international poverty line (US$1/day in purchasing power parity terms). Many poor households occasionally suffer from hunger or malnutrition. The reason for this is not that there is not enough food being produced throughout China. Neither is it because there is not enough food available. The major problem for such households is that they often suffer from lack of entitlement (that is, such households do not have access to enough income to purchase the food that is available on the market). Hence, while there has been significant decline in the number of people in poverty and poverty-reduction efforts will continue to make progress, for the foreseeable future, China will still be home to many poor people and this poses the greatest food security threat.

The poor quality of China's food and potential food-safety problems pose another possible set of food-security concerns. According to some estimates, nearly 25% of cultivated land is contaminated to varying degrees by the over-use of inorganic fertilisers and pesticides. Soil and water scientists have found that fertiliser residues especially (in the form of nitrates) have been increasing in the soils and water sources in certain areas. Although it is unclear how such figures are generated, it has been reported that about 10% of China's grain, more than 20% of livestock products and nearly half of the nation's vegetable and fruit production suffer from quality problems. Excess fertiliser and pesticide use is also a waste of resources and an avoidable cost. Perhaps more worrisome, given the rapid increases in livestock production, is the high incidence of animal diseases and pests, and the serious

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problem of animal wastes. Such problems are not solved by trade policies or by trying to force farmers to produce more (in fact, such policies often lead to poor food quality and food-safety problems), but rather are addressed by increased investment in agricultural research, extension and rural education.

Although some aspects of the nation's grain-reserve management system have been improved during the past several years (e.g. the separation of commercial trading from storage operations), it is still one of the weakest and least understood parts of China's food-security program. In many ways, despite the reforms, the grain-reserve system is dysfunctional. The rules for management and release are unclear. When should grain be sold? How much of it? At what price should grain be sold? At what price should grain be purchased? It has been estimated that China is wasting millions of dollars and prices are not being stabilised. There is also confusion among the different holders of grain. What is the role of the provincial and local grain reserves? How can provincial authorities coordinate their actions with the national government's grain reserves? The lack of transparency creates chaos in grain markets and contributes to variability in grain prices. Since no one knows the level of stocks or the quantities of planned (or actual) release, domestic producers and traders and international trading agencies cannot make decisions based on full information. Indeed, the national grain-reserve system is directly responsible for the absence of any grain storage by the private sector. Private trading companies and commercialised state-grain corporations cannot hold stocks since they would be at the mercy of unpredictable administrative decrees. In short, China's grain system operates in a way that is not transparent, is not accountable, and is at odds with the nation's market system. No other country runs its grain reserve like China. In fact, economists have shown that, during the 1990s, China's grain management system made China's prices fluctuate more than in the past and more than prices on the world market.

The most important reason to reform China's grain system and food security, however, lies in the productivity of its agricultural sector. Research by China's own economists has shown that, in the future, even if the nation completely liberalised all trade (which is beyond its current trade commitments under the World Trade Organization), most important agricultural products would continue to be produced at or near self-sufficiency levels. If China increases its investment in agricultural research, extension, irrigation and better manages its land and water resources, self-sufficiency in cereals will remain above 90%. Importantly, if leaders aggressively invest today, rice and wheat—the nation's major food grains—will still be almost

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fully produced in China in 2020. Projections indicate that China will continue to export rice to East Asian countries, with self-sufficiency rates reaching 104–108%. Wheat will remain at 93–98% self-sufficiency. Although the nation would become a net importer of feed grains, soybeans, edible oils and sugar (which would promote trade relations with many important trading partners), by 2020, the export of vegetables, fruits, livestock and aquatic products will make China an even more important net exporter of food.

In short, even under a completely free trade regime, China would not have a food-security problem. This is because, at a national level, the overall extent of climatic variation across the landscape (and thus variation in grain production) in China is lower than almost all countries in the world. Importing 10% of grain for feed is feasible for China and should not be considered as a threat to national food and grain security. Ten percent of China's grain demand is equivalent to only 2% of the world's total production and less than 10% of world grain trade. This level of imports will not have a great impact on national grain security. The main way China can protect its food and grain security is to invest in agricultural technology and water management and promote poverty-reduction programs that will raise the incomes of China's poor.

FOOD SECURITY AND CHANGES IN CULTIVATED LAND

The task force also believes that the concerns of the government over the conversion of cultivated land to industry, urban building projects and forests are unwarranted. Unlike the current policy debate—which is not based on reliable data— the task force brief on cultivated land protection provides recommendations using a new and powerful set of data. In short, we find that the impact on grain prices of all conversion of land since the mid 1980s until today is very small and plays almost no role in the recent rise in prices. Research by the Center for Chinese Agricultural Policy also shows that Grain for Green has not affected food security and is not an important cause of recent price increases. Slowing down the growth of the non-agricultural sector and stopping China's land set-aside program to pursue a policy of restricting the conversion of land to other uses does nothing but hurt China's modernisation and environmental goals while having little impact on food security.

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POLICY RECOMMENDATIONS

The following are the task force's major policy recommendations on food security:

Shift emphasis from grain security to food-grain security

In order to maintain the spirit of China's food and grain security policies without imposing excessively costly and ineffective restrictions, the national government should redefine its food-security goals in terms of rice and wheat.

Shift emphasis from aggregate national food supply to household food accessibility

High priority should be given to poverty-reduction efforts that aim to raise the average incomes of the poor and protect them against negative income shocks.

Emphasise long-term productivity growth instead of short-term subsidy program

China's food-grain security will rely mostly on raising long-run productivity. Subsidy programs such as the 'Grain direct subsidy' that was implemented in early 2004 will be very costly, will not be appreciated by households in the long run, will reduce the government's fiscal resources for public services, and have much less effect on national grain security than investment in R&D, extension, education, health, irrigation and other rural infrastructure. China should not follow other countries, but rather should build a productive, undistorted (by subsidies) agriculture that raises the income levels of its producers and provides the nation with a high degree of food security.

Balance land uses between agriculture and other activities

Efforts are needed to ensure that land-use policies do not impede the ability to continue rapid industrial growth. Employment, income and productivity growth are all associated with the conversion of land from low-productivity agriculture to high-productivity industry and services. Good land-use planning is needed. Land-use policies should not be homogeneous nationwide and priority should be given to fast-growing industrialising regions. Food security should not be invoked as reason for slowing Grain for Green.

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Change national grain-reserve management practices

Leaders need to undertake grain-market reform and change the management practices of the grain-reserve system. Rules for storage, purchases and sales of grain reserves need to be clear. No nation that wants to run a modern and efficient agricultural economy can keep its stocks secret or have an opaque reserve system.

Improve China's food-quality regulation and monitoring system

To ensure food quality and safety, international standards should be consulted to modify China's Food Sanitation Law or set up new regulations. Many countries are willing to share information on their food-safety and quality-assurance programs.

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9.2 CHINA'S FOOD SECURITY

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INTRODUCTION

China's effort and success in increasing food and fibre supply to meet its growing population in the past 50 years is well-recognised. Per-capita food availability reached 3040 kcal per day in 2000, a level that is 14% higher than the average of developing countries and 8% higher than the world average (FAO 2002). Moreover, China shifted from being a food net-importer to a net-exporter in the early 1980s and became one of the developing countries with the highest food and grain self-sufficiency, which contributes significantly to world food security.

There has been growing concern over China's grain security by national leaders and the public since late 2003. Several events contribute to this concern. First, after grain production and storage reached historically high levels in 1998 and 1999, both fell continuously thereafter (NSBC 2004). Second, it has been frequently reported in the media that there has been a large decline in cultivated land as a result of rapid expansion of economic development zones (or districts), housing and other uses of land in both urban and rural areas. Third, the outbreak and impacts of SARS in 2003 revealed the weakness of government in dealing with various national crises

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and security, including grain supply. Since then, leaders have called for plans and solutions to meet an emergency in grain supply should the nation face serious grain shortages in the future. The last, and probably the most important event, is the increase in grain prices in the autumn of 2003 and spring of 2004. Many agricultural officials and scholars claimed that China's grain supply is facing a great challenge and predicted that China will encounter grain crises in the coming years.

In response to the nation's grain-security concern, the government recently launched several policies to promote grain production. In 2004, an income-transfer scheme with 100 billion yuan was implemented through a 'Grain direct subsidy' program. This distributes cash to farmers on the basis of household cultivated land area in major grain-production regions. A plan is under way to increase the scale of the subsidies under this program and to expand it to cover more regions. Much stricter control of non-agricultural land use seems to have been implemented. This is reflected in a series of recent policy documents issued by the central government. Maize export subsidies were completely eliminated in April 2004, 3 years after China's World Trade Organization (WTO) accession. Grain-trading companies have recently completed import contracts with major grain-export countries. The Grain for Green program was scaled down substantially in 2004. While reduction of the Grain for Green program is largely due to problems with its implementation, the rising concern over grain security since late 2003 was also an important driver leading to its scaling down.

Governments at different levels, and academics, have expressed differing opinions and views on the current policies. Maize export subsidies have been eliminated (China's obligation to its WTO accession) and grain imports (to balance the short-term domestic supply deficit) are expected. Several questions have been raised by policy analysts inside and outside China. Is China's food and grain supply security a serious problem now? What will be the likely situation for China's food and grain security in the future? What should the focus be for China's food security (national versus household)? How serious is the removal of land from agriculture for other uses and what impacts will this have on China's grain security? What are the key determinants of China's future grain security? Can China rely on long-term productivity growth for grain security? This paper tries to answer these questions.

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FOOD AND GRAIN SECURITY

Achievements in the past decades

Over the past five decades, China has made great achievements in its national food security. At the national aggregate level, China has been a food net-exporter since the early 1980s. By 2002, total exports of food and feed reached US$14.9 billion (Table 9.1). Despite food imports over time, China's net exports (exports minus imports) have been increasing and were valued at about US$5.5 billion in 2002 (Table 9.1). Moreover, China has been a major grain exporter since the late 1990s. Over the 1997–2003 period, average annual cereal imports were 12 million tonnes (NSBC 2003) and as high as 14.9 million tonnes in 2000–2003 (Table 9.1).

In the short term, although yearly fluctuations in domestic production imply that import/export of grain from/to world markets is necessary to smooth domestic market supply, China's ability to buy grain and food from the world market is outstanding among developing countries. China has a foreign-exchange reserve ranked second in the world, which assures food-purchasing ability if the nation encounters a short-term grain shortage.

Table 9.1 China's food and feed trade, 1980–2003

	1980	1985	1990	1995	2000	2001	2002	2003
Food and feed (US$ billion)								
Export	2.97	3.74	6,49	10.61	12.73	13.34	14.94	
Import	2.92	1.53	3.29	8.74	7.14	8.78	9.44	
Net export	0.56	2.21	3.20	1.87	5.59	4.56	5.50	
Cereal (million tonnes)								
Export	1.3	8.0	4.2	0.7	13.9	8.7	14.9	22.0
Import	13.0	5.8	13.7	20.1	3.1	3.4	2.8	2.7
Net export	–11.7	2.2	–9.5	–19.4	10.7	5.3	12.0	19.3

Note: food and feed include livestock and meats, milk and its products, fish and its products, grains, edible oilseeds and oils, vegetables, fruits and sugar.

Sources: Anderson et al. (2004); Centre for Chinese Agricultural Policy, Chinese Academy of Sciences, China Agricultural Policy Simulation and Projection Model.

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In the two and half decades since 1978, based on China's official poverty line, more than 230 million Chinese rural residents have escaped poverty, those under the absolute level of poverty falling from 260 million in 1978 to less than 30 million in 2002 (Table 9.2). The incidence of rural poverty has fallen equally rapidly, plunging from 32.9% in 1978 to less than 3% in 2002. The greatest reductions in poverty occurred in the years immediately after the reforms and in the 1990s. When based on the international standard of poverty, which is set at one dollar per day (in purchasing power parity, or PPP, terms), the headcount and the incidence have fallen equally rapidly (Table 9.2).

China's success in poverty reduction and improvement in food security is even more impressive when compared with circumstances in other countries. With China excluded, and using the same international standard, between 1987 and 1998 the incidence of poverty in developing and transition economies fell from 28% to 24% (World Bank 2001). The absolute number of poor in developing countries as a whole (not including China) rose about 100 million during the 1990s (ESCAP 2003). Thus, China has good reason to be proud of its achievement in fighting poverty and improving household food security. The great improvement in national food security and household living conditions creates a healthy social and political environment and lays a sound foundation for agricultural and national economic development.

Understanding the recent rise in grain prices

Our analyses show that there are no serious threats to national food and grain security in China. In 2003, both exports and net exports (exports less imports) of food and grain reached historical highs (Table 9.1). In the late 1990s, it was excess national grain reserves that led to the persistent fall in grain prices and therefore production. While there are no published data on the quantities of government grain storage in the late 1990s, as these are regarded as national secrets, most analyses of China's grain issues indicate that government grain storage amounted to 240–300 million tonnes in the late 1990s. Excess grain was gradually released into the market from storage and inventories, and largely disappeared by early 2003 when the grain price began to stabilise. The increased grain prices at the end of 2003 were a normal market reaction resulting from the decline in grain production in 2003 and the reduced national grain reserve. However, over-reaction to the grain-security issue by the government and media might also have caused grain prices to increase in early 2004, due to expectations of future grain-price increases.

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Table 9.2 Poverty in rural China, 1978–2002

Year	Poverty based on China's official poverty line			Poverty based on international standards (US$1/day in purchasing power parity)	
	Poverty line (yuan/year)	Number of poor (million)	Poverty incidence (%)	Number of poor (million)	Poverty incidence (%)
1978		260	32.9		
1979		239	30.2		
1980		218	27.6		
1981		194	24.4		
1982		140	17.5		
1983		123	15.3		
1984	200	89	11.0		
1985	206	96	11.9		
1986	213	97	11.9		
1987	227	91	11.2		
1988	236	86	10.4		
1989	259	102	11.6		
1990	300	85	9.4	280	31.3
1991	304	94	11.0	287	31.7
1992	317	80	8.8	274	30.1
1993	350	75	8.3	266	29.1
1994	440	70	7.7	237	25.9
1995	530	65	7.1	200	21.8
1996	580	58	6.3	138	15.0
1997	640	50	5.4	124	13.5
1998	635	42	4.6	106	11.5
1999	625	34	3.9		
2000	625	32	3.4		
2001	630	29	3.2		
2002	627	28	3.1	78.6	8.7

Sources: Poverty data for 1978–1988 are from the World Bank (China: strategies for reducing poverty in the 1990s, 1992); 1989–2001 data are from the Rural Social and Economic Survey Service of NBSC (2003), 2002 data are computed by the authors based on NBSC's rural household income and expenditure survey in 2002.

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Relative to changes in international grain-market prices, rising grain prices in China were nothing exceptional (Figure 9.1). World grain prices were on the rise due to a decline in grain production in 2003. These movements were more significant than those in China's domestic market. Indeed, fluctuations of both wheat and maize prices in the USA were even larger than those that occurred in China. Rising grain prices in the world market have stimulated world cereal production in 2004 and world prices have fallen since April 2004.

The rising grain price in late 2003 was a signal of China's return to a normal grain-market situation. The average grain prices in real terms in May 2004 were about the same as average prices in the 1980s and 1990s, and still much lower than those in the mid 1990s. Although the increase in grain price might have negative effects for poor and unemployed urban consumers, it raised farmers' income, provided farmers a price incentive, increased grain production in 2004–2005 and therefore played an active role in national food security for the coming years. Furthermore, high grain prices provide a good opportunity for deepening grain-market reform

Remaining challenges: regional and household food security

Despite the significant improvement in the nation's aggregate food supply and substantial reduction of poverty and therefore improvements in food security at the household level, there are still nearly 30 million rural people living below the nation's poverty line and an even larger number (about 80 million) when the international standard of poverty ($1/day PPP) is applied (Table 9.2). The pace of reduction in rural poverty has slowed down significantly since the late 1990s. Moreover, although poverty and household food security in China are considered to be primarily a rural phenomenon, recent trends in economic reforms, which were thought to cause severe urban unemployment, have raised concern about the emergence of a new phenomenon of urban poverty (Fan and Zhang 2002).

If we combine the poor in both rural and urban areas, the number could reach more than 100 million (under the international poverty standard), which still poses a threat to food security at the micro level. In the early 21st century there are still about 100 million people in China who are hungry and under-nourished (FAO 2002). Since China is undergoing rapid economic growth and most people have reached or are striving for a well-off standard of living, household food security for those 100 million people should receive more attention from policy makers and the public.

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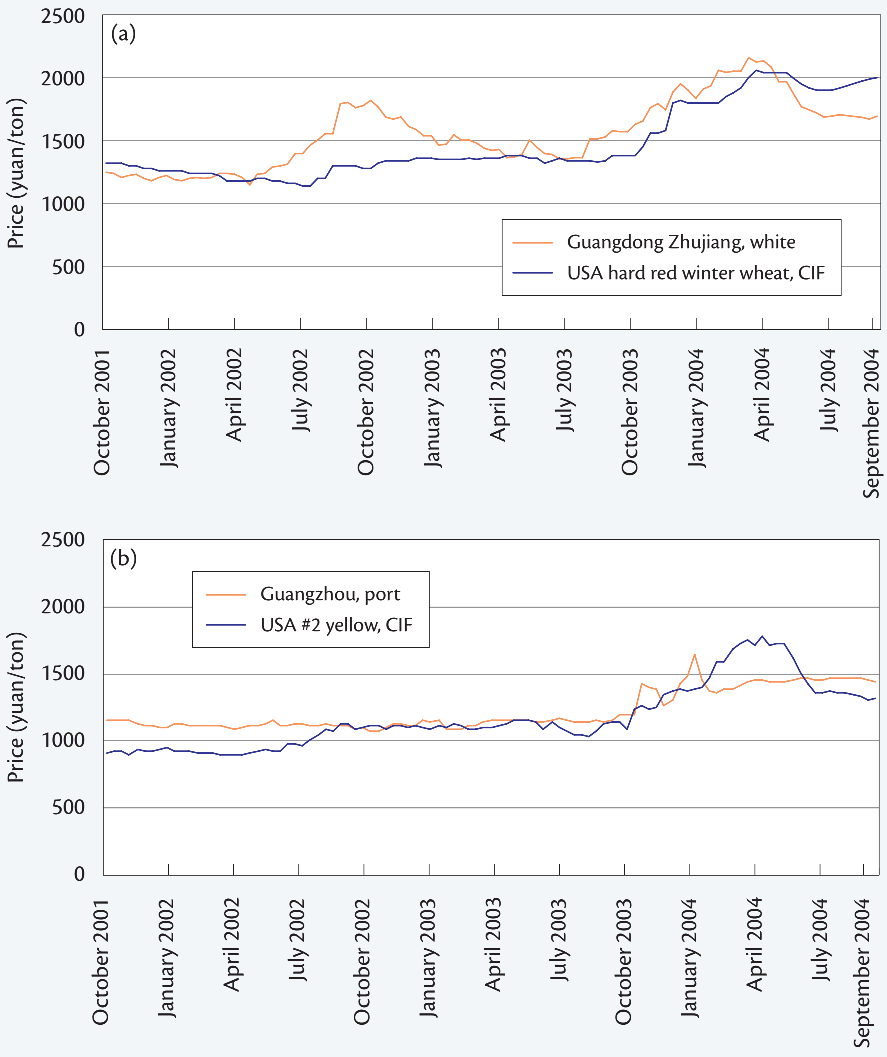

Figure 9.1 Domestic and international prices of (a) wheat and (b) maize, yuan/tonne, 2001–2004. Sources: National Grain Bureau, Grain Information Center.

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Poverty and household food insecurity are concentrated in resource-constrained remote uplands (World Bank 2001) and pastoral areas. The poorest of China's poor are concentrated in resource-deficient areas and comprise almost entire communities located mostly in upland sections of the interior provinces of northern, northwestern and southwestern China. The plight of the poor in the richer provinces has gradually ameliorated. Figure 9.2 presents the most recent estimates of rural poverty incidence, based on rural household income and expenditure survey data from the National Statistical Bureau of China in 2003. They show a pressing issue of regional distribution of rural poverty and household food security. For example, while the national poverty incidence declined remarkably from more than 30% in 1990 to 8.6% in 2003, variations are significant among provinces (Figure 9.2). Rural poverty incidence ranged from less than 0.5% in Shanghai, the most developed area, to about the national average in Shanxi and Jiangxi and to 20% and more in Yunan, Xingjiang, Qinghai, Gansu and Tibet, where most minorities live.

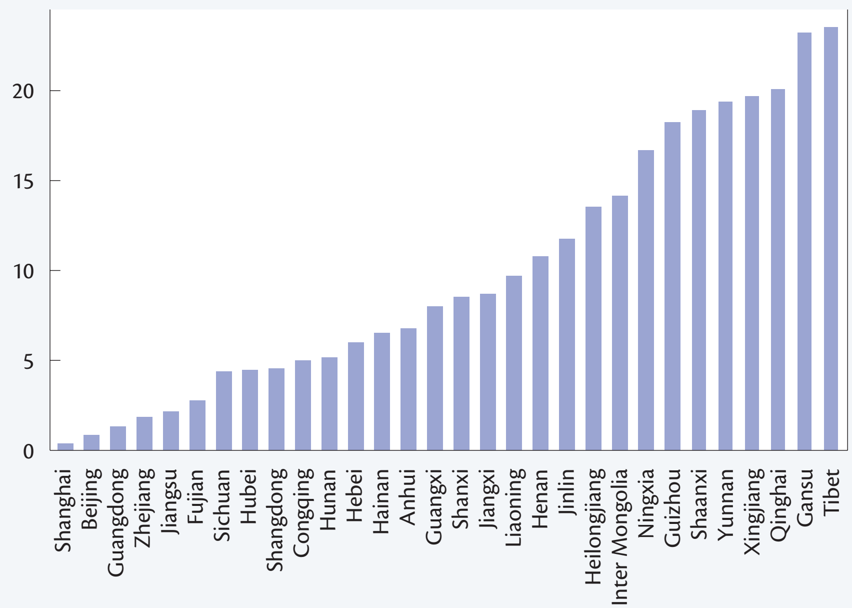

Figure 9.2 The percentage of population living on or under 1 dollar per day (in PPP) by province in rural China, 2003

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Food quality and food safety may be other major issues in China's food security. According to a report by the Chinese Academy of Sciences (CAS 2003), nearly 25% of farmland is contaminated to varying levels by various poisonous substances, and residual chemicals have been increasing in terms of variety and quantity. It also has been widely reported that about 10% of grain, more than 20% livestock products and nearly half of the vegetables have quality problems. Perhaps even more worrying are various animal diseases and pests.

Although some aspects of the grain-reserve management system have improved in the past several years (e.g. the separation of commercial trading from storage operations), it is still one of the weakest and least understood part of China's food-security program (Zhong and Zhu 2005). In many ways, despite the reforms, it is dysfunctional. The rules for management and release are unclear. There is confusion among the different holders of grain. The lack of transparency creates chaos in grain markets and contributes to greater variability in grain prices. Because no one knows the level of stocks or the quantities of planned (or actual) release, domestic producers and traders and international trading agencies cannot make informed decisions.

FOOD SECURITY IN THE FUTURE

Methodology

In order to have a better understanding of China's food security in the coming decades, projections on China's food demand, supply and trade have been made through application of the China Agricultural Policy Simulation and Projection Model (CAPSiM) developed by the Center for Chinese Agricultural Policy (CCAP). CAPSiM was developed to meet the need for a framework for analysing policies affecting agricultural production, consumption, prices and trade at the national level. CAPSiM is a partial equilibrium model. Most of the elasticities used in CAPSiM were estimated econometrically by CCAP staff using state-of-the-art econometrics and with assumptions that make our estimated parameters consistent with theory. Both demand and supply elasticities change over time, income elasticities depend on the income level, and cross-price elasticities of demand (or supply) depend on food budget shares (or crop area shares).

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CAPSiM explicitly accounts for urbanisation and market development on the demand side. In supply-side analysis, account is taken of changes in technology, other agricultural investment, environmental trends and competition for labour and land. Supply, demand and trade respond to changes in both producer and consumer prices. Details of the model can be found in Huang and Li (2003).

Scenario development

In projecting China's future food economy, several alternative scenarios are formulated. Each of them embodies key assumptions on the shifts in demand, supply and the external economy. In this paper, China's food economy in 2001–2020 is examined under three alternative sets of scenarios: a baseline run (WTO accession in 2001–2005 and further trade liberalisation in 2006–2020) and two scenarios with different assumptions on agricultural R&D and irrigation investments. WTO accession is formulated as the baseline because China joined the WTO in December 2001. The base year is 2001 and the projection periods are 2002–2020. Predictions of trends and future situations are risky, including those for the food economy in China. Any projections, including those presented below, are made under certain assumptions that may change over time. However, the projections under different scenarios may help us to understand the trends and major driving forces of the food economy in the future.

Baseline scenario

On the demand side, population increase, urban expansion and income growth will continue to be the major driving forces of China's demand for food in the future (Huang et al. 1999). On the supply side, institutional reform, technology change, input increase, irrigation expansion and market liberalisation have all contributed to China's successful agricultural growth in the past. However, in the future, China's agriculture and food production growth may largely depend on technology changes, particularly on the investment in agricultural R&D and irrigation (Fan and Pardey 1997; Rozelle and Huang 2000; Huang and Rozelle 2002).

Population will remain an important determinant of food balance in the future. Population growth peaked in China in the late 1960s and early 1970s. Since then, fertility rates and the natural rate of population growth have begun to fall. In the entire period of the 1990s, the annual population growth rate was only 1% (NSBC). According to United Nation's demographic predictions (UN 2002), China's population will increase from 1.27 billion in 2001 to 1.36 billion in 2010, with an annual

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growth rate of 0.72%. This rate of growth is considered moderate, as annual growth rate of population was only 0.70% in 2001 (NSBC 2002). According to the UN's projection, while the population will continue to increase after 2010, the annual growth rate will decline to 0.60 in 2011–2020, a level above recent projections by China's demographers. China's population will reach about 1.45 billion by 2020.

China's urban sector expanded rapidly in the past and is expected to continue to do so in the coming decades. For example, the shares of urban population increased from 27% in 1990 to 36% in 2000. Based on population projections of the United Nations (UN 2002), the shares of urban population will rise from 36% in 2000 to 44% in 2010, and 51% in 2020. Because consumption patterns in urban areas differ from those in rural areas (Huang and David 1993), we expect that urbanisation will have a strong influence on national food demand in the coming decades.

Given the past trends of urban and rural income growth and recent government concerns about growing income gaps between rural and urban dwellers, we assume that the growth of income in urban and rural areas will gradually converge in the next two decades. The baseline scenario assumes that per-capita income will continue to grow but with declining growth rates. Annual real-income growth in urban areas will gradually decline from 8% in 2002–2005 to 6%, 5% and 4% in 2006–2010, 2011–2015, and 2016–2020, respectively. The annual growth rates of per capita income predicted for rural areas are 4% in 2002–2010 and 3.5% in 2011–2020.

In the past 20 years, agricultural research investment in real terms grew by about 4% annually, but increased significantly recently. The recent recovery in research investments, together with China's commitment to a strong domestic grain economy, leads to the expectation that China will sustain its recent upturn in investment funding over the long run. Under the baseline scenario, it is assumed that the annual growth rate of agricultural research expenditure in real terms is 5% over the 2001–2020 period.

Public irrigation expenditures financed a big part of the construction of the national water control network. The investment in irrigation facilities has been by far the largest component of total construction investment in agriculture. It is several times higher than investment in agricultural research. Under the baseline, it is assumed that growth in irrigation investment will continue. The annual growth rate will remain at 4% in 2001–2020. These growth rates are higher than the average growth rates in the past 30 years, but are lower than the rates that have been achieved since the late 1990s.

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On trade policies, under the baseline scenario, the current tariff rates and non-tariff barriers are assumed to change over 2002–2010. For those agricultural commodities that have positive nominal protection rates, prices are assumed to decline as China changes policies to meet its commitments on WTO accession. These include wheat, maize, other coarse grains, soybean, edible oils and sugar crops (Table 9.3). The prices of other commodities such as rice, vegetables, fruits, livestock products (except for milk), and fish are expected to rise with China's WTO accession. It is assumed that the remaining border distortion will be eliminated by 2020.

Fertiliser price is assumed to decline by 1% in 2002–2005 (as the import tariff is lowered with China's WTO accession) and then remain constant over the remaining projection period. The opportunity costs of both crop land and agricultural labour are assumed to grow by 1% over the projection period.

Alternative scenarios

Two alternative scenarios are developed to examine the impacts of productivity-enhanced investment on China's food economy. They are high and low investments in both agricultural research and irrigation. It is noted that all assumptions embodied in the baseline remain in the alternative scenarios except for the assumptions on the growth of investment in agricultural research.

In order to see how the food economy is affected by agricultural research and irrigation investment policies, the high-productivity growth scenario assumes an improvement in agricultural productivity. The annual growth rate of agricultural research expenditure will be increased from 5% (the baseline assumption) to 7%, and the irrigation investment growth rate from 4% to 6% throughout the projection period. The low-productivity growth scenario assumes that the annual growth rate of agricultural research expenditure will decline from 5% in the baseline to 3.5%. The corresponding growth rates of irrigation investment decline from 4% to 2.5%.

The results of projections

To address the main concerns of policy makers on national deficits in food and grain supply, discussions of the projections are limited to an overall indicator of aggregate food security—the self-sufficiency rate. The results of self-sufficiency rates for major food commodities under the baseline scenario in 2001–2020 are reported in Table 9.4. The corresponding results for alternative scenarios in 2020 are summarised in Table 9.5.

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Table 9.3 Nominal rates of protection (tariffs or tariff equivalents) of agricultural commodities in China in 2001, and assumed rates in 2005 and 2010

Commodity	2001	2005	2010
Rice	−3.0	−1.5	−0.8
Japonica	−12.0	−6.0	−3.0
Indica	0.9	0.4	0.2
Wheat	16.0	14.0	14.0
Maize	22.0	14.0	14.0
Sweet potato	15.0	14.0	14.0
Potato	15.0	14.0	14.0
Other cereals	15.0	14.0	14.0
Soybean	17.0	16.0	14.0
Cotton	18.0	14.0	14.0
Oil crops	47.0	22.5	17.3
Sugar crops	50.0	36.0	25.0
Vegetables	−10.0	−6.7	−4.4
Fruits	−10.0	−6.7	−4.4
Pork	−20.0	−13.3	−8.9
Beef	−8.0	−5.3	−3.6
Mutton	−5.0	−3.3	−2.2
Poultry	−17.0	−11.3	−7.6
Eggs	−4.0	−2.7	−1.8
Milk	42.0	28.0	22.5
Fish	−15.0	−10.0	−6.7

Source: Authors' projections.

Baseline projections show that even if the nation completely liberalised all trade (which is beyond its current trade commitments under the WTO), many agricultural products will still achieve high self-sufficiency levels in 2020 (Table 9.4). Although imports will rise or self-sufficiency rates will fall for many land-intensive food products, for those commodities where China has comparative advantage, exports will rise and self-sufficiency levels will exceed 100% under greater trade liberalisation in the coming decades.

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Table 9.4 Projected self-sufficiency rates (%) of major foods in China under the baseline scenario (see text for explanation), 2001–2020

	2001	2010	2020
Rice	101	102	106
Wheat	99	90	96
Maize	105	80	72
Soybean	61	64	60
Edible oils	84	69	66
Sugar	96	83	76
Vegetables	101	103	104
Fruits	100	105	107
Pork	101	110	105
Beef	100	98	96
Mutton	99	96	95
Poultry	99	106	105
Milk	97	83	79
Fish	105	110	107

Source: Authors' projections.

Table 9.5 Changes in self-sufficiency rates (%) of major foods in China in 2020 under alternative scenarios (compared with the baseline scenario in Table 9.4)

	Change (%)		Self-sufficiency rates (%)	
	High R&D and irrigation investment	Low R&D and irrigation investment	High R&D and irrigation investment	Low R&D and irrigation investment
Grain	2.86	–3.27	92	86
Cereals	2.75	–3.14	91	86
Rice	1.78	–2.05	108	104
Wheat	2.8	–3.18	98	93
Maize	3.72	–4.27	75	68
Soybean	4.83	–5.46	65	55
Edible oils	6.1	–6.87	70	61
Sugar	4.36	–5.04	80	72
Vegetables	5.54	–6.27	109	99
Fruits	8.33	–9.16	115	98

Source: Authors' projection.

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It is projected that China will achieve more than 90% grain self-sufficiency and near self-sufficiency in food grains in the coming decades. China will continue to export its japonica rice to East Asian countries. After 2010, rice self-sufficiency will reach 102–106%, i.e. China will export 2–6% of its rice to the world market. Although China needs to import wheat, the imports will be less than the average imports in the 1980s and 1990s. After the initial shock of trade liberalisation, wheat imports are projected to grow after 2005 and reach their highest level in 2010, at about 10% of domestic consumption. However, China's per-capita wheat consumption has been falling and is projected to decline throughout the projection period. Rising incomes will not lead to increases in food-grain consumption in urban areas, simply because the income elasticities of demand for all grains (rice, wheat, maize and other coarse grains) are negative. In rural areas, the income elasticities in demand for rice and wheat are also estimated to be negative after 2010. Decline in per-capita grain consumption in urban areas and rapid urbanisation lead the national average per-capita consumption to decline. In 2001, per capita wheat consumption in urban areas (40 kg) was less than half of that in rural areas (82 kg).

It is projected that wheat imports will decline after 2010 and self-sufficiency levels will recover to about 96% in 2020. Moreover, after 2020 China is likely to achieve near self-sufficiency even in wheat as population growth approaches zero in the 2020s.

The nation will be a net importer of maize; imports will reach nearly 30% of domestic consumption, but this will not threaten China's food security or social and political stability. Maize is mainly used as feed. Food maize is not a staple food in urban areas. In rural areas, as incomes increase, per-capita consumption of food maize has declined significantly, from more than 30 kg in the late 1970s to less than 10 kg recently. Increasing imports of maize will promote China's livestock development, facilitate structural changes in agriculture and therefore increase farmers' income.

In short, even under a completely free trade regime, China would not have a food security problem. Importing 10% of grain (mainly feed) is feasible and should not be considered as a threat to national food and grain security. Ten per cent (or 50 million tonnes) of China's grain demand is equivalent to only 2% of the world's total cereal production and less than 10% of international grain trade. This level of imports will not have a great impact on national grain security nor be a fatal threat. The major way China can protect its future food and grain security is to invest heavily in agri-

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cultural technology, increase the efficiency of water use in agriculture (see the results presented on the alternative scenarios) and promote poverty reduction programs that will provide the poorest of China's households with a way to procure larger quantities of food.

Although imports of soybeans, edible oils and sugar will be high, about 30–40% of domestic consumption by 2020, the export of vegetables, fruits, livestock and aquatic products will grow (Table 9.4). For example, China imported 16% (or 84% of self-sufficiency) of its edible oil consumption in 2001, and the share of imports will rise to 31% in 2010 and 34% in 2020. This occurs for soybean, rapeseed and other edible oil crops. However, the baseline scenario also projects that labour-intensive agricultural production will expand more than domestic demand. Trade liberalisation will help China to boost its horticulture, livestock and fishery sectors as the nominal protection for these products is negative. Increases in the prices of these products, accompanied by rising productivity, will enable China's production to exceed its demand in the coming years. Exports will expand.

China now exports about 1% of its vegetable production to the world market and has only minimal amounts of fruit for export. The baseline scenario projects that domestic demand will grow for both vegetables and fruits with income growth and China will gradually become an important player in vegetable and fruit export markets. It is projected that about 3% of vegetable production in China will be exported in 2010 and the share will rise to 4% in 2020. Fruits will enjoy an even higher rate.

In the livestock sector, while the increases in domestic production nearly match the increases in demand for beef and mutton, the annual production growth rates of pork and poultry will exceed growth in demand. In the next 20 years, China will be able to export about 5–10% of its pork production and 5–6% of its poultry into world markets if the rest of world opens its markets to China's meat products (Table 9.4). Obviously, part of the meat that becomes available for export is due to China's willingness to import maize, as was projected under the baseline scenario. Cheaper maize and other feed from world markets helps China boost its livestock sector.

Fish has been the number-one agricultural export commodity in China. Projection of the baseline scenario shows that past export trends will continue in the future, and fish exports will expand. The export-to-production ratio will rise from its current 5% to a peak level of 10% in 2010 and remain at 7–10% during 2010–2020 (Table 9.4).

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The results of alternative scenarios show that the major way China can protect its future food and grain security at national level is to invest heavily in agricultural technology and increase the efficiency of water use in agriculture. China will be able to achieve one of the major components of its food security (grain self-sufficiency) target in the future under high research- and irrigation-investment scenarios. The only grain that will reduce to levels below 95% self-sufficiency in the long term is maize. China could maintain its grain and wheat self-sufficiency at 92% and 98% in the long term (after 2020) if the annual growth rate in agricultural research and irrigation investments could be raised to 7% and 6%. Imports could be significantly reduced for edible oils, sugar and cotton under a high-investment scenario. The difference in production between high and low scenarios could reach 7% for grain and more than 10% for edible oils, cotton, vegetables and fruits.

FOOD SECURITY AND CHANGES IN CULTIVATED LAND[1]

Changes in total cultivated lands and bio-productivity, and their likely impacts on grain production, are explored from Landsat TM/ETM digital images covering China's territory in the past 15 years, including the middle 1980s and 1999–2000, and the data since 2000 from the Ministry of Land and Resources.

The analysis shows that, in contrast to popular perception, China recorded a net increase in cultivated land of 2.65 million hectares in 1986–2000, accounting for nearly 2% of the cultivated land area in 1986 (Huang et al. 2004). During this period, although cultivated land converted to other uses totals 3.06 million hectares, new cultivated land created from other uses was 5.71 million hectares. Of the cultivated lands converted to other uses, 38% is built-up area largely located in coastal regions of eastern China.

The study also found that the average productivity of cultivated land declined by about 0.31%, since the bio-productivity of new cultivated land converted from other uses is, in general, lower than that of cultivated land converted to other uses. Despite a likely decline in total cultivated land in the future, the impacts on agricultural production will be minimal. China can maintain a healthy cultivated land base for food and agricultural production in the long term.

1 This part of the paper is mainly based on a recent work by Xiangzheng Deng, Jikun Huang and Scott Rozelle (2003).

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Cultivated land in China has declined significantly in recent years, but the main reason is not the notable expansion of cities and industrial development as widely perceived. Rather it was the Grain for Green program launched in China in 1999. In 2003, about 80% of the reduction in the area of cultivated land was the result of this program. In reality, between 1997 to 2003, little land was lost to urban expansion and industrial development. Recent study further shows that the Grain for Green program has had an insignificant impact on grain production, market prices and food security.

Based on the changes in cultivated land area during the years 1985–2000 reported by Huang et al. (2004) and land-use data for 2000–2003 from the State Land Bureau, cultivated land was reduced by 2.4%, with an average annual decline of only 0.14% during 1985–2003. When land changes due to the Grain for Green program are excluded, China's cultivated land had a net increase of 2.5 million hectares, or 1.85% in 1985–2003.

Considering that China has been experiencing rapid growth, the relatively low rate of decline in cultivated land is encouraging if not miraculous. China's economy in 2003 was about 8.5 times the size it was when economic reform began in 1978, but the decrease of cultivated land was only about 2%. International experience shows that rapid economic growth is often accompanied by a large shift of land from agriculture to industry, infrastructure and residential use. In Japan, for example, cultivated land area has been declining significantly during the last three decades. In the 1990s, Japan lost cultivated land at a rate of 1% per year (Uchida et al. 2004). A similar trend is evident in South Korea since the 1970s. The US is losing 0.1–0.3% per year of its agricultural land to development and land set aside for conservation.

CONCLUDING REMARKS AND POLICY IMPLICATIONS

China has a large resource base and a solid record of productivity in the past to ensure national grain and food security. China can also ensure the nation's food security in the future. In the coming years, however, China needs to make fundamental changes in national priorities for food and grain security and develop a new way to manage its grain economy. Major policy implications and recommendations are summarised below.

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1. Shift emphasis of grain security from all grain to food grain

In order to maintain the spirit of China's food and grain-security policies without imposing excessively costly and ineffective restrictions, the national government should redefine its grain security goals in terms of rice and wheat, the two major food grains. This would provide considerable protection against any external economic threat while being attainable without causing major distortions.

2. Shift emphasis from aggregate national food supply to household food accessibility

While China's aggregate supply of food and grain is not a serious problem, there are still tens of millions of households that live at or under the poverty line. For many, there are times when households face a crisis in not being able to provide sufficient food to keep their members healthy and productive. The main focus of national food-security policy should be placed on these households, and measures should be implemented that raise average incomes and protect these households against negative income shocks. These will be the most effective household food-security measures.

3. Emphasise long-term productivity growth rather than a short-term subsidy program

China's food-grain security will depend mostly on raising long-run productivity. Subsidy programs such as the 'Grain direct subsidy' implemented in early 2004 will be very costly, will not be appreciated by households in the long run, will reduce the government's fiscal resources for public services, and will bring much lower benefits to national grain security than will investment in R&D, extension, education, health, irrigation and other rural infrastructure. China should not follow other countries that 'protect' their farmers by subsidies and other means, but should build a productive, undistorted agriculture that raises the income levels of its producers and provides the nation with a high degree of food security.

4. Balance land uses between agriculture and other activities

With the future of China's development relying on rapid industrialisation, great efforts should be made to ensure that land-use policies do not impede the ability to be able to continue rapid growth. Employment, income and productivity growth

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are all associated with the conversion of land from low-productivity agriculture to high-productivity industry and services. Land-use policies should not be homogeneous nationwide and priority should be given to fast-growing, industrialising regions. Rights need to be given to farmers to ensure that those who lose their land are directly and fairly compensated. A system of land-conversion permits might be considered for use across China, allowing only a limited amount of land to be converted each year, but it is important to make such permits tradable so development can occur in the places that are most optimal. The current Grain for Green program should be continued and commitments fulfilled while increased effort is given to effective implementation.

5. Change national grain-reserve management practices

Leaders need to deepen grain-market reform and change the management practices of the nation's grain-reserve system. Rules for purchases and sales of national grain-reserve stocks need to be open; public information on markets can internalise all of the factors that will influence short- and long-run price expectations, which will affect production, storage and sales decisions.

6. Improve China's food-quality regulation and monitoring system

International standards for food quality and safety measures could be consulted to modify China's Food Sanitation Law or implement new regulations or laws on food safety to improve food quality.

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CHAPTER 10

MANAGING CONVERSION OF CHINA'S CULTIVATED LAND

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10.1 PROTECTION OF CHINA'S CULTIVATED LAND

CCICED ARD Task Force members

ASSESSING CHINA'S CULTIVATED LAND ISSUES

Land is a critical input needed to keep the development process moving, allowing for the rapid shift of people in an orderly way from rural to urban areas. However, it is possible that as cultivated land is converted to built-up area it will conflict with national food-security goals. While little was heard about this conflict in the late 1990s through late 2003, as grain prices rose in the early part of 2004, policy makers and scholars began to debate the role of cultivated land conversion and the rise in prices. On the one hand, local leaders and developers in many parts of coastal China and in suburban areas around inland cities are in the middle of a period in which they have already committed large amounts of capital to development zones, factories and housing projects and are stressing the need for access to land so their plans can be fulfilled. Tens of millions of jobs in construction in the short run and hundreds of millions of jobs in the longer run depend on completing these projects and continuing with more in the future. On the other hand, others have labelled the conversion as an irreversible destruction of cultivated land that will hurt national food security.

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MAJOR ISSUES IN LAND PROTECTION AND ACQUISITION

Many issues have emerged in the matter of conversion of cultivated land to non-farm uses:

- The major issue is the perception that China is losing farmland at an alarming rate. The concern is that the reduction in land is reducing grain output, raising prices and weakening the nation's commitment to national food security. In recent years, estimates that China has lost more than 5 million hectares of farmland have been used to show that reduction of cultivated area is a major problem.
- Although there are many policies and regulations covering land use, it is often said that the major problem in land protection is their weak enforcement. Regulations specify that only provincial governments and the central government have the authority to approve the acquisition of cultivated land. For acquisition of high-quality cultivated land, the only jurisdiction is that of the State Council. Despite such clear regulations, however, it is known that large areas of cultivated land have been acquired without authorisation.
- It is also said that land acquisition has created large numbers of landless and unemployed farmers. According to the Ministry of Land Resources, during the period 1987–2001 about 55 million farmers have lost their land base. Observers worry that this could lead to social instability.
- One of the most pervasive problems, even in times when formal approval has been given, is that compensation to farmers is very low. On average, compensation amounts to only 5–10% of the land value. Farmers often do not know the details of the transaction and, even when they are given fair payment, believe that they were not treated fairly. The main benefits from the conversion of cultivated land into non-farm use accrue to local officials, local government coffers and land developers.

A number of factors contribute to rampant land acquisition:

- First and foremost, observers believe that unclear definition of land ownership is one of the most fundamental reasons for these problems. China's Land Management Law states that land is 'collectively owned'. Land is untitled.

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Distribution has historically been controlled by village leaders with support from township officials. Such vague definitions lead to confusion when land transactions are being made.

- There is no clear land-use planning procedure. In almost no part of China is there any formal differentiation between land for public use, land for business use and land for agriculture. To add to the confusion, the Constitution and the Land Management Law state that, to meet the need of the public interest, the state may acquire land. Other regulations proclaim that users of land cannot negotiate directly with its owners; the government purchases the land from the collective and sells it to the final users. This procedure occurs even when the acquisition is for development. According to a 16 province survey, nearly half of the land acquired has been used for housing and business activities. Only 10% of acquired land is for public goods.
- Given China's ownership structure and the role that the government plays as middleman in most transactions, it is not surprising that land acquisition almost always proceeds without consulting farmers. Arbitration procedures and appeals in disputed cases are not very well defined and favour the government. When assessing the incentives for converting land, it quickly becomes evident that there are many reasons why local governments have strong incentives to acquire land. There are almost always budgetary gains associated with the land acquisition process. According to research, the budgetary gains from the process of land acquisition can account for 35–60% of government revenues.
- In response to these emerging issues, the government—both earlier and in more recent years—has developed a number of measures to deal with land-management issues. There has been a shift in land policy to emphasise protection of cultivated land, central control over cultivated land and other measures. In general, both laws and regulations on land management have become clearer and stricter.

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IDENTIFYING THE PROBLEMS

Changes in cultivated land; changes in agricultural potential

The task force believes that well-founded research can show that, at least until 2000, the food-security concerns of the government over the conversion of cultivated land to industry, urban building projects and forests were misplaced. Based on digital images from the Landsat earth-orbiting satellite covering China's territory from the mid 1980s to 1999–2000, and more recent data from the Ministry of Land and Resources, scientists of the Chinese Academy of Sciences have explored the changes in total cultivated land and its productivity, and their likely impacts on grain production. The basic findings are as follows:

- Between 1986 and 2000, although the cultivated land converted to other uses totalled 3.06 million hectares, new cultivated land created from other uses was 5.71 million hectares. Therefore, rather than suffering a decline in cultivated areas, China actually recorded a *net increase* in cultivated land of 2.65 million hectares.
- Although it is true that the quality of land that has moved out of cultivation is generally of higher quality than newly opened cultivated land, according to careful, GIS-based research, the total net decline in bio-productivity is less than 0.5%. Hence, China's overall production potential (2% increased cultivated areas minus 0.5% decreased quality) still rose by almost 1.5% between 1985 and 2000.
- Landsat-based analysis also shows that most of the change is occurring in the coastal areas and around cities—exactly in the places where the conversion should be occurring. In other words, there is no evidence of excessive waste, such as turning vast tracts of wheat or rice land in central provinces into empty development zones.
- Less is known about changes in more recent years. The Landsat-based data end in 2000. According to statistics from the Ministry of Land Resources, cultivated land loss has accelerated in recent years. However, if these data are accurate, then, while true, it is important to understand that the nature of recent land conversions is different from those in the past. The main reason for grain-area declines due to conversion of cultivated land in recent years is the nation's Grain for Green program launched in 1999. In 2003, about 80% of the total reduction in cultivated land area was due to this land set-aside program. Between 1997 and 2003, there

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was little change in rate of conversion of cultivated land into urban expansion or industry. Moreover, unlike the land being converted into urban area, Grain for Green land is generally of extremely low quality. According to a State Forest Administration report, the average grain yields of such land are only around 50 jin per mu.

- Compared to the rest of the world, China's protection of cultivated land is outstanding. International experience shows that rapid economic growth is often accompanied by a large shift of land from agriculture to industry, infrastructure and residential use. For example, in the 1990s, Japan lost cultivated land at a rate of 1% per year. A similar trend is seen in South Korea since the 1970s. The US is losing its agricultural land at a rate of 0.1–0.3% per year to development and conservation set-aside. The fall in cultivated area in China (including Grain for Green) is only a fraction of that occurring in other countries.

Impact on prices or imports

- Since there is a net increase in total cultivated area and only a marginal decrease in quality between 1985 and 2000, not only is there no negative impact of cultivated land conversion, but also food security is increased because of the greater output potential. It is important too to note that the increase in employment from converting land to industrial uses is significant and real, and will improve household food security for those rural residents who gain new employment and enjoy rising incomes.
- According to research conducted by the Center for Chinese Agricultural Policy, the price impact of Grain for Green was minimal. Less than 5 percentage points of the 40% grain price increase that occurred between 2003 and 2004 is due to the Grain for Green program. Research shows that the reason for the small drop is twofold: one, the initial net decline from the land set-aside is small since the yields on the retired cultivated land are so low; two, yields on the rest of a farmer's cultivated land increase since they have more time available and can intensify their production on their remaining land.
- With almost no price effects, the analysis shows that the impact on imports is even smaller, and is virtually zero.

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Rights to participate in the land-acquisition process and right to receive fair compensation

Although the task force believes that the trends in the conversion of cultivated land are not problematic, the process is problematic and often leads to disenfranchised farm households which have lost their land without the right to participate in the process and without the right to fair compensation. In recent years, there are very few cases where rural households end up being satisfied. Compensation is low or non-existent. The lack of transparency in the process, even when fair and justified, leaves people suspicious and unhappy. Conversion of cultivated land to non-farm uses is inevitable, but the process that alienates the former owners of the land can and must be addressed.

Rational land-use plans

While the task force does not believe that too much land has been converted and that it is generally occurring where it should be expected, this is not to say that land-use planning does not need to be improved. Currently, as in many rapidly developing nations, long-term land planning is not well done. Resources are needed to ensure well-publicised protocols and principles that set and guide land acquisition and development of industrial, residential and other infrastructure needs. In addition, the World Bank has generated evidence that land pricing and conversion regulations create a bias that gives developers and local governments incentives to convert land in suburbs and ignore development opportunities inside the city limits. In China, as in other parts of the world, the cost to build inside the city versus the rural suburbs is often several times higher in terms of land and land preparation costs. Regulations and the political voice of the residents and users inside the city limits often refocus attention outside the city. Although such decisions are often consistent with short-run cost minimisation, when all costs and externalities are included, building in the rural suburbs can have adverse consequences (in terms of land value) for those living in the cities.

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KEY POLICY IMPLICATIONS

It is our recommendation that the fundamental principle underlying the policy is that the conversion of cultivated land into non-farm uses should be permitted. This is an inevitable part of development. Restricting it will retard development. If China invests heavily in productivity-enhancing projects and agricultural research and development, cultivated land conversion will **not** be a threat to national food security.

However, this process needs to be carefully managed, not just to ensure that the loss of irreplaceable, good quality cultivated land is minimised, but also, and more importantly, to ensure that the rural households that are dispossessed by the acquisition of their land are adequately compensated. To ensure a more orderly and equitable transfer of cultivated land to higher-value uses and to protect the interests of the predominantly poor rural households adversely affected by this process, the central government needs to clarify land-ownership rights and improve the legal recourse and protection available to all whose land rights are threatened.

Since Grain for Green has not contributed greatly to recent price rises and is not a threat to food security, future program expansion should not be impeded by its effects on grain production. While there may be reasons to slow down the expansion of Grain for Green, food security is not one of them.

Other distortions, such as poor land use and uneven land prices between urban core areas and suburban areas, should be rectified. Better land-use planning is needed. The nation should gradually move towards a market-based, government-regulated land-market system.

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10.2 CULTIVATED LAND CONVERSION AND BIO-PRODUCTIVITY IN CHINA

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INTRODUCTION

International experience shows that rapid economic growth is often accompanied by a large shift of land from agriculture to industry, infrastructure and residential use. Cultivated land in Japan, for example, has been declining significantly during the past three decades. In the 1990s Japan lost cultivated land at a rate of 1% per year (Uchida et al. 2004). A similar trend is found in South Korea since the 1970s (Uchida et al. 2004). The US is losing its agricultural land at a rate of 0.1–0.3% per year to development and land set-aside for conservation (Uchida et al. 2004).

Although starting later than the US and its East Asian neighbours, China has grown rapidly in recent years. China's economy in 2002 was about 8.5 times bigger than what it was when the economic reform began in 1978. Rapid economic growth has significantly improved the livelihood of China's population. During the reform era (1978–2002), GDP grew at an average annual rate of about 9% (NSBC 2003).

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The growth in food and agricultural production was also substantial. During the reform era, agricultural GDP grew at around 5% annually, largely exceeding the annual population growth rate (1.2%) over the same period. Rising income and food production have considerably improved China's food security and substantially reduced the incidence and severity of poverty. Interestingly, during the period of rapid economic growth, China has been a net food exporter since the early 1980s and net grain exporter after the mid 1990s (Anderson et al. 2005).

Although China's economy grew rapidly, concern over national food security remained and, in fact, may have intensified. Structural change allowing the emergence of cash crops, new export opportunities for labour-intensive fruits and vegetables and rising wages encouraged some of China's farmers to move out of grain production. In recent years, as in Japan and Korea, urbanisation and industrialisation began to accelerate, and cultivated land began to be converted to non-agricultural uses, such as industry, residences and urban infrastructure. These trends are expected to continue into the future as China's growth is expected to double the nation's economic output during the first decade of the 21st century. Since these trends, including the conversion of cultivated land, have all occurred just as China's agricultural production hit a period over the past five years during which there have been five successive reductions in grain sown-area and production, grain security once again has become a top priority in national agricultural policy. Although prices of grain fell during most of the past five years, as soon as the price of China's major grains began to rise in late 2003, the issue of the effects on grain production, imports and food security of conversion of cultivated land into built-up area moved to the top of the policy agenda of China's national leadership. Among other actions, in the early part of 2004 the State Council issued strongly worded directives about the importance of slowing down the conversion of cultivated land to built-up area. When the price rises continued in February 2004, a directive came from the top leadership banning any further conversion, except under several extreme conditions. Interviews with local leaders, and commentaries in local and national periodicals, show that there are strong views both for and against continuing with the conversion of land among different sets of actors. Some claim it is critical to maintain national food security; others say that it will cripple China's economic growth if the ban is kept in place for long.

Surprisingly, although the issue is important and has potentially far-reaching effects, there is almost no empirical research on the economic consequences of land conversion in China. Several key questions are in need of answers:

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- During the reform era, how much cultivated land has been shifted for non-agricultural use?
- Of the cultivated area that has been lost, how much has gone to urbanisation and industrialisation?
- While land is being converted out of cultivated area, how much land has been converted into cultivated land?
- What are the implications of cultivated land changes for the nation's food security?

Answers to the above questions are critical for China to be able to formulate policies that can ensure both food security and high economic growth in the coming decades. The overall goal of this study is to answer these questions by examining the changes in the cultivated land base, the effect on productivity and its ultimate impact on food security. To meet the goal, changes in China's cultivated area over time and its conversion to built-up area and other uses due to urbanisation, industrialisation and rural settlement expansion are examined using digital images from the TM/ETM sensors carried by the Landsat earth-orbiting satellite covering China's entire territorial area during the past 15 years. After identifying areas that have changed from cultivated areas to built-up areas, we then calculate the corresponding changes in agricultural land bio-productivity, using a methodology that uses agro-ecological zones (AEZ) to produce measures of bio-productivity.

The paper has five sections. Section two briefly introduces the methodology used in the study. Section three describes the unique data-set that we use in our analysis. The results are in the fourth section. The final section draws conclusions and discusses the policy implications for the future management of China's cultivated land.

METHODOLOGY

Land-use models, 1-km area percentage data models

The vector-data model and the raster-data model are two of the most widely used models in spatial data analyses.[1] In a vector-data model, each location or point is recorded as a single coordinate (x, y). A line is a series of ordered coordinates. Areas are recorded as a series of coordinates defining line segments that enclose an

[1] <http://gis.washington.edu/cfr250/lessons/introduction_gis/spatial_data_model.html>.

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area. The term polygon in our analysis means a many-sided figure (Felleman 1990; Jianping Xu and Lathorp 1994; Shupeng Chen et al. 1999). Vector-data models represent each surface as a series of isolines. For example, elevation is represented as a series of contours. While the vector-data model is useful for displaying information, its disadvantage is that it is not a convenient platform for analysing land surfaces with more than two characteristics, such as slope and elevation, along with some other aspect (Shupeng Chen et al. 1999).

An alternative to the vector-data model, the raster-data model is more like a photograph than a map. In a raster-data model, each location is represented as a cell. The matrix of cells, organised into rows and columns, is called a grid. Each row contains a group of cells with values representing some geographic phenomenon (Shupeng Chen et al. 1999). Cell values are numbers, which represent nominal data such as land-use types and measures of light intensity.

Although there are other choices, vector and raster-data models have a number of advantages (Felleman 1990; Jianping Xu and Lathorp 1994; Shupeng Chen et al. 1999). By combining the advantages of these two kinds of data models, Jiyuan Liu et al. (2002) further developed a 1-km area percentage data model (1-km APDM), or 1-km area with different land uses model, to detect and represent the land-use changes on a 1 km by 1 km grid scale. This model has been widely used in the past to analyse spatial and inter-temporal characteristics of land-use change in China (Xiangzheng Deng et al. 2002, 2003; Jiyuan Liu et al. 2002, 2003).

Based on the prototype of the 1-km APDM, we develop a set of programs to generate 1-km area percentage data. The generated 1-km area percentage data are based on map-algebra concepts, a data manipulation language designed specifically for geographic cell-based systems (Jiyuan Liu et al. 2002; Xiangzhen Deng et al. 2002). The procedures to generate the 1-km area percentage data are conducted in five steps. The first step is to generate land-use maps during the study periods, at a scale of 1:100,000. This is done by man-computer interpretation in the ArcGIS 8.02 software environment (Xiangzhen Deng et al. 2002; Jiyuan Liu et al. 2003). The second step is to generate a 1-km FISHNET vector map geo-referenced to a China boundary map at a scale of 1:10,000. The third step is to intersect the land-use change map with a 1-km FISHNET vector map. This is followed by aggregating the conversion areas for each land-utilisation type (LUT) in each 1-km grid identified by 1-km FISHNET vector cell IDs in the TABLE module of Arc/Info 8.02. Finally, the area percentage

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vector data are transformed into grid raster data to identify the conversion direction and intensification. The design and well-established data-handling procedures ensure that there is no loss in area and produce the basic data that are used for monitoring land-use change (the encroachment of urban land onto cultivated land).

Bio-productivity

There are several ways to estimate the potential productivity of cultivated land, or bio-productivity. Whatever method is used, a number of assumptions must be made about the crops or mix of crops that can be produced on each plot of land. Other assumptions are needed to estimate the acceptable level of output, the social acceptance of land-cover conversions, and the constraints related to land use that may be overcome by technology, management and investment (Keyzer 1998; Albersen et al. 2000; Fischer 2000, 2001; Günther 2001; Heilig et al. 2000;).

The Food and Agriculture Organization of the United Nations (FAO), in collaboration with the International Institute for Applied Systems Analysis (IIASA), has developed a method of calculating bio-productivity—the agro-ecological zones (AEZ) methodology—that is now in common use. The AEZ methodology serves as an evaluative framework for biophysical limitations and production potential of major food and fibre crops under various levels of inputs and management scenarios at global and regional scales (Albersen et al. 2000; Fischer 2000, 2001). In its simplest form, the AEZ framework contains three elements: selected agricultural production systems with defined input/output relationships, termed land-utilisation types (LUTs); geo-referenced land-resources data (including climate, soil and terrain data); and procedures for calculating potential yields, matching crop/LUT environmental requirements (by land units and grid cells) with the corresponding environmental characteristics available in the land-resources database.

The land-use change (LUC) group of IIASA has applied the AEZ methodology in China to assess the cultivated land potential throughout the country. In IIASA's procedure, the land-resources inventory of China comprises 375,000 grid cells measuring 5 by 5 km. As part of the agro-climatic characterisation, Fisher et al. (2001) employed a water-balance model in each grid cell, based on monthly historical data from 1958 to 1988, to simulate when and for how long water is available to sustain crop growth. The model also uses soil moisture, together with other climatic characteristics (such as radiation levels and temperature profiles), in a simple crop growth

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model to calculate potential biomass production and yield. In the next step, the LUC group combined the potential yield of each cell in a semi-quantitative manner with several reduction factors directly or indirectly related to agro-climatic factors (e.g. pests and diseases) and/or soil and terrain conditions (Fischer 2001). The reduction factors vary according to crop type, the specific environment of each grid cell, and assumptions about the level of inputs and management. The final result consists of attainable crop yields under various production circumstances. To ensure that the results relate to sustainable production, fallow periods are imposed, and terrain slopes and soils too susceptible to topsoil erosion are excluded (Fischer 2001). In this study, we follow the results on cultivated land production from IIASA as baseline values to estimate the changes of bio-productivity of cultivated land due to LUT conversions.

DATA

One of the strengths of our study is the quality of data that we use to estimate cultivated land use change and bio-productivity. For our purposes, digital images from satellite remote sensing are the most suitable data for detecting and monitoring LUC at global and regional scales. There are a number of choices. Satellite sensors, such as the advanced very high resolution radiometer (AVHRR), the Landsat thematic mapper (TM), and the French SPOT system, have been used successfully for measuring deforestation, biomass burning and other land-cover changes, including deforestation (e.g. Skole and Tucker 1993) and the expansion and contraction of deserts. Remote-sensing techniques also have been used widely to monitor the conversion of agricultural land to infrastructure (i.e. the process of urbanisation).

In our study, we use a LUT data-set developed by the Chinese Academy of Sciences (CAS). Our study's data are from satellite remote-sensing: US Landsat TM/ETM scenes[2] with a spatial resolution of 30 by 30 m. The database includes time-series data for three time periods: (a) the late 1980s, including Landsat-TM scenes for 1986–1989 (henceforth referred to simply as 1986 data); (b) the mid 1990s, including Landsat-TM scenes for 1995–1996 (henceforth 1995); and (c) the late 1990s, including Landsat-TM scenes for 1999–2000 (henceforth 2000). For each time period, we used more than 500 TM scenes to cover the entire country. Specifically, we use 514 scenes in the late 1980s, 520 scenes in the mid 1990s and

2 <http://www.reidc.ac.cn>.

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512 scenes in the late 1990s. The Landsat-TM images have been geo-referenced and ortho-rectified. To do this, the data team used ground control points that were collected during fieldwork, as well as high-resolution digital elevation models. Visual interpretation and digitisation of TM images at the scale of 1:100,000 were made to generate thematic maps of land cover (Xiangzheng Deng et al. 2002; Jiyuan Liu et al. 2003). A hierarchical classification system of 25 land-cover classes was applied to the data. In this study, the 25 classes of land cover were grouped further into six aggregated classes of land cover—cultivated land, forestry area, grassland, water area, built-up area and unused land (Table 10.1).

The interpretations of TM images and land-cover classifications were validated against extensive field surveys (Jiyuan Liu et al. 2002). The Chinese Academy of Sciences conducted ground-truth checks for more than 75,000 km of transects across China. During the ground-truthing, more than 8000 photographs were taken using cameras equipped with a global position system (GPS). The average interpretation accuracy for land-cover classification is 92.9% for the late 1980s and 97.6% for the late 1990s. The database from 1999–2000 was used for our analysis of current patterns of land cover in China. By comparing land-cover patterns between the late 1980s and the late

Table 10.1 The classification system of land-use categories used in this study

Land-use types	Explanations
Cultivated land	Original data include both paddy and non-irrigated uplands, which is aggregated into total cultivated land for this study.
Forestry area	Natural or planted forests with canopy covers greater than 30%; land covered by trees less than 2 metres high, with a canopy cover greater than 40%; land covered by trees with canopy cover between 10 to 30%; and land used for tea-gardens, orchards and nurseries.
Grassland	Lands covered by herbaceous plants with coverage greater than 5% and mixed rangeland with the coverage of shrub canopies less than 10%.
Water area	Land covered by natural water bodies or land with facilities for irrigation and water reservation, including rivers, canals, lakes, permanent glaciers, beaches and shorelines, and bottomland.
Built-up area	Land used for urban and rural settlements, industry and transportation.
Unused land (remaining area)	The rest of all other lands.

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1990s, we determined the change in land cover for the entire country during 1986–2000. Additional details about the methodology which we used to generate the databases of land cover from Landsat-TM data have been documented by Jiyuan Liu et al. (2003).

In order to obtain even more accurate estimates of land use, we also designed a matrix to help us discount the areas in which there are thin ground objects. To do this, we used information from aerial patches based on the CAS LUC data-set. The precision of measurement was down to the centimetre level. The widths of linear objects, including small canyons, ditches and roads, were measured via the ZOOM IN functions in the ArcGIS 8.10 environment (the smallest of the magnifying functions is 10 times). Irregular, linear, thin objects were divided into more-regular ones and measured one by one, then aggregated into areas of the entire thin objects. When handling the data in this way, we guarantee the accuracy of the discounting of linear thin objects as well as the measurement for the aerial patches. In addition, for small objects, their true areas were measured rather than generalised areas (which is the traditional way and less accurate) in order to guarantee the accuracy of aerial patches and ensure that they are relatively free from aggregation errors.

RESULTS

Changes in cultivated land

Using the methods and data described above, our study shows that China's conversion of cultivated land to other uses was surprisingly low during the study period of 1986 to 2000. According to our results, the conversion of cultivated land to non-agricultural uses totalled 3.06 million hectares over that period (Table 10.2, row 1, column 6). When compared with total cultivated area in 1986, the converted land accounted for 2.21% of total cultivated land (column 7). Conversion of this amount of land implies that the annual rate of conversion of cultivated land to other uses was only 0.15% during the study period, a rate that is much lower than that experienced in many other countries during the times at which their economies were growing rapidly.

Using the output of the GIS mapping and spatial analysis, we are able to create a map showing the conversions of cultivated land into other land-use categories (Figure 10.1; Table 10.2, columns 1–5). Among land converted out of agriculture, about 38% was converted to built-up areas. The vast majority of the area is in China's eastern coastal region. We can see too that smaller shares of cultivated land in the Loess

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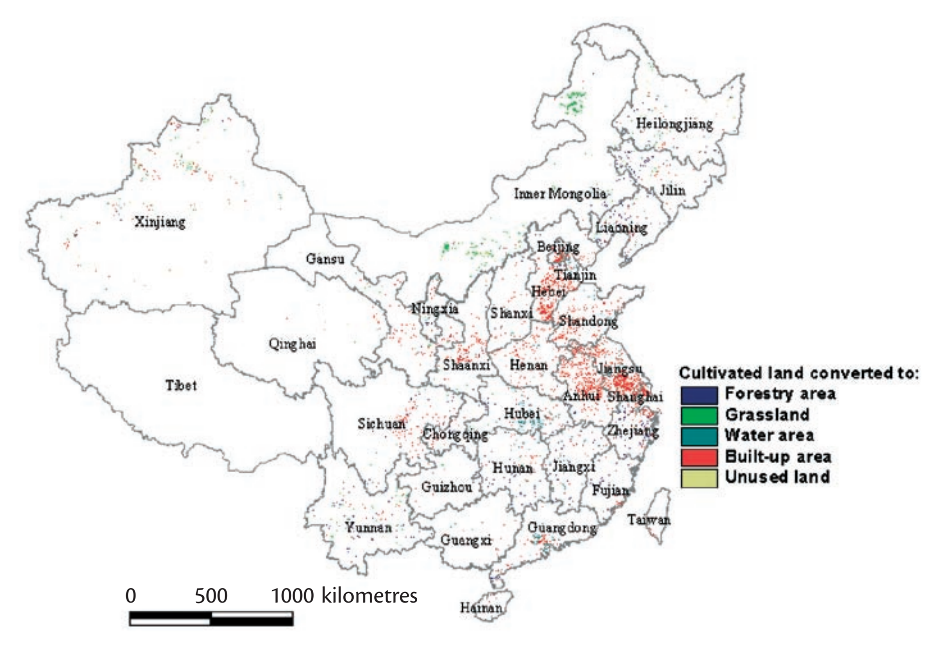

Figure 10.1 Distribution of land converted *from* cultivated land *to* other uses in China, 1986 to 2000

Plateau and the Sichuan Basin were converted into built-up areas. In addition to the area turned into industry, infrastructure and residences, 17% of the cultivated area was converted for forestry (in the south and southwest), 30% to grasslands (mostly in the northeast) and 16% to other uses.

Although a considerable area of cultivated land was converted to other uses between 1986 and 2000, during the same period an even greater area of land was converted from other uses into cultivated area (Table 10.2, row 2). Overall between 1986 and 2002, 5.71 million hectares of new, cultivated land was created (Table 10.2, column 6). As a share of cultivated land in 1986, the conversion of other land to cultivated land resulted in a gross expansion of 4.12%. Among the different types of land, most of the newly converted cultivated land, 55.23%, came from grassland, 27.76% from forested areas, and around 20% came from wetlands, the reclamation of unused land and other uses.

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The mapping analysis also shows the distribution of the newly converted area (Figure 10.2). Most of the area converted from grasslands is, as expected, mainly located in the northwestern part China and the eastern parts of Inner Mongolia. In north and north-eastern China, the map shows that there were large tracts of forests that were converted to cultivated land during the study period, while some areas of Sichuan also changed from forests to cultivated area. Finally, in northeastern China, especially in Heilongjiang, large tracts of unused wetlands and wastelands were converted to cultivated area, although in some cases, the analysis shows that there was considerable conversion of one type of cultivated land (e.g. paddy) to other types of cultivated area (e.g. upland).

When looking at the aggregate record of China during the study period, we can see that the tendency to convert cultivated land into built-up area and other uses is, in large part, offset by the conversion of grasslands, forestry and other land types into cultivated area. Hence, when taking the net gain (5.71 million hectares) from the net loss (3.06 million hectares), we find that, between 1986 and 2000, the cultivated land area of China actually increased by 2.65 million hectares (Table 10.2, row 3). When compared with the base of cultivated area in 1986, China's farmers were cultivating 1.91% more land in 2000 than they were in 1986.

Comparing Figures 10.1 and 10.2 shows, unsurprisingly, that the location of land converted into cultivated area differs fundamentally from that converted from cultivated land into other uses, including built-up area. In Figure 10.3 we summarise the data by ranking the provinces by the net percentage of total cultivated area (using

Table 10.2 Conversion of cultivated land in China, 1986–2000

	Land use (million hectares)						As percentage of 1986
	Forestry area	Grass-land	Water area	Built-up area	Unused land	Total	
Change from cultivated land being converted to:	0.51	0.92	0.29	1.17	0.17	3.06	2.21
Change from cultivated land being converted from:	1.58	3.15	0.23	0.07	0.67	5.71	4.12
Net change	1.07	2.23	–0.06	–1.10	0.50	2.65	1.91

Data source: Authors' data and calculations.

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1986 as a base) that was converted into or out of cultivated land. The results of this analysis show that, in more than half of the provinces, cultivated land area decreased. In general, cultivated land fell most sharply for the large municipalities and those provinces in southern and eastern China. It should be noted that Beijing and Shanghai are the only two provinces that experienced reductions of cultivated land that exceed 5%. In contrast, in one-third of the provinces the area of cultivated land rose. Most of the provinces that experienced net increases are in northeastern and some parts of northern China.

Changes in bio-productivity due to land conversions

Using the results of the AEZ analyses in conjunction with our data on the net changes of cultivated land, we can estimate the net change in bio-production (defined as the product of cultivated land times bio-productivity) due to the conversion of land into and out of cultivated area. The effect of conversion of cultivated

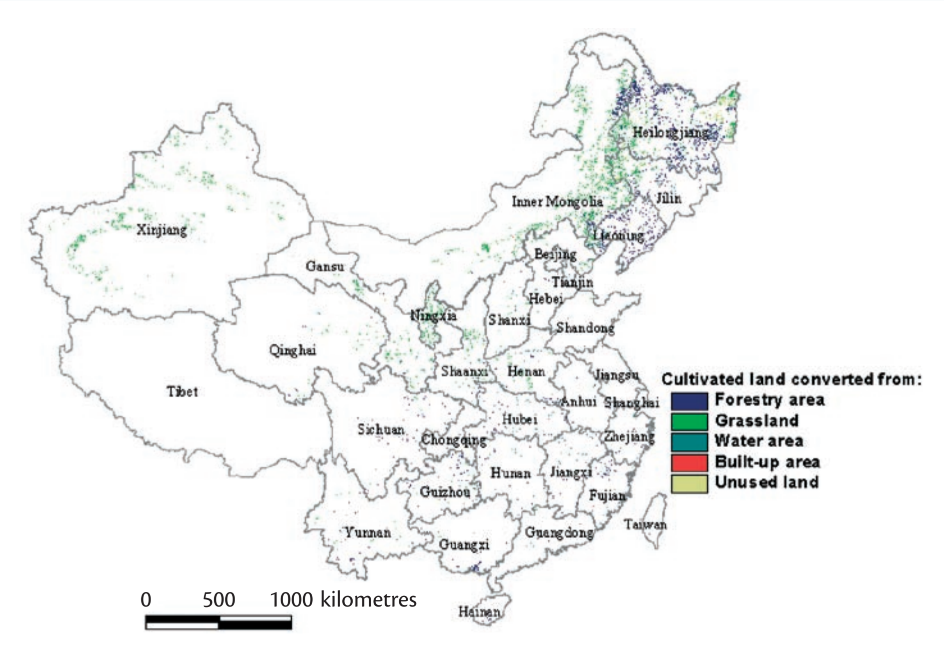

Figure 10.2 Distribution of land converted *to* cultivated land *from* other uses, 1986 to 2000

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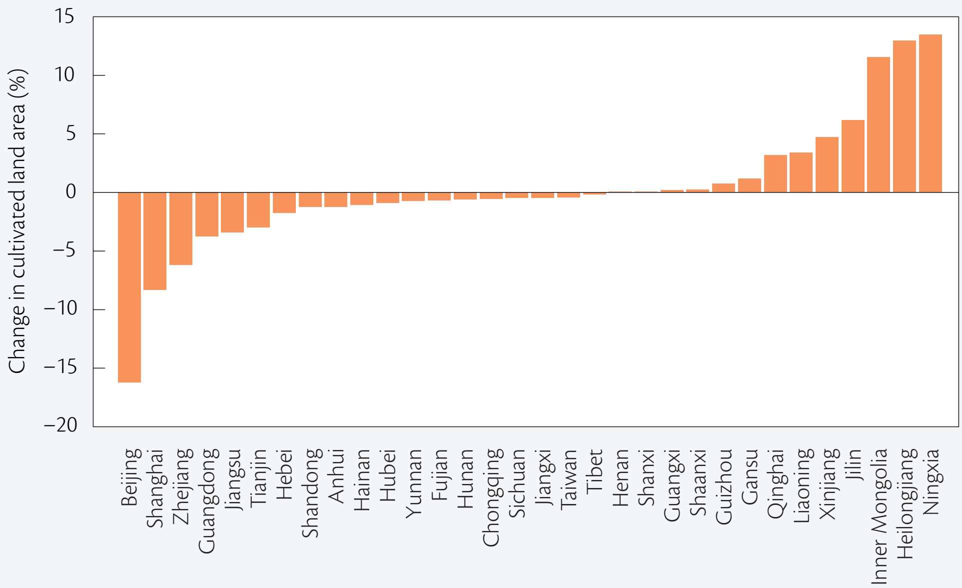

Figure 10.3 Percentage change in cultivated land area by province in China, 1986 to 2000

land is negligible. In total, the bio-production of cultivated land fell between 1986 and 2000 by 5858 billion kcal, or 0.31% (Table 10.3). This means that the average bio-productivity per unit land during the 15-year study period fell by 2.2%.

While overall there is only a small change, our analysis requires us to further disaggregate the net change by land type, so we can assess how much the conversion of cultivated land to built-up area has affected bio-production (Table 10.3). In total, the conversions of cultivated land to other uses led to a net loss of 34,829 billion kcal or 1.77% of total bio-production in 1986. Of this total amount, a decrease of 20,489 billion kcal or about 59% of the total fall in bio-production (or 20,489/34,829) is due to the conversion of cultivated land to built-up areas. The high percentage due to the conversion of built-up area is due in large part to the fact that the land being converted into built-up area is of higher quality than the other types of land moving out of agriculture. In a bio-productivity sense, higher quality is due to the fact that the converted land is in the south and east (so it can support two or more seasons) and is on less-steep slopes in areas with more precipitation. In addition, of the total reduction

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in cultivated area due to conversion, 16.14% (or 5623 billion kcal) is due to conversion to forestry, a figure that would be higher in 2004 since the nation's Grain for Green program (or a cultivated land conversion program) did not begin until 1999.

At the same time, the conversions of other uses to cultivated land have also led to an increase of cultivated land bio-production. In total, newly converted land accounted for 28,971 billion kcal more in bio-production. As a percentage of bio-production in 1986, newly converted land raised bio-production by 1.47%. Of the total, conversions from grasslands (47.91% or 13,879 billion kcal) and forests (35.67% or 10,335 billion kcal) account for most of the increased production. Hence, between 1986 and 2000, China recorded a net decrease in bio-productivity (–2.2%), which showed that, although the quality of land that was converted into cultivated area was less than the land converted into other uses (especially for that converted into built-up area), the increased land that could be cultivated in 2000 versus 1986 significantly offset the lower productivity due to conversion to built-up area.

When ranking China's provinces by the changing rates of bio-production, we can see that there exists an obvious spatial distribution pattern (Figure 10.4). The developed provinces in northern China, e.g. Beijing and Tianjin, account for a large share of the reduced bio-production. The eastern and southeastern provinces also account for a large fraction of the reduction. In contrast, the large shares of land reclaimed as cultivated land in northeastern China, Inner Mongolia and some inland provinces help boost productivity.

Table 10.3 Bio-production shifts (measured in billion kcal) associated with changes in cultivated area in China, 1986 and 2000

	Land use (billion kcal)						As percentage in 1986
	Forestry area	Grass-land	Water area	Built-up area	Unused land	Total	
Changes from cultivated land being converted to:	5,623	2,687	5,432	20,489	598	34,829	1.77
Changes from cultivated land being converted from:	10,335	13,879	2,351	82	2,323	28,971	1.47
Net change	4,713	11,192	–3,082	–20,407	1,726	–5,858	–0.30

Data source: Authors' data and calculations.

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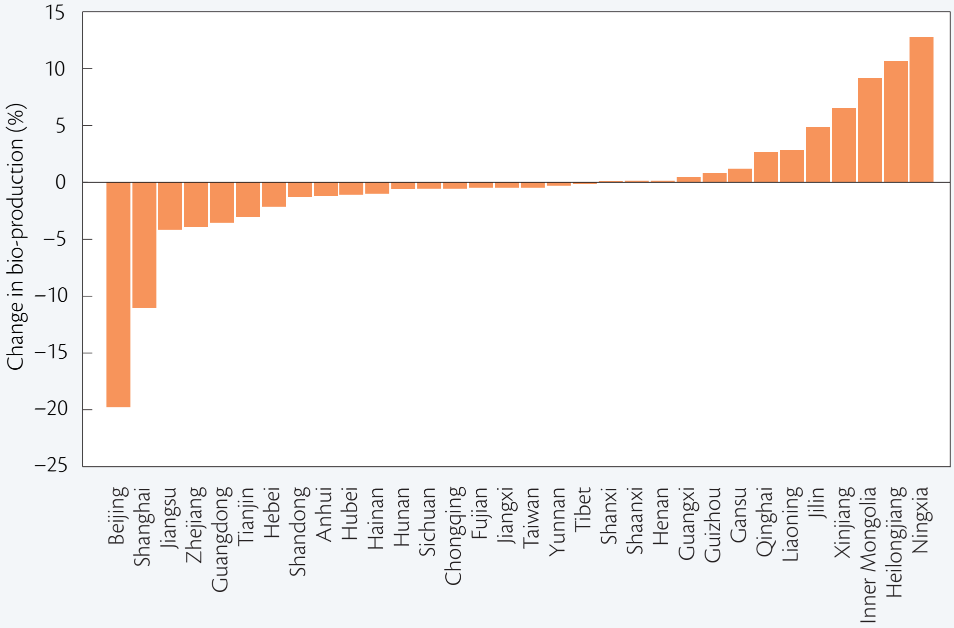

Figure 10.4 Percentage change of total bio-production associated with changes in cultivated land by provinces in China, 1986–2000

CONCLUSION

Our study finds that, contrary to popular belief in some quarters, the rapid economic growth in 1985–2000 has not resulted in a large loss of cultivated land. In fact, in terms of retention of cultivated land, China's agriculture is doing well, with the net area of cultivated land actually increasing during 1986 to 2000. Breakdown of cultivated land changes show that nearly half of the cultivated land lost went to grassland (30%) and forest (17%). Of the remainder, most went to built-up area (40%). However, there was a considerable amount of newly cultivated land as well, some shifting from grassland and some from forest area.

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Although the newly cultivated area rose, bio-productivity fell. The most important reason is that the quality of the land converted from cultivated area to built-up area is higher than that converted from other uses. Despite this, however, when examined in aggregate for the entire period, the effect on bio-production is negligible. Although decline in cultivated land has been significant since 2000, most of the reduction of land was due to land conservation programs such as Grain for Green, which have little impact on domestic grain prices and the balance of food demand and supply.

When considering the main message to policy makers, one of the most important lessons is that, at least through 2000, there is no real problem. It is true that land needs strict management to facilitate its rational use in the short and long-run, but our work suggests that the current ban on land conversion is not warranted. Since the process of development is one of shifting the population from rural and agriculture to urban and industry, a complete ban on conversion, especially at the recent growth rates of China, may pose a serious threat to rapid development.

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10.3 LAND ACQUISITION IN CHINA:

POLICY DEVELOPMENT AND REFORM RECOMMENDATIONS

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INTRODUCTION

Land issues are of the utmost importance for agricultural and rural development as well as overall economic development and social stability in China. This is primarily due to the twofold functions of land in Chinese agriculture: land as a production/economic tool and land as security for its smallholders. There are frequently conflicts in the efforts to let those two functions operate. For the nation as a whole, there are also conflicts between two major types of land use: for agriculture/food security and non-agricultural purposes. The conflicts have become increasingly evident in recent years, as large areas of farmland have been taken away for non-agricultural purposes, such as massive infrastructure construction and explosive urban expansion. Major problems from massive land acquisition include: (1) a sharp decline in crop land and grain production, which arouses widespread concern on food security; (2) substantial infringement of farmers' rights and interests due to unfair compensation methods and low compensation standards; and (3) social insecurity for a large number of the farmers made landless and the social instability associated with this. It is of the utmost importance and urgency to solve those conflicts so that the land demand for industrialisation and urbanisation can be efficiently met while farmland and farmers' interests are protected.

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There are complex reasons for the problems, but the most fundamental ones are the deficiency of, and loopholes in, the existing land laws and regulations and their weak enforcement. The effects on landless farmers and compensation methods have changed fundamentally since the reform era. The conditions for solving the associated problems have changed completely within the new market system. In the past two decades, the scale of land acquisition, the magnitude of the challenges, the main goals and the instruments available for land-acquisition have all changed. The policy framework has not kept pace with those changes. On the other hand, it has become a nationwide phenomenon that local governments are extraordinarily enthusiastic about acquiring farmland from farmers for non-agricultural uses, leading to weak enforcement of land protection and acquisition laws and regulations.

In the second section of this paper, the development of the legal and policy framework on land acquisition in China over the past two decades is reviewed and analysed. The changes in land area are presented, then, in the third section, the major contributors to land area decline are discussed. In the fourth section, the most outstanding problems in land management and major reasons for those problems are analysed. Finally, in the fifth section, recommendations to improve the existing policy framework and its enforcement are made.

A REVIEW OF THE DEVELOPMENT OF LAND-ACQUISITION POLICY

A large number of laws, regulations and decrees have been made and promulgated by the Congress or the State Council on the matters of land use, land protection and land acquisition. Those major laws and regulations are listed in Table 10.4.

Over the past two decades, fundamental changes in land management and land-use policies have occurred. The major changes and the main features of the current policies can be summarised as follows.

First, the system of land tenure has been fundamentally changed, and individual farmers have gained use-rights to farmland. Under the Household Responsibility System introduced in the late 1970s, the ownership of the land remains with the village collectives, but the right to use the land, to gain benefit from land use, and to transfer

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or to terminate the land-use right is granted to individual farmers, as long as the land is used for agricultural purposes. The most explicit statement of those rights is provided in the *Law for Rural Land Contracting* effective since 2003. According to the law:

> The state protects the legal right of the collective land owners, the contractual land use right of the contractors; no organizations or individuals are allowed to infringe those rights.
>
> The state protects the contractors in transferring out their contractual land use right based on their own willingness, against compensation and according to laws.
>
> The contractors…have the right of using, benefiting from and transferring the contracted land…

Table 10.4 Major land laws and regulations in China

Name of regulation	Authority	Year of promulgation/ revision
Land Management Law	People's Congress	1986, 1988,1999
Law for Rural Land Contracting	People's Congress	2003
Decree on Land Acquisition for Construction	State Council	1982
Decree on Land Use for Housing Construction in Villages and Towns	State Council	1983
Regulations on Land Reclamation	State Council	1989
Decree on Implementing the Land Management Law	State Council	1991, 1999
Regulations on Basic Farmland Protection	State Council	1992
Urgent Notice on Prohibition Misuse and Unapproved Farmland Acquisition	State Council	1992
Decree on Village and Town Planning and Construction Management	State Council	1993
Decree on Basic Farmland Protection	State Council	1994, 1999
Notice on Strengthening Land Management and Farmland Protection	State Council	1997
Notice on Streamlining All Development Zones and Enhancing Construction Land Management	State Council	2003
Decisions on deepening reform and strengthening land management	State Council	2004

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The term of the land contract was first set at 15 years, then extended for another 30 years.

Second, protection of farmland has gained increased attention from policy makers, and a basic farmland protection system has been established. The protection of farmland has long been a focus in land management laws and regulations. The *Decree on Land Acquisition for Construction* promulgated in 1982, indicated that:

> Saving land is the basic national policy. All construction projects must follow this principle to increase land use efficiency. Acquisition of farmland for construction is not allowed when there is suitable wasteland; acquisition of fertile farmland, in particular economically high-productive land such as vegetable land, garden plots and fish ponds, is not allowed for construction when infertile land can be used.

The wording of the 1999 version of the *Land Management Law* has become more explicit and strict:

> It is the basic national policy to highly cherish land, reasonably use land and strictly protect farmland. Governments at all levels should adopt effective measures to thoughtfully plan, strictly manage, protect and develop land resources, and to prohibit illegal activities of farmland acquisition.

The focus on land has been shifted from a general statement of protecting land to emphasis on protecting basic farmland. The *Decree on Basic Farmland Protection* was first formulated in 1994 and revised in 1998. It established the system of basic farmland protection. Accordingly, four types of high-quality land are defined: farmland located in the areas previously defined as production bases for grain, cotton and oilseeds; farmland with good irrigation and erosion-prevention facilities, and other potentially high-yielding land; production bases for vegetable production; and land for agricultural research and teaching experiments. In each province, designated basic farmland should exceed 80% of the total farmland. According to the law, strict protection measures should be applied to the designated basic farmland, including the following:

- The amount of the basic farmland should not decline.
- No organisations or individuals are allowed to change the nature or use purpose of basic farmland. For state-designated key construction projects that cannot avoid occupying basic farmland, the land acquisition plan can be approved only by the State Council.

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- Given the approval of the State Council, the acquisition of basic farmland must be compensated by the same amount of reclamation of new basic farmland by the land user. When reclamation is not possible in the locality, the land user should pay reclamation fees that can be used for reclamation in other localities.
- It is prohibited in the basic farmland areas to construct brick factories, housing projects or graveyards, to mine for construction materials or other raw materials, to dispose of solid waste, or to engage in other activities having damaging effects on basic farmland.
- No organisations or individuals are allowed to use basic farmland to develop forestry or fruit orchards, or dig fish ponds.

Third, the coverage of state land acquisition is very broad, and almost all non-agricultural construction projects have to apply for land through the state land-acquisition process. All groups and individuals must apply for state-owned land for construction. State-owned lands include those previously collectively owned and acquired by the state. This means that all construction must occur on state-owned land. When construction occurs on land not owned by the state, the land will first be turned into state ownership by the land-acquisition process. Only those lands that are used by villages or townships for business and public facilities are allowed to maintain collective ownership, though changes of land use from agricultural to non-agricultural purposes should also be approved by related authorities. In the *Decree on Land Acquisition for Construction* no distinction is made between construction for public and non-public purposes. Land needed for all kinds of construction was to be obtained by acquiring land from rural collectives. In the revised version of the *Land Management Law*, there is an article noting that: 'The state may acquire collectively owned land for the need of public interest'. This indicates that the aim of state land-acquisition is to serve the need of public interest. However, it is unclear how to judge whether the land acquired is for public interest or non-public/commercial interest. There is one exemption to this rule, namely the land for establishing township and village enterprises or for other public facilities in townships/villages, or for villagers' own housing, may retain its collective ownership when such uses are approved. This is to say, when farmers want to use their farmland for non-agricultural purposes for themselves, land ownership may remain unchanged without the state land-acquisition process, as long as such changes of land-use purposes are approved by the authorities.

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Fourth, the method of land-acquisition control has changed, and the jurisdiction for approving land acquisition has gradually moved to higher authorities. This is one of the measures taken to ensure stricter control of land acquisition from the agricultural sector and to reduce the tendency for local governments to misuse or overuse farmland for non-farm purposes. According to the *Decree on Land Acquisition for Construction*, acquisition of farmland with an area of 1000 mu (1 mu = 1/15 ha) or more and other land of 10,000 mu or more should be approved by the State Council. The acquisition of land in suburban areas of provincial level municipalities should be approved by the municipal government. Land acquisition in other areas should be first checked by the prefecture or county government and finally approved by the provincial government. Land parcels of less than 3 mu farmland, or 10 mu forest land or grassland, or 20 mu other land, should be approved by county or prefecture governments.

The 1998 revision of the *Land Management Law* limited jurisdiction for land acquisition more strictly, to two levels: the national level and the provincial level. Governments at county and prefecture levels were deprived of the power to approve land-acquisition plans regardless of the size of the parcel of land in question. Land-acquisition plans that have to be approved by the State Council include those involving basic farmland, non-basic farmland exceeding 35 hectares (525 mu) or other land exceeding 70 hectares (1050 mu). Land-acquisition plans not covered by the jurisdiction of the State Council are to be approved by the provincial government. The county and prefecture governments have the right to make detailed construction plans only within the framework of the approved land-acquisition application by the provincial or central government.

Fifth, the procedures for land acquisition specify that potential land users make the application, and the related government authority reviews and makes approval decisions, with very weak participation by farmers. According to the *Decree on Land Acquisition for Construction*, land acquisition usually involves the following steps:

1. Site selection. Given approval of the construction project, potential land users/units apply to the local (county/prefecture) government for land acquisition and review, after which the construction site will be selected.
2. Consultation with original land owners. Once the site is chosen, local government will arrange for the potential land user/unit and the original land owners to discuss the areas to be acquired, a compensation plan, and signing of the draft agreement.

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3. Verify the land area and finalise the agreement. Once the land-acquisition plan is approved by the appropriate authority, the local land administration will arrange the signing of the formal agreement.
4. Transfer of the land. This will be organised by the local land administration.

Sixth, upper and lower limits have been set in the regulations on compensation standards associated with land acquisition. Compensation consists of four parts: for land-use rights, personnel allocation, facility losses and crop losses. Compensation standards stipulated in the *Land Management Law* (1998) are significantly increased from those in the *Decree on Land Acquisition for Construction* (1982). According to the *Land Management Law* (1998), compensation for land-use rights should be between 6 and 10 (previously 3–6) times the average production value for the previous three years. Compensation for personnel allocation is based on the size of the farmer's family and per-capita land holding before land acquisition: between 4 and 6 (2–3 previously) times the average production value of the previous three years per person, with a ceiling at 15 (previously 10) times for the whole family. Compensation for facility and crop losses is to be determined by the provincial government. Units using suburban farmland should pay a special fee for construction on vegetable land. The provincial government can increase the compensation level to prevent a fall in a farmer's livelihood, but the combined compensations for land use and personnel allocation should not exceed 30 times the average production value of the previous three years. This restriction has been removed in a recent decision by the State Land Administration.

In October 2004, a new document entitled 'Decisions on deepening reform and strengthening land management' was released by the State Council. This demonstrates increased resolve of the central government to implement more-stringent land-management measures to protect farmland. This largely resulted from the recent warning about grain shortage after consecutive years of production decline. Major decrees in the document are:

1. It is strictly prohibited to lower land price to attract foreign investment, and those who violate this principle will be prosecuted.
2. To improve the land acquisition procedures: before the land-acquisition plan is submitted for approval, the plan, the compensation standards and new employment arrangements should be made known to farmers, and public hearings should be organised if necessary.

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3. The gains generated from land price differences between that paid to farmers by the government and that paid by land users should be first delivered to the state treasury and then divided by ratio between the central and local government.
4. A state land-supervising system is to be established to strengthen the enforcement of land management and protection laws The state will appoint a supervisor-general and send supervisors to local governments.

CHANGES IN FARMLAND AREAS IN THE PAST TWO DECADES

In China, farmland accounts for only about 13% of the total land area, far lower than most countries. The current land use pattern in China is summarised in Table 10.5.

In the past two decades, changes in farmland areas have shown the following trends.

Continued decline in total farmland area

Since the end of the 1970s, the accumulated net reduction in China's farmland is over 172 million mu, or 9% of the current land amount of 1851 million mu. The first peak appeared in 1985, when the yearly net reduction of farmland exceeded 15 million mu. It can be noticed that the reduction has become especially serious in

Table 10.5 Land uses in China, 2003

Land use	Proportion (%)
Residential and industry	2.67
Transportation	0.23
Irrigation facilities	0.38
Arable land	12.98
Horticulture	1.17
Forest	24.61
Grassland	27.68
Other agricultural land	2.68
No specific use	27.6

Source: Statistical yearbook of China 2004.

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the past four years, with the figure in 2003 standing at 38 million mu, or more than 2% of total farmland. The total amount and yearly reduction of farmland in China is presented in Table 10.6.

Farmland area measured in per-capita terms is low and continues to decline

Farmland area in China is currently below 1.5 mu per person. Due to the continued population expansion and decline in total farmland area, the farmland area per capita has been falling continuously, as indicated in Table 10.7.

Table 10.6 Annual reductions in farmland area (million mu) in China, 1979–2003

Year	Total farmland	Yearly reduction	Year	Total farmland	Yearly reduction
1979	1492.47	…	1992	1431.39	3.42
1980	1489.58	2.89	1993	1426.52	4.87
1981	1485.53	4.05	1994	1423.60	2.92
1982	1479.10	6.43	1995	1424.57	+0.97
1983	1475.39	3.70	…	…	…
1984	1467.80	7.59	1996	1951.00	…
1985	1452.69	15.11	1997	1949.00	2.04
1986	1443.44	9.25	1998	1945.00	3.92
1987	1438.33	5.12	1999	1938.00	6.55
1988	1435.83	2.50	2000	1923.00	19.13
1989	1434.84	0.99	2001	1914.00	9.26
1990	1435.09	+0.25	2002	1889.00	25.31
1991	1434.81	0.29	2003	1851.00	38.06

Sources: Data for 1979–1995, Agricultural statistics in new China, Chinese Statistical Press, 2000; Data for 1996–2002, SEPA, Report on environmental situation in China, various years; Data for 2003, Ministry for Land Resources, Report on land resource in China 2003.

Note: There is a break in the farmland series in 1996 when a national agricultural census revealed previously under-reported farmland areas of over 37%.

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Table 10.7 Changes in total and per-capita farmland area in China, 1996–2003

Year	Total farmland areas (million mu)	Mu per capita
1996	1951	1.59
1997	1949	1.57
1998	1945	1.56
1999	1938	1.54
2000	1923	1.52
2001	1914	1.50
2002	1889	1.46
2003	1851	1.43

Sources: Data for 1996–2002, SEPA, Report on environmental situation in China, various years; Data for 2003, Ministry for Land Resources, Report on land resource in China 2003.

The reforestation program has been the main reason for farmland reduction

Table 10.8 shows where land lost to farming has gone. The largest part of the farmland reduction took place due to implementation of the Grain for Green program, which encourages farmers in mountainous western China to set aside hillside fields for ecological purposes, such as reforestation or grass planting. Farmland located on slopes steeper than 25 degrees is to be set aside. The government provides cash and in-kind grain subsidies, which are worth more than the return that could be generated from cropping this unproductive land. The policy was first trialled in three western provinces—Sichuan, Shaanxi and Gansu—in 1999, and then gradually extended to other provinces. After three years of pilot practice, the project was officially launched in more than 1000 counties (half of the total) in 25 provinces in 2002. The land set-aside program did exist before the abovementioned project, but only on a rather limited scale. It can be seen from Table 10.8, that after the Grain for Green program was introduced, set-aside areas increased dramatically. About 62% of the reduction in farmland area in the observation period is attributed to the introduction and implementation of this program.

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Table 10.8 Farmland reduction (million mu) in China, 1997–2003: how the land transferred was used

	Total reduction	Con-struction	Set-aside/ reforestation	For non-crop use	Land damaged by catastrophe	Reclam-ation	Net reduction
1997	6.94	2.89	2.46	0.89	0.71	4.90	2.04
1998	8.63	2.64	2.47	1.05	2.47	4.72	3.92
1999	12.63	3.08	5.92	1.61	2.03	6.08	6.55
2000	23.49	2.45	11.45	8.67	0.93	4.37	19.13
2001	12.45	2.46	8.86	0.68	0.46	3.04	9.26
2002	30.43	2.95	21.38	5.24	0.86	5.12	25.31
2003	42.72	3.44	33.56	4.97	0.76	4.66	38.06
Total	137.28	19.89	86.09	23.09	8.21	32.87	104.26
%	100.0	14.5	62.7	16.8	6.0		

Sources: Data for 1996–2002, SEPA, Report on environmental situation in China, various years; Data for 2003, Ministry for Land Resources, Report on land resource in China 2003.

The second-largest part of the reduction in recent years is the land taken away from crop cultivation for other agricultural uses, such as fish ponds or trees, a process called 'restructuring'. In 2003, restructuring accounted for about 17% of the total decrease in farmland area.

Non-farm construction activities accounted for a large share of the land reduction

According to official statistics, the area taken away from agricultural use for construction is fairly stable, at about 3 million mu per year, making the total amount in the 7-year period from 1997 to 2003 nearly 20 million mu. However, this figure seems to be under-reported. This is because many local governments are very keen on construction projects to promote local economic growth through new investments and to gain revenue from the land-acquisition process. The many cases of illegal land acquisition reported in the national media in recent years are obvious evidence, as discussed in more detail in the following section.

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The potential for reclamation is limited

From statistical figures, the area of land reclaimed annually is between 3 and 6 million mu, larger in any given year than that for construction. However, this quantitative comparison is misleading, since most of the land taken from agriculture is usually high-fertility farmland with high yields and a high cropping index, and is generally close to markets, while the newly reclaimed land is often the opposite—of much lower productivity and in remote areas. This also indicates that the potential for new reclamation in China is very limited. The newly reclaimed land is, as a rule, located in ecologically fragile areas.

MAJOR PROBLEMS IN LAND MANAGEMENT AND LAND ACQUISITION

Concerns about problems associated with land management and land acquisition have become more open in recent years. Disputes on land issues have moved to the top of the complaints of farmers to the agricultural administration at various levels. Major problems in land acquisition can be summarised as follows:

Land acquisition and misuse by development zones

By the end of 2003 (Ma Jia 2004), there were 6015 'development zones' of various kinds and at various levels nationwide, with a total area of 35,100 km^2, or 3.66% of the total land area in China. Huge areas have been acquired, mostly taken away from farmland, and many remain to be developed. Comparison of this figure with the existing land-use structure reveals the huge scale of land acquisition by development zones. The sum of the existing residential, industry and transportation areas is only 2.90% of the total land area in China and is exceeded by the 'to be developed' development zone areas.

Of the total 6015 development zones, 259 have been approved by the central government, 1559 have been approved by provincial governments, and the remaining 4197 were approved by prefecture, county and township governments. Over 80% of the development zone areas were taken from farmland. Some 43% of the land area acquired by development zones had not been used (Han Changfu 2003) at the end of 2003. In one prefecture in Shandong Province, there were 161 development zones approved by governments at various levels, totalling 971.3 km^2. Of those areas,

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only 57% have been developed, and 47% remain idle (Liu Zhen 2003). Nationwide, there are over 900 provincial-level development zones with a total approved area of 30 million mu, of which only 13.5% had been used by the end of 2003, with the remaining 26 million mu land area lying idle.

Weak enforcement of farmland protection regulations

According to related regulations, only provincial governments and the central government have the authority to approve farmland acquisition. For acquisition of basic farmland, the only jurisdiction is the State Council. However, large areas of farmland have been acquired for establishing development zones without approval. Of the 6015 development zones, only 1818 have been approved by the State Council or provincial governments (Mu Jia 2004). It can be assumed that a very large number of the development zones have been illegally established. Since 2000, over half a million violations of land-management regulations have been detected. In 2003 alone, 178,000 such cases were found (Niu Feng 2004). According to investigation results from 10 provinces in 2003, 69% of the total development zone areas are not legally approved (Wang Weimin 2004).

Farmers interests are often not considered in the land-acquisition process

Land acquisition has created large numbers of landless and unemployed farmers, which seriously affects social stability. In the process of land acquisition, though there is some compensation to farmers, the levels are very low. On average, compensation fees are only several thousand yuan per mu, accounting for only 5–10% of the true value of the land. The remaining benefits from turning farmland into non-farm use are split among local government, the land developing companies and villages. According to some investigations, about 60% of the farmers whose land has been acquired cannot find alternative jobs or other income sources (Zhang Yan 2004). According to statistics of the Ministry of Land Resources, during 1987–2001 total acquired land areas, legal and illegal, amounted to 44.2 million mu, creating about 55 million landless farmers (Mu Jia 2004). In 2003, the Ministry of Land Resources received 3394 letters of complaint and visits from 1015 farmer groups. A large share of those complaints is related to illegal land acquisition, accounting for 52% of the complaint letters and 32% of visitors. The second-largest share is related to the issue of compensation for land acquisition, accounting for 12% of the complaint letters and 30% of the visitors (Teng Wen 2003).

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There are a number of reasons for these problems. First, poorly defined ownership of farmland is the fundamental reason. According to the *Land Management Law*, rural land is 'farmers collectively owned'. The definition is rather vague and no further explanation can be found in the existing laws. The *Decree on Implementing the Land Management Law* provides a detailed list of land owned by the state, but without any clarification on rural land ownership or the meaning of 'farmers collectively owned'. There are three levels of 'collective unit', namely natural village, 'administrative village' (consisting of several natural villages), and township. There are several factors underlying the uncertainty of land tenure: (1) Who is the representative of the collective ownership? In practice, the village leaders usually take this role. (2) What is the relationship between ownership and contract right? Individual farmers have the contract right. A special law has been promulgated to regulate the issues in this area and protect farmers' contract rights. However, in practice, farmers are often not sure about the nature of their contract right, in particular when village leaders use the ownership right against the contract right. (3) Who are the farmers in the village? In practice, the concept of 'farmers' in land-right issues is often understood as three different groups: those doing farm work, farmers' households, and the whole village population. In all three cases, the groups are dynamic and under constant changes driven by births, marriages, deaths and various kinds of migrations. Adding those factors together leads to the aggregate effect that land acquisition encounters less resistance from farmers than under a clearly defined individual land ownership system.

Second, there is no clear separation or differentiation between land for public use and land for business use in the laws for land acquisition. In the Constitution and the *Land Management Law*, there is a statement that, to meet the need of public interest, the state may acquire land. However, in the articles related to land acquisition, all land needed for construction must first be acquired by the state, without any differentiation of public or business purposes. A large share of the acquired land has been used for business purposes. According to surveys in 16 provinces, about 35% of the acquired land has been used for housing, enterprises and other business activities. In one provincial capital in the coastal region, the share for real public goods construction accounts for only 10% (Teng Wen 2003).

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Thirdly, according to the law, land acquisition is compulsory, with little consultation with farmers. Only on the issue of compensation are farmers' opinions sought, before the compensation plan is decided. When disputes arise, it is the authority approving the land-acquisition plan that makes the final arbitration.

Fourth, the *Decree on Implementing the Land Management Law* stipulates that, when all members of a collective economic organisation become urban residents, the land collectively owned by those members will be changed into state ownership. This regulation empowered local governments to get land by changing suburban rural populations into urban populations.

Finally, the most fundamental and decisive factor is that local governments have a strong interest in land acquisition due to the budget gains associated with the process. Because the compensation level for land acquisition is low, and the acquired land is usually in a good location and of very high value, the profit to local governments from land acquisition is enormous. According to some investigations, the budget gains from the process of land acquisition and then transition of land use rights by local governments accounts for 35% to 60% of the government revenue in some prefectures and counties (Tian Yongsheng 2004). Governments at all levels can participate in the benefit-sharing process of land acquisition, from municipality, county, township and even village. This is also revealed in the complaint cases received by the central government, where the accused are mostly local governments at all levels, as well as village leaders.

MAJOR CONCLUSIONS AND POLICY-REFORM RECOMMENDATIONS

The land issue relates to long-term national food security, farmers' interests, social stability and macro-economic development. In the process of overall national economic development, it is unavoidable that more farmland will be taken away from agriculture. The existing land-administration policy needs to be further reformed to meet the reasonable demand for land for macro-economic development, to protect farmland from misuse and overuse, to protect farmers' interests and to prevent social instability arising from the creation of landless farmers.

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The roots of the problem lie in constraints of the existing legal and policy framework, weak enforcement and rampant violation of laws and regulations. Therefore, both policy formulation and implementation should be reformed and improved. Major reform recommendations are as follows:

Improvement and modification of existing laws and regulations

First, measures should be taken to more clearly define land ownership in the village. This will help farmers to increase their awareness and protect their assets and property, and will also increase the awareness of the local government to respect farmers' land rights. This can be achieved through different approaches. In the long-term, privatisation is a favourable solution. This requires change in ideology and political acceptance, which should not be impossible as the privatisation of valuable assets in other economic sectors has long been practised and even encouraged. As a short-term alternative, emphasising the 'land contract right' and enhancing legal protection of this land contract right should be given more attention. This can be accomplished through an institutional arrangement. For example, individual farmers should be given a certificate of their contracted land by the central government agency or at least by provincial governments. This will increase the authority of the 'contract' and the land contract term of 30 years or longer. A certificate issued by the provincial or central government will protect the holders against intervention from local officials.

Second, the compensation mechanism for land acquisition should be reformed, regardless of the nature of the land acquisition, whether for public or non-public/commercial purposes. The market mechanism should be used in determining the value of, and the compensation levels for, the acquired land. Many scholars suggest having a clear differentiation of land acquisition for public benefit and for private business activities. A set of criteria should be set up for public-benefit activities, or an approach could be adopted whereby all activities of a public-benefit nature are listed; what is not on the list is private business. The policy implication of the two types is that there will be different land-acquisition procedures. However, in both cases, farmers should be compensated with the market value of their land, not with arbitrary levels set by local bureaucrats. The market-value compensation mechanism will serve two goals: to effectively protect farmers' interests and to reduce motivation of local governments for excessive land acquisition. For non-public/private business purposes, land-right transfer should not be compulsory, rather it should be based on

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negotiations between farmers or farmers' organisations and potential land users. The land can enter directly into the market, without the necessity of first becoming state land. Alternatively, even without changing the current land-acquisition procedures, the market principle can be followed in the way that the state obtains the land, sells the land by auction and returns the gains to farmers. The land value will significantly increase from the change of use purpose from farm to non-farm use. Sharing this increased value between the public (government) and individual farmers should be done on clearly defined legal bases, not by the arbitrary decision of local government officials as it is practised currently. Payments to farmers could be made in two steps; the first payment before auctioning and the final payment after auctioning and other deductions. For public purposes, there would be more compulsion inherent in land acquisition. Nevertheless, the compensation levels should again be consistent with the market value of the land. Since auctioning may be impossible, the market value of similar land should be taken as a reference.

Third, a more rules-based, benefit-sharing system should be established for the value increase when farmland moves to non-farm uses. The total gain from auctioning the land could be divided into three parts: a kind of land value-added tax, cash payment to farmers and payment to a social security account set for the farmers. The establishment of a land value-added tax in place of the existing land-transfer fee system has the benefits of transparency and being rules-based. This will be of special importance in reducing the enthusiasm of township governments and village organisations for land acquisition. The township government and village organisations are often the major sources of violations of farmers' legitimate land rights. How this tax should be split between local and central government, as well as the tax rate, need further study. However, in any case, the prevailing share of the appraised land price should go to farmers with the land-contract right, taking into account both the cash payment and the payment for the social-security account. The tax rate might not exceed one-third of the total value.

Fourth, a nationwide social-security system should be established for landless farmers. For Chinese farmers, land is everything. Increased compensation levels will not solve all the problems for those becoming landless. Unlike urban residents, the rural population in China does not have a nationwide social-security system. The once and for all payment, even if significantly increased, will not provide security. As discussed in the previous paragraph, part of the gains from land acquisition should be placed in a social-security account for landless farmers. This will be a

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very important measure to avoid social instability among landless farmers. Without such measures, even if the compensation is very high and farmers get all the money, there are great dangers that the money will be used up in a relatively short period. This system should be nationally uniform, though the level of payment and other operational details can be regionally decided. The social-security account should apply not only to farmers whose land has been acquired compulsorily, but also to farmers who voluntarily sell their land right. Depending on local conditions, local governments or central government should also make contributions to (subsidise) those accounts.

Fifth, farmers should be allowed to use their land-use rights as an asset to support investment in non-farm construction projects and get due returns. There are already experiments of this kind of practice in some coastal areas. Experience from existing practice should be reviewed, evaluated, adjusted and extended. In places where the collective organisations still have the dominant role in the local economy and the farmland is still collectively cultivated, the land-use rights of individual farmers can be transformed into market value and divided among individual farmers. In doing so, social-security arrangements can be made according to the concept discussed above.

Improving enforcement and implementation of laws and regulations

The first step to improve enforcement of the laws and regulations is to put more efforts into awareness building. The most-important point is to get better understanding of the nature of the land-use rights of individual farmers. The legitimate land rights of individual farmers should be better understood, not only by local governmental officials and village leaders, but also by farmers themselves. Local officials should pay due respect to that right and farmers should learn to use legal means to protect their right.

The second step is to improve public participation and transparency in land acquisition. In the decision-making process, conformity of any specific land-acquisition plan with land laws and regulations must be presented to the farmers involved and to the public. Public hearings should be conducted.

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The third step is to improve institutional control of land acquisition. The land administration is usually the jurisdiction for approving land-acquisition plans. To secure farmers' interest and protect the agricultural resource base, the department of agriculture should also be involved in the process, since the agriculture administration generally has a close relationship with farmers' representatives. Any land-acquisition plan should also be reviewed and endorsed by agricultural administrations before sending to the public hearing.

The fourth step is to have a stricter accountability system. In order to strengthen the implementation and enforcement of the laws and regulations, the accountability system should be followed more strictly. This must apply not only to officials in charge of land administration but, more importantly, to the major leaders in the local governments, since many land-acquisition plans are made by the top government leaders in the locality.

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PART FOUR

ENVIRONMENTAL CONSEQUENCES OF RURAL DEVELOPMENT

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CHAPTER 11

RURAL DEVELOPMENT AND THE ENVIRONMENT

CCICED ARD Task Force members

Implementation of the Household Responsibility System and other reform policies in 1978 and beyond, combined with new technology in seeds, fertilisers, pest control and irrigation resulted in phenomenal growth in food output in China in the past 25 years. Food-grain security goals were achieved. At least one-third of China's grain output is now used for animal feed, as Chinese consumers add animal products to their diets. China has had a positive trade balance in agriculture for 20 years. Consumer attention is now focusing on diet diversity, food safety and quality assurance.

In the process of developing China's food-production capacity, in some places and in some sectors an accumulated environmental debt remains as a legacy. It has many dimensions and includes soil erosion on cultivated lands, degradation of grasslands, salinity on irrigated lands, ineffective river-basin management, depletion of groundwater and surface aquifers, pollution of soils, air and water from excessive application rates of fertilisers and pesticides, and poor management of livestock wastes. If left unchecked, these environmental problems could be a serious threat to farm incomes and the nation's food-security aspirations. Some problems may grow as China tries to comply with World Trade Organization (WTO) standards and as consumers consider their food purchase choices.

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The current environmental malaise is not a technology problem. The science associated with good land and water stewardship is well known. Much of the science and technology needed to tackle environmental problems is already in China, but investment in applied research and demonstration is low. Public extension services have been drastically reduced. The formal education level of most farmers is low. Standards and regulations covering crop input manufacture, application rates and waste management are not rigorously enforced. Input prices, especially for water, do not reflect environmental costs. The tenure situation on cultivated land and grassland is not conducive to good stewardship. Poor access to capital and credit makes adoption of new technology for better land and water management difficult to obtain.

China has been able to supply enough food for its growing population primarily by increasing the intensity of its farming systems, using modern inputs. Inorganic fertilisers and pesticides are key ingredients in this rising intensity. While judicious use of modern technologies is essential to efficient food production the world over, inappropriate uses, such as excessive application rates or imbalances in input combinations, result in serious environmental problems and food safety concerns.

China is now the world's leader in both inorganic fertiliser and pesticide consumption. In the past 30 years, while world total nitrogen fertiliser application increased by 7 times, China's nitrogen use in crop production increased 45 times. On average, nitrogen use per hectare is about 3 times the world average. Pesticides have been used on a large scale since the 1950s to protect crops from damage inflicted by insects and diseases. Recently, China surpassed Japan as the world's leading pesticide consumer. Various pesticide compounds have been produced and applied to crops. Many whose use has been curtailed or banned in other countries are still widely used in China. Among them are pesticides that are known to leave toxic residues in the environment.

Intensive fertiliser and pesticide use can have several adverse effects and the concerns are rising. In addition to the direct costs of fertilisers and pesticides, long-term, highly concentrated application of fertilisers and pesticides may contaminate farm produce, pose serious danger to the agro-ecosystem and adversely affect human health. There is growing concern about the increasing use of fertilisers and pesticides that cause pollution of rivers, lakes and the sea from run-off and seepage, and thereby become sources of ecological problems. China's accession to WTO has raised food-safety concerns due to residual effects of high rates of fertiliser and pesticide application.

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Several studies have shown that high rates of fertiliser and pesticide application are partially due to ineffective extension services to advise farmers on input rates and nutrient balance. Application rates are often excessive from both biological and economic perspectives. Overuse of nitrogen has been increasing, frequently by more than 30% in rice production. Half of the applied nitrogen often simply volatilises into the atmosphere. The excessive application of pesticides is an even more serious problem, particularly in cotton and rice production. Use of proven integrated pest management (IPM) techniques is still not widespread. Pesticide application rates in China are still rising while they are falling everywhere in Southeast Asia. Pesticide applicators, many of whom are women, are exposed to alarming health risks.

Research by the Center for Chinese Agricultural Policy shows that both fertiliser and pesticide uses could increase with trade liberalisation if more-effective regulations and technology-extension systems are not implemented. Trade liberalisation will influence fertiliser and pesticide use through its effects on product and input prices and will therefore affect crop production patterns (or crop-area allocations) and application rates of inputs.

Fertiliser use is expected to increase by about 1% in 2005 and 2.4% in 2010 due to China's WTO accession (2001–2005) and further trade liberalisation under the Doha Round (2005–2010). The increases in fertiliser use come from both crop structural changes and higher application rates. Liberalisation will cause domestic fertiliser prices to fall by about 0.5% in the coming years as imports of cheaper and better fertilisers rise slightly. The areas sown to vegetables, fruits and rice will expand.

The analyses show that the impacts of trade liberalisation will have more impact on pesticide use than on fertiliser application. Liberalising the pesticide sector will lead to reductions in prices of pesticides by about 1% per year over 2002–2010. Falls in pesticide prices and price rises for horticultural crops and rice (the crops with most-intensive pesticide use) may significantly increase pesticide demand. The CCAP study shows that trade liberalisation will raise pesticide use by 3.2% in 2005 and nearly 6% by 2010.

More economically rational application rates of crop inputs and wider use of IPM and other new technologies could substantially reduce application rates and total usage and mitigate environmental concerns. A recent study by CCAP shows that nitrogen fertiliser use by rice farmers could be reduced by 20–30% without yield loss through site specific nitrogen management (SSNM). But extension of SSNM

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requires substantial investment in training and agricultural extension. Other recent studies by CCAP show that planting of transgenic rice could reduce pesticide use by more than 90% in rice production, and Bt cotton could reduce pesticide input in cotton production by about 65%. Relative changes in fertiliser ingredient prices may result in better nutrient balance in fertiliser products used by farmers. Science and technology to support such changes are readily available from domestic and international sources. Food safety challenges from domestic and international consumers of Chinese products may induce or even force reductions in pesticide usage.

Trade liberalisation is expected to reduce China's comparative advantage in several crops including maize, wheat, cotton, sugar and edible oil. Increased imports of these land-intensive products due to WTO membership could reduce the pressure to expand agriculture in marginal areas and thus have a positive impact on land management on fragile landscapes. Pressure on scarce water supplies might also be reduced.

Demand for livestock products is increasing in response to rising incomes, changing food preferences and WTO-induced changes in relative prices. Increased livestock production and its concentration near urban areas will increase the environmental pressure associated with animal-waste management. Public policy responses and regulatory enforcement will be critical to mitigate associated environmental and health risks.

The new *Rural Land Contracting Law* vests more-secure land-user rights in the hands of farmers (see Chapter 7). This has important implications for conservation of land resources and environmental protection. More-secure rights provide incentives to undertake land-management practices that sustain long-term productivity (e.g. protecting soil carbon levels and limiting erosion) and simultaneously convey positive impacts on the environment. Also, with vested land rights, farmers have borrowing potential (collateral) for investment in improved land-management technology that protects the asset value of the land for economic and environmental benefits.

FUTURE DIRECTIONS AND POLICY IMPLICATIONS

Environmental and economic goals in agriculture can be compatible and complementary. There are many examples in developed and less-developed economies. The lessons learned in other countries can help China to leapfrog many years of international experience in dealing with environmental externalities.

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It is difficult, if not impossible, to definitively separate the environmental effects of the many developmental changes occurring in rural China—liberalisation of input and product markets, off-farm employment, education, feminisation of agriculture, new technologies, deterioration in public extension services and accession to WTO. It is important for the national government to ensure compatibility between economic and environmental objectives of rural-development policy and institutional changes.

The volume and general safety of the world food supply testify that economic and environmental objectives can be complementary. People live longer and healthier than ever before—food supply, nutritional balance and safety are important aspects of that outcome, in China and elsewhere. China therefore needs to ensure that its food-production system is compatible with international standards and practices. The following are some measures appropriate to that objective:

- The Task Force suggests that China needs to consider policy reform in its public agricultural extension system and food safety and regulatory institutions. These are urgent needs. Reform of China's food-quality regulation and monitoring systems is crucial and is in China's own public interest as the nation becomes more urbanised. It is also critical to China's future economy under globalisation. China's discerning urban consumers will purchase their food taking safety and quality into account, even if this requires purchasing *imported* commodities. Upgrading China's food quality and safety regulations and enforcement capabilities to international standards is an urgent public policy imperative. China's domestic food industry and its export aspirations are dependent on these policy and institutional adjustments.
- The development of farmer associations must be facilitated. Farmers, in their own best interests, will manage their production systems for both economic and environmental outcomes when the policy and institutional framework is conducive to such behaviour. Farmer associations have been very instrumental in furthering these changes in other countries.
- There must be increased investment in public R&D, with more emphasis on applied research. Appropriate technologies for better environmental management have been proven in China. Their widespread application needs appropriate economic incentives and education of farmers who ultimately use this information in their own production decisions.

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- Improved security of land rights is required. More-secure tenure creates incentives for better stewardship of resources and provides an asset base for additional investment in land-management technologies that have economic and environmental benefits.
- Success should be built on. There are many good examples of cooperation between Chinese scientists and international institutions. These need further attention to extend their reach into agricultural practice in China. A good example is collaboration between the International Rice Research Institute and Chinese scientists in developing IPM systems for pest control in rice. Initial successes in areas like Bt cotton and transgenic rice suggest high rates of return and positive environmental benefits from additional investment in biotechnology.
- Public good services in rural China need improving. Good environmental management by Chinese farmers depends on education and other public good services, access to financial services and higher incomes.
- A change in focus from national grain self-sufficiency to food self-reliance would have positive environmental impacts arising from reduced grain production on marginal lands with scarce water supplies. This is entirely consistent with China's decision to enter the WTO.
- A CCICED Task Force on Environmental Goods and Services from Agriculture could be considered. There is great potential for environmental services in many areas, including carbon sequestration, reduction of soil erosion losses, IPM technology for pest management in intensive production systems, biomass energy production from agricultural wastes, water-use efficiency and biodiversity improvement. A new task force could further elucidate these and other opportunities and assess their potential.

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CHAPTER 12

IMPEDIMENTS TO SUSTAINABLE AGRICULTURE IN CHINA

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INTRODUCTION

China has made enormous strides in recent decades in agricultural productivity and food output. Despite rapid population growth and increased food demand, China has achieved a high level of food security and food production capacity, but the environmental costs have been very high (Smil 1997; Norse et al. 2001). Serious environmental degradation has occurred and is continuing and threatens the sustainability of China's food-production capacity.

Environmental degradation of the agricultural resource base is manifested in many ways including: desertification, soil erosion, reduced grassland carrying capacity, saline irrigated land, air and water pollution from excessive crop input application (Zhang et al. 1996; Zhu and Chen 2002; Yan et al. 2003), water shortages due to low water-use

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efficiency and competition from urban and industrial users, organic matter and soil fertility loss due to burning of crop residues, and loss of biodiversity. In all of these cases, there is little evidence to suggest imminent reversal of the deleterious trends.

China's agricultural policy has had its primary focus on food-grain security at national and provincial levels. International border controls, internal trade restrictions, indirect subsidies on inputs, production quotas, R&D investment and large budgetary expenditures on grain purchases and storage are all aimed at this objective. These and other current policies and practices have become impediments to sustainability because of their adverse effects on the land and water resource base. Economic and environmental objectives are frequently in conflict.

New technology is considered to be the main driving force for continued growth in agricultural productivity. While crucial to future growth, technology, by itself, is unlikely to result in an agricultural sector that is economically and environmentally sustainable. Policies and practices need to change in order to create an atmosphere where economic and environmental objectives are complementary, and where win–win solutions are possible.

This paper describes a number of important policies and practices that have adverse environmental consequences and suggests some changes that are needed for protection of the resource base and long-run sustainability of agriculture. The paper is based mainly on the observations and findings of the Sustainable Agriculture Working Group (SAWG) of the China Council for International Cooperation on Environment and Development (CCICED) over the period 1997–2001 and which are presented in Sonntag and Sun (2002). The principal mandate of the SAWG was to make recommendations to the Government of China via CCICED on policies to improve the sustainability of agriculture in China.

COMPLEMENTARY ECONOMIC AND ENVIRONMENTAL OBJECTIVES

Economic and environmental objectives are often considered to be antagonistic or competitive. There are, however, many situations in agriculture where these objectives can be complementary. We cite some examples.

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Phien and Acton (2000) assessed the use of hedgerows on sloping lands in Vietnam. Traditional practices had resulted in severe soil erosion and loss of productivity. Incorporating hedgerows into annual and perennial cropping systems increased above-ground biomass, reduced soil and nutrient losses and maintained or increased yields of alley crops between the hedgerows. The positive economic and environmental effects of hedgerows increased with time.

Heong (2000) described management strategies for pest control in rice in China. Rice pest management is dominated by prophylactic pesticide applications. Through various policies and practices farmers are encouraged to regularly apply pesticides. Research in tropical rice systems has shown that about 80% of the insecticide sprays are unnecessary and compromise natural biological control. Surveys in China have shown that insecticide applications are commonly two to three times the recommended rate (Norse et al. 2001). Thus, pesticides increase production costs, pose health risks to farmers, pollute farmland and water bodies, and have little or no positive effect on yields and may even lower them. Hence, rational pest-management strategies can reduce costs of production, health risks, and pesticide contamination, all while maintaining or even increasing yields and net farm incomes; clearly a case of potential complementarity between economic and environmental objectives.

Zentner et al. (2000) examined the agronomic, environmental and economic effects of various crop-production practices over an 18-year period in Saskatchewan, Canada. Farmers had adopted a number of new cropping practices over this period in their search for sustainability. The analysis showed that extending and diversifying crop rotations and adoption of new, reduced-tillage technology improved overall sustainability of annual crop production systems in this semi-arid region.

Lindwall and Norse (2000) noted that conservation tillage systems have been shown to improve soil and water conservation, increase water and nutrient-use efficiency, raise soil organic matter content and crop yields and boost farm incomes. All of these benefits help minimise the production of greenhouse gases and enhance agricultural soils' capacity as a carbon sink. They list several fairly universal practices that can increase soil carbon content and improve the sustainability of the farming operation but which are not fully utilised in China. These include:

- reduced tillage, direct seeding
- conversion of marginal cropland to perennial grass or trees

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- rotational grazing
- manure or compost application to land
- optimal and variable rate fertiliser application.

Avery (1996) discussed complementary relationships between environmental and economic objectives at another scale. He presented a case for high-yield agriculture and use of proven technologies for food and fibre production (economic objective) on the best land in order to prevent cultivation of wild-lands for low-yield food production (environmental objective). High yields are needed on the good land to preserve millions of square kilometres of wildlife habitat from low-yield crop production, and allow marginal cropland to be converted to more sustainable uses (Norse 1992; Bruinsma 2003). Well-managed, high-yield farming can be the best approach to prevent soil erosion, improve soil tilth and quality and reduce run-off of water. Research into more knowledge and technology for crop and animal productivity enhances our ability to protect more wild-lands.

The Prairie Farm Rehabilitation Administration (PFRA) of Agriculture and Agri-Food Canada developed a number of community pastures beginning in the 1930s to overcome problems of grassland degradation and serious wind erosion on cultivated lands in the Canadian prairies. Through application of numerous land-management techniques (fencing, stocking rate management, re-seeding of eroded areas, livestock watering systems) the carrying capacity of the grasslands has been restored and continues to improve while environmental indicators also improve (soil carbon, biodiversity, ecotourism). Other public and private grassland in the North American Great Plains area experienced similar economic and environmental improvements (Luciuk et al. 2002)

The main point of the examples cited is to demonstrate that there are many opportunities in agriculture for simultaneous attainment of economic and environmental objectives. We suggest that these and similar opportunities are available for improving the sustainability of China's agriculture. Policies, practices and institutions, however, need to change to create an atmosphere that will enable the many potential complementarities to operate effectively.

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UNSUSTAINABLE POLICIES AND PRACTICES

The SAWG studied agricultural sustainability in several regions considered to have agricultural development potential, albeit with significant environmental challenges. The main sources of information for SAWG, in addition to published sources, were local officials, farmers, scientists, SAWG member observations and international experts invited to workshops in the areas studied. Numerous economic, environmental and social issues were observed and analysed. Recommendations were made to CCICED on policy changes needed to address the principal issues. Some of the issues are discussed here as examples of policies and practices that are deemed impediments to sustainable agriculture in China.

Excessive and imbalanced use of mineral fertilisers

China has some of the highest application rates of inorganic fertilisers in the world, and well above those of most intensive production systems in developed countries (Zhu and Chen 2002). Application rates for vegetables can exceed 1000 kg/ha/year (Zhang et al. 2004a). These unsustainable practices include nitrogen application rates 10–50% or more above crop nutrient needs, and unbalanced fertiliser mixtures that commonly have inadequate potash and sometimes phosphate.

The negative consequences are both economic and environmental, and global as well as local. The economic costs hurt the farmer by raising their production costs, and the wider community through the air pollution from fertiliser factories, the eutrophication of fish ponds and lakes, and the reduction in drinking-water quality. In the case of rice, these costs are currently some 20 billion yuan/year and could at least double over the next 30 years (Norse et al. 2001). The environmental impacts of over-use also include:

- increasing numbers of red tides—up several-fold in the past 10 years
- high emissions of greenhouse gases and ammonia contributing to global climate change and local acidification of soils and freshwater ecosystems.

It follows that the solutions have to be multi-dimensional, combining technological, regulatory and economic pressures and incentives (Zhu and Chen 2002; Zhang et al, 2004b; Norse, 2005). Some options that could be considered include:

- removal of indirect subsidies on fertiliser production

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- progressive introduction of pollution taxes on nitrogen fertiliser
- improvements in soil-testing services, fertiliser quality (including affordable slow-release formulations)
- better education of farmers and extension workers, and greater incentives for them to adopt and promote sound fertiliser use.

Pesticide usage

While pesticides of various kinds are important elements in producers' technology toolkit for high productivity in food and fibre production, excessive, and often unnecessary, applications are an important impediment to sustainable crop production, especially in the intensive production regions (Mao 1996). During the past 10–20 years, there has been a growing consensus that farmers generally apply more pesticides to grain, vegetable and fruit crops than they need to for adequate pest control. This excessive use can:

- lead to illness or death of farmers
- lower farm incomes because of the unnecessary expenditure on pesticides and days off sick, which can amount to 10–20% of the pesticide expenditure
- reduce the value of fish production by over 1 billion yuan
- add to the need for costly water purification to meet drinking water standards
- adversely affect the health of consumers through cumulative consumption over time.

Yet pesticide use has been increasing. In the case of rice, it doubled in value terms between 1980 and 1997 (at constant prices), and now represents around 7% of the total material costs of rice production (Norse et al. 2001). Moreover, this is despite clear evidence from local trials in China and nationwide programs in other Asian countries that an approach called integrated pest management (IPM) can reduce pesticide (especially insecticide) use two to three-fold or more without lowering rice, cotton and other crop yields, improve farmers' net incomes and health, and protect the environment (Heong 2000). At the national level, the cost savings from reduced pesticide use can be substantial, and for China could exceed 10 billion yuan.

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The need for urgent action to stop the overuse of pesticides is supported by five other trends. First, the continued reduction in the area available for grain production, which leads to more-intensive use of production inputs like fertilisers and pesticides, and greater likelihood of pest and disease outbreaks. Second, the reduction of direct funding for agricultural extension is forcing extension services to be self-funding and commonly leads to them placing too much emphasis on the sale of pesticides. Third, several government departments have conflicting roles in the regulation, production and sale of pesticides. Fourth, China's entry into the World Trade Organization (WTO) and the need to improve international competitiveness make it important to maintain farm incomes by reducing the costs of production. Fifth, pesticide residues in foods are an increasing threat to competitiveness in domestic markets, expansion of agricultural exports and to compliance with WTO requirements.

China should develop a national strategy for IPM. The strategy should become part of wider development strategies for environmentally responsible production practices and safer foods. It should be consistent with policies to reduce pesticide-residue levels in foods, and backed-up by stronger measures to ensure widespread compliance with such policies

Tillage

Intensive tillage, and the land degradation that results directly from it, are a universal problem in arid and semi-arid regions around the world. The associated practices (ploughing, disking, harrowing, removal of crop residue) cause large erosion losses, organic matter loss, destruction of soil micro-organisms, soil moisture loss, yield reductions and weed problems. Application of reduced-tillage technologies can often reverse all of these deleterious effects and produce both economic and environmental benefits. Conservation tillage technologies have been widely applied in many regions of the world where sustainability of annual crop production was in jeopardy a few decades ago (Lindwall and Norse 2000). Application of these technologies has the added benefit of carbon sequestration in agricultural soils to offset greenhouse-gas emissions from other activities.

Conservation tillage technologies are being tested and demonstrated in China. One example is the Hebei Dryland Project of the Canadian International Development Agency at the Hebei Academy of Agricultural and Forestry Sciences. Outreach activities from that project were conducted in several provinces. Adoption of the

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technology by Chinese farmers is not occurring at a very rapid pace. One important constraint to adoption is the lack of credit availability for Chinese farmers, and a dearth of suitable equipment for some situations. Current land-tenure policy and limited financial services in rural China result in very little collateral to support the capital investment necessary for adoption of conservation-tillage technology.

Irrigation

Irrigation is a vital component of food and fibre production in China. About two-thirds of the water consumed in China is used for irrigation. About half of the cultivated area is irrigated, and yields more than two-thirds of cereal production. Cropping intensity on irrigated land is about double that on rain-fed land, and yields on irrigated land are often double those on rain-fed areas. All of these ratios vary greatly among irrigation zones—the southeast 'rice irrigation zone' (annual rainfall more than 1000 mm), the central and northeastern 'unstable irrigation zone' (400–1000 mm rainfall) and the northwest 'perennial irrigation zone' (less than 400 mm rainfall with high seasonal variability). The major portion of China's agricultural land is in the unstable irrigation zone. Thus, China's food output is highly dependent on irrigation, and food-production capacity into the future is dependent on sustainability of irrigation systems (Nyberg and Rozelle 1999).

Irrigation systems in the unstable and perennial zones are experiencing a number of problems that threaten their sustainability. These include:

- large water conveyance losses due to poor system design and construction
- soil degradation on irrigated land due to inadequate drainage
- excessive water application rates due to water pricing that is not related to the real costs of supply or the volumes used
- declining watertables in most groundwater aquifers.

These problems result in low water-use efficiency (WUE), extensive and permanent salinisation of irrigated land and lost production potential, and downstream water shortages.

A number of measures should be examined urgently to ensure the economic and environmental sustainability of irrigated production capacity, including:

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- increased investment in irrigation and drainage systems rehabilitation for improved WUE, improved water distribution among users and maintenance of productive capacity
- increased investment in water-saving technologies (land-levelling, application methods, crop selection) that reduce water demand
- introduction of systems for volumetric measurement and pricing of water to improve WUE, generate system maintenance revenue and provide environmental benefits (resource base conservation)
- establishment of self-financed irrigation-management institutions to manage water supplies and to operate and maintain irrigation systems. On large river basins where many provinces share the basin this may also require river basin authorities with powers that supersede provincial authorities to effectively manage entire basins for environmental and economic sustainability.

Food-grain security policy

The target of 95% self-sufficiency in food grains is a central tenet of China's national policy. China has achieved this policy objective despite rapid population growth and a relatively small per-capita arable land base. Institutional change (Household Responsibility System) and application of new crop-production technology are considered to have been the main factors in achieving this target.

Much of the responsibility for food-grain security was delegated to provinces and autonomous regions through the Provincial Governors Responsibility System. The provincial targets were at the same percentage level as the national target. This policy, combined with restrictions on internal grain trade, resulted in increased grain production in all areas in China, frequently on land not suitable for production of annual crops. These targets and trade restrictions have been relaxed in recent years, but they leave a legacy of degraded land in marginal grain-production areas.

The national food-security policy resulted in large mandatory provincial and local government expenditures on food-grain purchases and storage. This restricted local and provincial government fiscal capacity to undertake other initiatives targeted at environmental, developmental and social programming such as infrastructure, poverty alleviation, education, applied research and technology demonstration.

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The food-grain security policy had several deleterious environmental effects, including the following:

- Soil erosion. It resulted in grain production on fragile landscapes where annual cultivation makes land susceptible to wind and water erosion.
- Grassland degradation. Land that is fairly stable when used as grassland was converted to cultivation for grain production to satisfy production targets.
- Salinity. Production targets resulted in extensive grain production on irrigated land where inadequate systems exacerbated salinity problems.
- Water pollution. Excessive application rates of fertilisers and pesticides to ensure high yields resulted in non-point pollution of water bodies, especially in intensive cropping systems in the southeastern provinces.
- Crop residues. A high proportion of crop residues is burned. This practice has several adverse environmental effects—air pollution, carbon dioxide emissions and soil erosion.
- Comparative advantage. The regional application of the policy precluded market forces from determining efficient locations for grain production.

Some measures that could be considered to maintain a high level of food-grain security while simultaneously addressing environmental concerns include the following:

- Reduce the 95% grain supply target to a lower level to reflect China's improved capacity to utilise the international market to augment periodic shortages in grain. Even if the 95% target is retained as a national imperative, its environmental impact could be lessened substantially by permitting comparative advantage to determine where grain production should occur. Recent analyses by Huang and Rozelle (2005) conclude that conversion of large areas of low-productivity land to forestry through the Grain for Green program has had no significant impact on China's ability to meet food-security objectives.
- Re-define grain security targets in terms of food grains (wheat and rice) rather than aggregate grain (food and feed) supply. Feed-grain needs could be met through international markets.
- Increase public investment in rural public goods (e.g. R&D, extension services, education) to ensure future productivity growth.
- Establish more-secure land user rights to foster stewardship of resources.

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- Establish a legal framework for development of independent, voluntary farmer associations that pursue their own economic and business interests and responsibly manage their resource base.
- Reform rural financial services to improve financial intermediation for rural citizens

Grassland management

Serious degradation of China's vast northern and western grasslands is well-documented. The frequency and severity of spring dust storms are obvious indicators of this problem. The causes are many: too many grazing animals for too little grass, deforestation of fragile landscapes, cultivation of land not suitable for annual crop production and land-tenure policies that impede sustainable management of grasslands. The issue also has constraining social dimensions, with too many poor people dependent on the grasslands for their livelihood.

Experience and research in the North American Great Plains and elsewhere in the world has demonstrated clearly that land control is an essential element in sustainable grassland management. This has been achieved through both public and private land-management institutions. Land control enables stocking density to be matched with sustainable grassland output. Many degraded grasslands can be restored with conservative stocking rates and other grassland-management techniques. Other environmental aspects improve coincidentally—soil carbon levels, biodiversity (flora and fauna) and WUE (Luciuk et al. 2002).

Livestock waste management

China's economic success and rising incomes have led to the rapid development of the livestock sector (especially pork production) over the past 20–30 years. Average annual growth rates have been 2–5% faster than the crop sector, and the livestock sector's share of total agricultural GDP has doubled. However, these economic benefits have carried severe environmental penalties in addition to the overgrazing mentioned above. The environmental costs have been high, with large volumes of solid wastes from pig and poultry units; 40% or more of wastes being discharged without treatment into watercourses; and increasing emissions of nitrous oxide and

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ammonia to the atmosphere. Moreover, the relative importance of this pollution is likely to grow in the future as point-source industrial and domestic wastes are brought under control.

The main issue is not a lack of appropriate technologies—these generally exist, although some may need to be imported and adapted to Chinese conditions. The problem is that there is no national strategy to deal with the waste-disposal problem. Some provinces have responded to the problem, but have been hindered by the lack of adequate regulatory and economic mechanisms to ensure compliance. Actions that should be considered and evaluated include:

- development of a national livestock waste management strategy
- enforceable discharge and emissions standards and effective waste disposal charges
- meaningful penalties for breaches in regulations
- well-targeted education programs
- planning constraints and guidelines to optimise the location of livestock production units
- support for the adoption and dissemination of appropriate technological measures.

CONCLUSIONS

We have provided some examples where it is clear that there is significant potential for complementary economic and environmental objectives, i.e. for win–win outcomes for sustainable agriculture. We have given some examples where economic and environmental objectives are in conflict in current policies, practices and institutions. These impediments should be changed in the interests of sustainable agriculture in China.

China is placing its hopes for continued output growth in agriculture on application of new technology. While vital to continued growth, technology, by itself, is unlikely to be sufficient to attain the desired outcomes. New technology, institutional change and policy change must be integrated for agricultural sustainability into the future.

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