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The Effects of China's Rural Policies on the Sustainability of Agriculture in China*

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ABSTRACT

Major rural policies in China before the reform include the state-monopolized procurement and marketing system (SMPMS), collectivization and grain self-sufficiency policy. All these three policies were shaped by heavy-industry-oriented development strategy, adopted in the early 1950s. SMPMS was implemented to provide cheap food and raw materials for urban areas. Collectivization was a vehicle for implementing the procurement policy. Grain self-sufficiency was for national security and for saving scarce foreign exchanges for the development of industries.

The above three policies generally have negative impacts on the sustainability of agriculture. Low price SMPMS led to wasteful usage of natural resources. National self-sufficiency led to over-extraction of resources so as to meet increasing domestic demand from population and economic growth. Local self-sufficiency led to misallocation of resources. Collectivization caused low incentives in agricultural production. But these policies also gave local governments the ability to mobilize labor for construction of irrigation project, increasing the crop intensity and so forth. Some of these may be favorable for environment.

The reform started at late 1970s improved farmers' incentives. But land and forest are still collectively owned. Some of the impacts of rural reform on environment are positive and others are negative. The negative impact is because that the property right is not secure so farmers have less incentive to concern about long-term sustainability and the government is less effective in mobilizing labor for environmental protection projects. The reform, however, may also have positive impacts. As the property rights are well defined and income increased, farmers' demand for better environment will increase.

The direction of future reform are to secure property rights, to liberalize price and market control, to give up national and regional self-sufficiency and to reduce government's direct involvement in economic activities. Suggested areas for future research are the environmental impacts of regional

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self-sufficiency, insecure land tenure system and the rapid development of township-and-village enterprises.

As a developing country transiting from a command economy to a market economy, China's agricultural policy and its effects on the sustainability of agriculture are quite different from other market economies. Some of the environmental problems are specific to transition, while others are common to the general process of development.

The rural policies before the reform started at the end of 1970s caused the distortion of the price mechanism and the misallocation of human, capital, and natural resources. The reform of the procurement system at late 1970s corrected some of the old problems, but on the other hand raised some new problems. These new problems are partly due to the remains of the old government policies and partly due to the failure of the new market mechanism.

This paper will first discuss the rural policies before the reform and its environmental effect, then discuss the reform of the agricultural policy since late 1970s and its effects on the sustainability of agriculture.

I. Rural Policies from 1950s to 1970s

In 1949, the Chinese communists gained control over China, the world's most populous nation. The major rural policies in China from early 1950s to late 1970s included the state-monopolized procurement and marketing system (SMPMS), collectivization and grain self-sufficiency policy. All these three policies were shaped by the heavy-industry-oriented development strategy. STPMS was implemented to provide cheap food and raw materials for urban areas. Grain self-sufficiency was for national security and for saving scarce foreign exchanges for the development in industries. The low price procurement made the national grain self-sufficiency degenerated to local self-sufficiency. Collectivization was a vehicle for implementing the procurement policy and acreage planning policy.

1.1 The Rural Policies between 1950s to 1970s

The Chinese government adopted a heavy-industry-oriented development strategy in the early 1950s for nation building. The heavy industry was capital intensive while China was a capital-scarce, low-income, agrarian economy at that time. The heavy industry could not develop spontaneously under such economic condition. As such the government adopted a series of institutions to facilitate the implementation of this strategy. The state monopolized procurement and marketing system (SMPMS), collectivization, and the grain self-sufficient policy were three basic rural institutional arrangements for the purpose.

A. The SMPMS

Along with the adoption of the industrial development strategy, the government adopted a policy of low wages for industrial workers, under the assumption that the low wages would help state-owned enterprises create large profits that could be reinvested in infrastructure and capital construction. To implement the low wage policy, the government had to provide urban dwellers with inexpensive food. A food rationing system was instituted in the urban areas from 1953 to 1992.

The "unified purchase and unified sale" system for grain and oil-bearing crops was introduced in November 1953. The system was initially prompted by grain shortages in urban areas following rapid urbanization occurring at this time. The direct aim of this program was to ensure adequate supplies of grain and oil to urban areas without a substantial increase in purchase prices. Planned purchase and sales programs of slightly different design followed for cotton in 1954, hogs in 1955, and a wide variety of other farm products in 1956 and 1957. (Ministry of Commerce,

Institute of Commercial Economic Research 1984, pp. 56-63)

The grain procurement system had two major characteristics: (1) low price; (2) the purchase of grain was completely monopolized by the government, and all private grain wholesalers are driven out from the market. The government used quantity planning in the form of targets and quotas to allocate resources. The large size and powerful status of the government enabled it to enforce production targets and commercial quotas.

The state-monopolized procurement and marketing system has been widely reformed in 1980s and 1990s, but the policy is still remained for cotton and re-actives recently for grain.

B. The Collectivization

When the communist party first came to power in 1949, it carried out a program of land reform, confiscating all rented land and distributing to the poor and landless peasants. Private household farming system was retained.

The adoption of the heavy industry-oriented development strategy greatly increased the demand for grain and other agricultural products due to the urban industrialization. Therefore, the government needed an institutional arrangement that could facilitate the implementation of the SMPMS and at the same time increase agricultural production. This institutional arrangement was collectivization. After adopting the heavy industry-oriented development strategy, the government switched to the promotion of agricultural collectivization. Since small collective farms did not solve the problem of mobilizing labor for large-scale projects, the government formed "people's communes" in 1958. The government promoted collectivization because (1) it had scale economy, and (2) it provided a feasible means to control the agricultural production and to carry out cultivation plan. It also reduced the transaction costs of implementing the SMPMS because collective leaders were appointed by and responsible for the government.

C. The Regional Self - Sufficiency Policy

The third element of key rural institutions was regional grain self-sufficiency policy. Grain is a land-intensive crop and China is a land-scarce economy. China did not have comparative advantages in grain production. However, to avoid the use of scarce foreign exchanges from the import of capital equipment to the import of grain, the government adopted a grain self-sufficient policy. Under the low-price SMPMS, the more grain the surplus region sold to the state the more implicit tax the region paid. Therefore, the grain surplus region did not have incentives to produce and deliver more grain to the grain deficit regions to meet their additional demands arising from population and economic growth. Therefore, the national grain self-sufficiency policy gradually degenerated into regional grain self-sufficiency policy. The policy left local governments in grain deficit areas no option but to force collectives to produce grain in areas where climate and soil conditions were more suitable to produce other crops. This policy was relaxed at the beginning of the rural reforms in 1979. However, the policy was reinforced by the central government when the grain price increased in early 1990s.

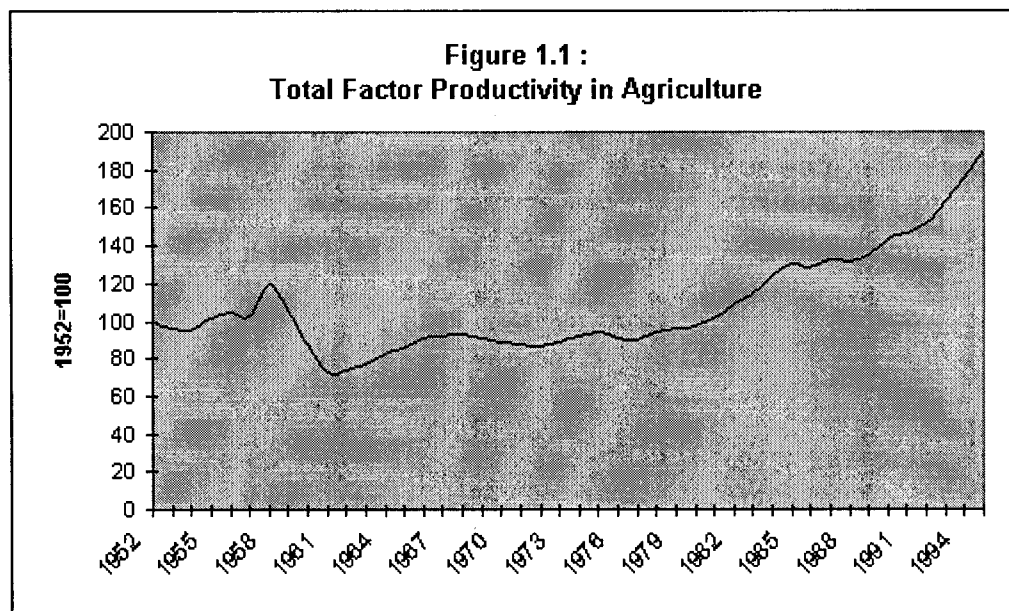
1.2 The Effects of the Policies on Agricultural Productivity

The industrial development strategy resulted in a great demand for agriculture products. This increase in demand arose from three sources. (1) A dramatic increase in urban work force and population increased demand for food. (2) A rapid industrial development increased the demand for industrial raw materials such as cotton. (3) The bulk of China's exports consisted of agricultural products in 1950s and 1960s. In order to import more capital goods for industrialization, China had to export more agricultural products, which in turn increased the total demand for agricultural products.

The state-monopolized procurement policy and collectivization had an adverse effect on farmers' incentives to increase productivity. These policies caused a contradiction: the low price hurt

farmers' incentives of production and caused agricultural stagnation, which in turn would have an adverse impact on industrial expansion, but the government was reluctant to divert resources from industry to agriculture. In the 1950s, the government mainly relied on traditional methods, such as mass mobilization of rural labor to work on labor-intensive irrigation, flood control, and land reclamation project, and adoption of labor-intensive techniques such as closer planting, intensive weeding, and application of organic fertilizers. Some of these efforts might be favorable for environment, such as irrigation and flood control, some might be unfavorable for environment, such as increasing cropping intensity. However, the result of these policies and institutional changes was a severe agricultural crisis in the 1959-61, which result in which resulted in an excess death of 30 million (Lin 1990).

After the crisis, the government started to rely on modern technologies (Lin 1990). The use of chemical fertilizers increased after 1962. Most of the traditional rice and wheat varieties were replaced by modern dwarf varieties in 1960s, which in turn were replaced by higher-yielding hybrid rice in 1970s. However, agricultural productivity remained low throughout the collective period in the 1960s and 1970s (Wen 1993, Fan 1997).



Source: Fan (1997)

The regional grain self-sufficient policy, according to Lardy (1983,1984), was likely to result in a violation of regional comparative advantage and possibly contributed to the decline and stagnation of agricultural productivity. However, some empirical analyses show that the imposition and relaxation of the regional grain self-sufficient policy could hardly be justified as a major explanation for the productivity loss in the commune period and after decollectivization (Lin 1994). The main reason for low productivity arising the detrimental effect of compulsory collectivization on farmer's incentive (Lin 1990).

1.3 The Effects of the Policy on the Sustainability of Agriculture

The state monopolized procurement system forces farmers to produce large quantity of grain and then sell all of them to the government (except their own food grain). This policy deprived the farmers' right of choices of product and resources to use in the process of production, forced them to over use natural resources.

The rural policies from 1950s to 1970s have tremendous effects on the sustainability of

agriculture in China, including positive and negative effects.

1.3.1 Major Mechanisms

The agricultural policy affected the sustainability of agriculture through two major mechanisms:

1. Price or shadow price mechanism. The relative rise in the prices of capital goods and manufacturing products and the lowering of the prices of agricultural products by the government, forced the relative price of natural resource (as the input of agricultural production) reduced, which in turn caused the waste in natural resources. The relative lowering in the price of agricultural products can be observed from the general price parity index of industrial and farm products published by the State Statistical Bureau. The reduction in the price of human and natural resources, as the input cost, can be reflected by the decrease in the price of agricultural products.

2. Ownership structure. The ownership of many natural resources was destroyed in 1950s after the revolution. Many natural resources became common assets without a well-defined owner taking care of them. The destroying of ownership caused over use of natural resources too.

1.3.2 The Positive Effects

The positive effects of rural policies from 1950s to 1970s include:

(i) The Construction of Irrigation System

The government organized the construction of irrigation system by massive using of rural labor force. The irrigated area expanded from 18.49 percent in 1952 to more than 45 percent in 1978, increased nearly 20 million hectares (Rozelle, Gregory and Huang 1997).

(ii) Research and Development

The government made a great effort to support the research and development in agricultural technology since 1960s. China started to promote the semi-dwarf, chemical fertilizer responsive rice varieties in 1964, which was two years earlier than the release of IR-8-- a variety that was often regarded as marking the start of Green Revolution-- by International Rice Research Institute in Philippines in 1966. In 1976, China started to replace the semi-dwarf varieties with hybrid rice, which was about 20 percent more productive than the semi-dwarf varieties. Up to a few years ago, China was the only countries in the world that commercially produced hybrid rice (Lin 1991a). Achievements were also made in the improvement of wheat, soybean, and maize varieties.

1.3.2 The Negative Effects

The rural policies from 1950s to 1970s also had negative impacts on the sustainability of agriculture in China. The increase in population and food demand led to over use of natural resources and environment degradation. The industry-oriented development policy raised the relative price of capital and industrial products and lowered the relative prices of human capital and natural resources. The reduced resource prices led to overuse human and natural resources with growing scarcity and shortages. The incorrect price structure also resulted in putting scarce resources to inferior, low return and unsustainable uses, when superior uses existed.

The negative effects of the rural policies from 1950s to 1970s on the sustainability of agriculture include:

i) Great Reduction in Marginal Land

The total land area of China is about 9.6 million square kilometers, or slightly larger than the United States including Alaska. About half of this area is occupied by largely nonagricultural provinces, which are thinly populated and possess the world's highest mountain and largest plateau. Only about a little portion of China's total area is cultivated. Estimates of China's total cultivated area vary from 100 million (cited in Chinese official publications before 1996) to 130

million hectares (UN sources). The Chinese government sources updated its estimation recently, which is closer to UN estimation. Clearly, China is land poor on a per capita basis in comparison with most other countries.

About 140.67 and 279.33 million mu wasteland was reclaimed in 1950s and 1960s, respectively. The reclaimed area went down since 1970s. About 66% of farmland in China is located in mountain areas, including 91 million mu land sloped more than 25 degree (National Land Administration 1998). Cultivation has been extended into submarginal steppe regions with inadequate irrigation, and wind erosion was severe (Murphey 1982).

Table 1.1 Reclaimed Area in China

Time	Total reclaimed area (million mu)
1950s	140.67
1960s	279.33
1970s	74.45
1980s	38.89

Source: China Natural Resources Series Editorial Committee 1996, p.107.

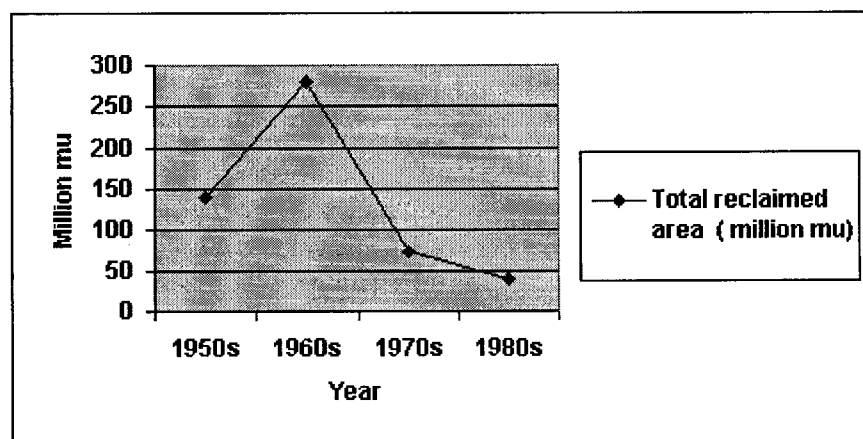


Figure 1.2 Total Reclaimed Area in China

Much of these marginal land that has been cultivated should be returned to grassland. This is

especially true for Inner Mongolia and western Manchuria.

The incorrect price structure and the pressure to produce large quantity of agricultural products caused the following environmental problems:

ii) Soil Erosion

Soil erosion has been a result of farming marginal lands, developing hillside fields, and inappropriate construction of irrigation systems. The total area of soil erosion in China in 1950s was 1.16 million square km (Hu 1991), while in 1992, according to the Chinese Academy of Science, the area of soil erosion increased to 3.75 million square km (Zhou 1996), about 39% of the total area of the country. The farmland endangered by soil erosion accounted for about one third of the total area of farmland in the country. Slit from the easily eroded loess soil-banks runs into Yangtze and Yellow River quickly fills reservoirs and clogs water distribution system.

In Loess Plateau, one of the most heavily eroded areas in China, the soil erosion area is 450 thousand square km, accounting for 83% of its total area. The seriously eroded area is 82 thousand square km in the district.

Soil erosion in Yangtze River valley became seriously in 1970s. Area of soil erosion in Yangtze River valley increased from 360 thousand square km in 1975 to 740 thousand square km in 1986, accounting for 41% of the total area. 600 million ton of sand drifted through Yangtze River annually, which was one third of the drift sand from Yellow River. Yangtze River is becoming the second Yellow River.

The total sand drifting into ocean annually in China accounts for 2100 million ton, 13.3% of the world's total. The total volume of soil eroded weighted 5000 to 6000 million ton, equal to 1 cm soil loss for all farmland in China. The total nitrogen, phosphorus, and potassium lost by soil erosion account for 40 million ton, more than the total chemical fertilizer use annually in 1980s in China. (Zhou 1996, pp. 113-114)

The shortage of level land is a chief problem for agriculture in south and west China. As the demand for grain increased, terracing was pushed up onto slopes that in many areas were too steep to repay the enormous costs involved. The shortage of level land is one of the reasons of soil erosion.

Soil erosion caused waterway silted up, lake shrinking, and riverbed building up. Soil erosion is the one of the main causes of flood today in China.

iii) Salinization of Soil

Excessive dependence on irrigation magnifies the risk of salinization. Irrigation of semiarid areas, as in other parts of the world, has increased the risk of soil deterioration through the buildup of salts, alkalines, and water logging (Murphey 1982). The inappropriate constructed irrigation system stored water but ignored the draining off of water, which caused the problem of salinization. There is 6.67 million ha. salinization land currently in China. (China Natural Resources Series Editorial Committee 1996, p.105)

iv) The Decrease in Soil Fertility

The decrease in soil fertility due to over use of farmland such as double or triple cropping of rice. According to the Second National Survey of Soil, in 1403 counties over China, the organic substance in farmland is only 1.5%, and less than 0.6% in 10.6% of the farmland (Zhou 1996). 59% of total farmland are lack of nitrogen, 23% of the total farmland are lack of phosphorus, and 14% of total farmland are lack of both nitrogen and phosphorus. The high yield farmland is only 21% of total farmland (China Natural Resources Series Editorial Committee 1996, p.105).

Table 1.2 Distribution of Different Output Level Farmland in China

output (kg / mu)	area (million mu)	%
<100	109.09	6.7
100-150	224.82	13.8
150-200	264.94	16.3
200-250	306.61	18.8
250-300	348.51	21.4
300-350	238.18	14.6
350-400	106.73	6.6
400-450	21.26	1.3
450-500	6.77	0.4
>500	0.56	0.03

Source: China Natural Resources Series Editorial Committee 1996, p.105

1 mu = 0.0667 ha.

v) Desertization and the Degradation of Grassland

There is 0.371 million square km desertized land in China in early 1990s. (Yang 1996) From 1950s to 1970s, the desertization land increased 1560 square km annually. In 1990s, the desertization land increases 2100 square km (Yang 1996).

There is 312 million ha of grassland in China. 27 million ha of grassland has been cultivated, 1/3 of which has become desert. Due to the excessive grazing, the degradation of grassland was 15% in 1970s and 30% in 1980s. (Zhou 1996)

vi) Logging and the Decrease in the Area of Forest

Logging and the decrease in the area of forest, especially during the massive steel-smelting campaign in 1958. According to the third national survey of forest resource, the forest covering area is only 125 million ha, or 12.98% of total land area, much lower than the world average of 30.6%. The per capita forest covering area is only 0.11 ha, 18% of the world average.

vii) Decrease in the Area of Inland Rivers and Lakes

The massive reclamation dramatically reduced the area of inland rivers and lakes. The area of inland lakes reduced by more than 20 million mu since 1949. 12.4 million mu of lakes in Hubei province in 1950s reduced to 3.04 million mu in 1980s. The area of Lake Dongting, once the largest lake in China, reduced by 35% from 1950s to 1980s (China Natural Resources Series

Editorial Committee, 1996). The Lake Boyang, the largest lake in China today, reduced by 1137 square km, or one quarter in area.(Xinhua New Agency, October 13, 1998) In the 25 years since 1970s, the Yellow River run out of water for 18 times, 6 times in 1970s (averaging 7 days each time), 7 times in 1980s (averaging 7.4 days each time), and 5 times in 6 years in 1990s (averaging 53 days each time).

viii) Increasing in Natural Disasters

Soil erosion, deforestation and other environmental problems caused increase in flood and drought-prone land. The great flood in 1998 in Yangtze River is one example. From 1991 to 1995, economic losses caused by natural disaster amounts to 656.2 billion yuan, or 131.2 billion yuan annually, accounting for 3-6% of GDP. (Xinhua News Agency, October 13, 1998)

The rural policies before the reform forced the farmers to produce more agricultural products than they want to produce under the existing low price. The over production over used some natural resources that should be left to other uses or the future generation. The rapid industrialization not only extracted the labor resources of farmers, but also extracted the natural resources base that should be left to the future generation. The over use of natural resources damaged the resource base of the sustainability of agricultural development.

Although some of the above problems are common to all developing countries, the main cause of these problems is due to the industry-oriented development strategy and the misallocation of human and natural resources.

II. The Rural Reforms and Their Impacts

The state-monopolized procurement and marketing system, collectivization and self-sufficient policy was under the pressure of change at the end of 1970s.

The main consideration of the government to change the policy is its incentive structure. Due to the incentive structure of this policy, the performance of agriculture in China continued to be poor. The environmental effect of the policy was not the main consideration for the government to change the policy.

The government's burden of financial subsidy to urban consumers due to the low retail price of grain was another reason for changing the policy.

2.1 The Rural Reforms

The household responsibility system reform started in late 1970s. The commune, brigade, and production team system of agriculture production management, with its work point system of compensation, was changed in late 1970s and early 1980s. Farmland was reallocated to individual households by contracts. The duration of the contracts was 15 years at the beginning of 1980s. In 1993, the government allowed the contracts to be extended for another 30 years after existing contracts expire. The current policy allows land to be subleased to other households. The households can also hire temporary farm workers.

But under the new system land is still collectively owned. The current household responsibility system for land is actually a village-based communal land tenure system, in which individual families have the right to cultivate parts of the village land but do not have the legal titles to them. The restrictions on land markets, frequent land redistribution according to population changes and small scale landholdings rooted in this village-based land tenure system have become the major hindrance to the efficiency of resource allocation and the improvement of agriculture productivity.

The government also reformed the pricing system while carrying out the household responsibility system reform. Higher prices were set for state purchase of farm products. Country fairs, where farmers sold their surplus products, were revived and expanded. After fulfilling procurement quota obligations, farmers were allowed to sell their surplus products.

In 1985, the mandatory quota procurement system was changed to a contract procurement system. Under this system, procurement quantity was determined by contracts based on mutual agreements between the government and individual farmers. The contract price was fixed and calculated as a weighted average of the basic-quota price and the above-quota price. The contract procurement system met problems in its first year, and reverted to the original compulsory quota-procurement system by the end of 1985.

The household responsibility system for farmland was extended to forest resources in late 1980s.

2.2 The Effects of the Reforms on Agriculture Productivity

The shift to the household responsibility system has been the most successful reform in China since late 1970s.

The household responsibility system greatly improved the incentive structure of agriculture production (Lin 1988). Econometric analyses show that a big portion of the output growth can be attributed to the reform (Lin 1992). The farmers were given more autonomy in the production decision and allocated resources to more profitable activities, such as fruit production, fishery and township-village enterprises. It also improved farmers' incentive to adopt new technologies (Lin 1991 b).

2.3 The Effects of the Reform on the Sustainability of Agriculture

The household responsibility system reform is actually an institutional reform. The improvement of institution affected the allocation of resources. This is a process of gradual changes and improvements.

The reform improved farmers' incentives. But land and other natural resources are still collectively owned. The contract of lending cultivated land to individual household with insecure property right may reduce farmer's incentives to maintain soil fertility. The contract of forestland to individual household also led to deforestation in some cases. Decollectivization also hurts the government's ability to mobilize mass labor for agricultural infrastructure.

Ownership of farmland, forest and other resources played an important role in determining the way in which farmers use natural resources. Different forms of property rights (collective, contract, private, etc.) over land, forest, management and farm products affect the use of natural resources and the protection of environment. The evolution of property right structure affected farmers' behavior and decision making process. Yao (1996) find positive links between tenure security and land investment and land yields, which supports the idea that further reforms be taken to strengthen individual land rights.

In many cases, the evolution of property rights affects the way of using natural resources through farmers' expectations. In the early 1980s, when the government gave the farmers short period using rights of land, the farms expectations were of short-term, and the land were over used with few long-term investment in land. When the using rights were extended to 30 years in early 1990s, farmer s' behavior improved. Researches on forest sector shows that there were some negative effects on forest resources at the beginning of household responsibility system for forest, when the contract extended the results became positive (Rozelle and Huang 1997).

The reform has both positive and negative effects on the sustainability of agriculture. The positive effects are due to the better incentive structure of the new system and the more secure ownership of resources. The negative effects are due to the remains of the old system and market failures in the new system.

2.3.1 The Negative Effects

The negative effects of rural reform on environment are mainly because that the property right is not secure so farmers have less incentive to concern about long-term sustainability and the government is less effective in mobilizing labor for environmental protection projects.

The negative effects of the reform on the sustainability of agriculture growth are:

i) Short Term Expectations Caused the Over Use of Land and Forest Resource

At the beginning of the reform, when the farmers' property right of the land was not clearly defined, the farmers' short term expectations of land ownership caused the over use of land resource and less long term investment on land. There was a dramatic increase in total eroded area in the 1980s due to deforestation and degradation of grassland especially in the Northwest and Inner Mongolia. Recall in section 1 we mentioned that Soil erosion in Yangtze River valley became serious since 1970s. Area of soil erosion in Yangtze River valley increased from 360 thousand square km in 1975 to 740 thousand square km in 1986. Some researchers believe that the rural reforms and increasing demand for agricultural products have brought about the increasing intensification of cropland use and the continued cultivation of marginal land for production (Sun 1988).

The short-run expectations of ownership at the beginning of the reform and the increase of demand for wood caused the damage in forest. The expending in time period of contracts corrected this problem to some degree.

ii) Area under Irrigation Decreased

The reform reduced the ability of government to mobilize massive labor to build large irrigation system and to maintain that kind of systems. The proportion of cultivated area under irrigation decreased in the early 1980s due to the collapse of the commune system.

Table 2.1 Irrigation Area in China, 1978-1985

Year	Irrigation Area (1000 hectares)
1978	44965.3
1980	44888.1
1985	44035.9

Source: *China Statistical Yearbook 1997*, p.373.

iii) More Chemical Fertilizer and Pesticide Were Used

Because the increase in labor cost, less organic fertilizer were used and more chemical fertilizer and pesticide were used, which resulted in damage of soil structure. The consumption of chemical fertilizers increased from 8840 thousand ton in 1978 to 503814 thousand ton in 1996. (*China Statistical Yearbook 1997*, p.373.) Per hectare chemical fertilizer used in China has been over that of the world average level.

Table 2.2 Consumption of Chemical Fertilizer in Selected Countries in the World, 1988

Country	Per hectare consumption of fertilizer (kg/ha)
China	262.1
India	65.2
Japan	415.2
U.S.	93.6
Developed countries	124.6
Developing countries	76.8
World average	98.7

Source: Zhou 1996, p.15.

The incorrect use of chemical fertilizer causes environmental degradation. Continuous excessive use of chemical fertilizer may result in soil quality reduction, fertility loss, and hardened soil. The increase in nitrogen in soil caused the increase in nitrite in vegetables. The international standards of nitrite content in vegetables are 250 to 360 mg / kg, while the nitrite content in vegetables in some areas in China are well above the international standard.

Table 2.3 Nitrite Content in Vegetables in Some Areas in China

Item	Nitrite content (mg/kg)
Vegetables, Shandong	200-400
Spinach, Beijing	2358
Radish, Beijing	2177
Leaf vegetables, Hangzhou	2349
Root vegetables, Hangzhou	1656
Bean and pea vegetables, Hangzhou	568
Eggplant vegetables, Hangzhou	555
Garlic vegetables, Hangzhou	152
Melon vegetables, Hangzhou	136

Source: Zhou 1996, p.16.

iv) Township and Village Enterprises (TVE)

The market-oriented reform also directed local governments' attention to industrial growth. The government is not limited to provision of public goods also direct involved in economic activities. The reform may induce government to sacrifice environment for growth.

When the farmers have more choices and are allowed to make their own production decisions, more township-village enterprises are developed, which become one of the main source of pollution in rural China.

According to some survey data, most of TVE's pollution figures are worse than national average in 1989 (Table 2.4).

Table 2.4 Comparison of the Pollution Disposal of TVE
and National Average in China, 1989

	National average	TVE	Difference
Wastewater disposal / 10000 yuan output	194	144	-50*
Wastewater treatment ratio, %	43	30.2	-12.8**
Wastewater disposed meeting standard, %	47.7	11.8	-35.9**
Treated wastewater meeting standard, %	57.6	16.2	-41.4**
Waste air cleaning ratio, %,	57.25	21.58	-35.67**

Source: Zhou 1996, p.23.

* indicates better then national average. ** indicates worse than national average.

Rozelle, Gregory and Huang 1997 find that environmental degradation has had a major effect on grain production in many of China's agricultural areas. They use a nationwide fixed effect grain-yield function, which incorporates both traditional input variables and an additional set of variables that reflect trends in environmental degradation at the provincial level. The model suggests that environmental degradation may have cost China as much as 5.7 million metric tons of grain per year in the late 1980s.

The first and second effects (land and irrigation effects) will be reduced as property rights become more secure.

2.3.2 The Positive Effects

The reform also has some positive impacts. As farmers' income increases, the demand for better environment increases as this demand has very high income elasticity. The government may also have more resource to invest in environment improving projects as the output increased.

The positive effects of the new policy on the sustainability of agriculture growth are:

i) Production Structure Improvement

The reform improved the structure of the production of grain and other agricultural products. It reduced the area of grain cultivation and increased the area of other product cultivation. A quiet structural adjustment has been carried out by market force. Some of the marginal land that has been cultivated has been returned to grassland, which is good for maintaining the natural base of agriculture. This is especially true for Inner Mongolia. From 1986 to 1990, farmland reduced by 0.711 million ha annually, including 0.325 million ha marginal farmland transferred back to forest or grassland (China Natural Resources Series Editorial Committee, 1996).

Table 2.5 Structure of Gross Output of Farming, Forestry, Animal Husbandry and Fishing %

Year	Farming	Forestry	Animal Husbandry	Fishing
1978	80.00	3.44	14.98	1.58
1985	69.25	5.21	22.06	3.48
1990	64.66	4.31	25.67	5.36
1996	57.82	3.32	30.23	8.62

Source: *China Statistical Yearbook 1997*, p.369.

ii) Forest Protection

When forests are contracted to farmers by long-term contracts and the signal is clear, the farmers have some incentives to protect the forest resources. Rozelle and Huang 1997 show the evidence in Fujian and Yunnan provinces, which supports the above conclusions.

iii) Irrigation Area Increases

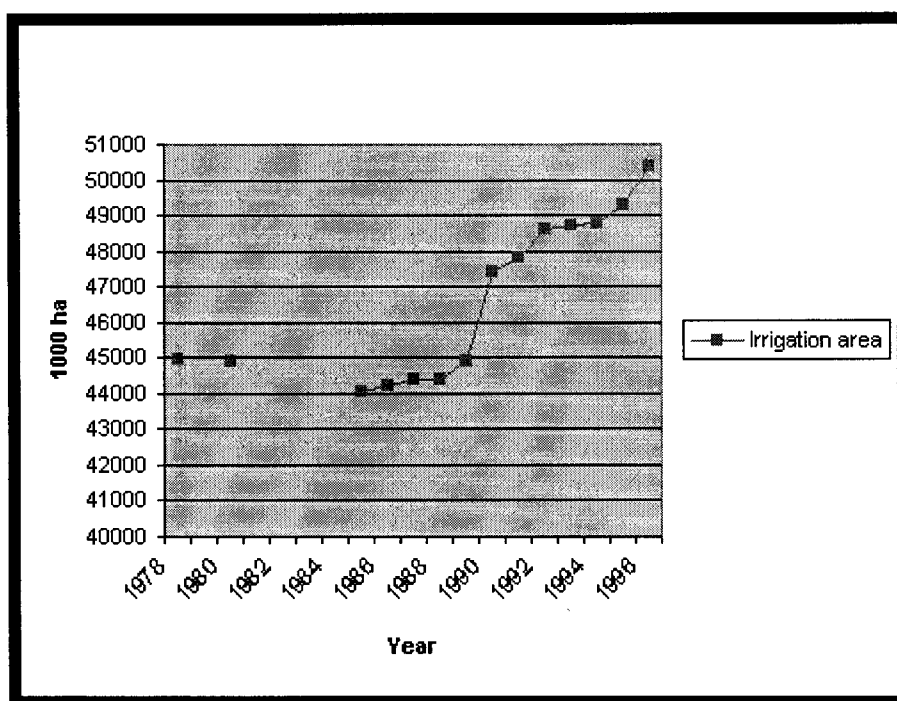
Reversing to the declines of the early 1980s, the proportion of cultivated area under irrigation increased to 49.5% in 1990, due to the re-construction of rural community structure after the reform.

Table 2.6 Irrigation Area in China, 1978-1996

Year	Irrigation Area (1000 hectares)
1978	44965.3
1980	44888.1
1985	44035.9
1986	44225.8
1987	44403.0
1988	44375.9
1989	44917.2
1990	47403.1
1991	47822.1
1992	48590.1
1993	48727.9
1994	48759.1
1995	49281.2
1996	50381.4

Source: *China Statistical Yearbook 1997*, p.373.

Figure 2.1 Irrigation Area in China, 1978-1996



Source: *China Statistical Yearbook 1997*, p.373.

The above observations leads to policy issues such as whether further reforms should be taken to strengthen individual land rights. Our suggestions to policy makers include: (1) extending the current land and forest leasing terms; (2) fixing the current landholding in the entire contract period without readjusting to population changes; and (3) relaxing the restrictions on land transfer.

III. The Provincial Governor's Responsibility System for the Balance of Grain Demand and Supply

In 1993, both procurement price and retail price of grain were decontrolled. The market price of grain took an unexpected rise after market liberalization. The government resorted again to administrative intervention in the grain market. In 1995, the central government held each provincial governor responsible for the balance of grain demand and supply in his/her province, and hence intensified the local governments' intervention in grain production and marketing.

As mentioned in section 1, the nation wide grain self-sufficient policy gradually retrogrades to a regional grain self-sufficient policy. At the beginning of reform, there was a relaxation of this policy. The provincial governor's responsibility system was return to the regional grain self-sufficiency policy, which causes misallocation of resources within and among provinces. The industrialized provinces have to use their scarce resources to produce grain with high opportunity cost. On the other hand, those agriculture-oriented provinces waste some of their capacities of grain production.

In general, China is not well endowed with agricultural resources and these resources are not evenly distributed among different areas. The following facts (from China Natural Resources Series Editorial Committee, 1996) shows the distributional characteristics of the agricultural

resources in China.

- Farmland / total land ratio. The current national farmland / total land ratio is 14.2%, higher than the world average farmland / land ratio 11%. In terms of province, Shandong is 58.3%, Jiangsu, Henan is over 53%, while Xinjiang, Qinghai and Tibet are 2.4%, 1.2% and 0.3% respectively.
- Forest cover ratio, defined as forest area / total land. The national forest cover ratio is 12.98%, lower than the world average of 31.3%. The forest resources are quite unevenly distributed among provinces. Taiwan's forest cover ratio is 54.2%, the highest in the country; Fujian, Zhejiang, Jiangxi, and Heilongjiang's forest cover ratio are 40.4%, 39.0%, 35.9%, and 34.35%, respectively; while Xinjiang and Qinghai's forest cover ratios are only 0.9% and 0.4%, respectively.
- Per capita farmland. The national average per capita farmland is 1.79 mu. The highest is Ningxia, while the lowest is Fujian and Zhejiang, if exclude Beijing, Shanghai and Tianjin.

Table 3.1 Per Capita Farmland and Forest in China

National rating	Farmland per capita mu		Forest per capita mu	
National average	1.79		2.71	
1	Ningxia	5.86	Tibet	80.73
2	Heilongjiang	4.81	Inner Mongolia	11.52
3	Inner Mongolia	4.74	Heilongjiang	8.82
4	Xinjiang	3.98	Yunnan	8.63
5	Gansu	3.91	Qinghai	6.01
26	Tianjin	1.05	Henan	0.45
27	Zhejiang	0.94	Shandong	0.24
28	Fujian	0.81	Jiangsu	0.06
29	Beijing	0.73	Tianjin	0.04
30	Shanghai	0.43	Shanghai	0.006

Source: China Natural Resources Series Editorial Committee, 1996, p.95.

Many provinces are facing severe land constraints as a result of growing populations and increasing demand for agricultural products. The use of marginal land for crop production is vital to meet subsistence grain requirements (Glaeser 1990). In other provinces, higher-quality land is being cropped more intensively to meet the demand for cash crops and to meet high production quotas (Zheng and Yu 1990). The type and extent of land degradation varies throughout provinces. In the Huang-Huai-Hai Plain, the problem of erosion is minimal, but salinized cropland is increasing. In Southwest, the opposite is true: erosion is the greatest threat, while salinity problems are minor (Rozelle, Gregory and Huang 1997).

The provincial governor's responsibility system re-produced the environmental problems in the more developed areas by over use their land and other natural resources. On the other hand, the policy caused inefficient use of the agricultural resources in those less developed areas, which has comparative advantages in agriculture.

Rozelle, Gregory and Huang 1997 find that the agricultural losses due to environmental degradation are not evenly distributed throughout China, the regions which brought considerable amounts of marginal land into cultivation during the earliest years of the reform period currently face the greatest problems. Xinjiang and Gansu in the Northwest, the Loess Plateau provinces, and Yunnan and Guizhou in the Southwest reported stagnant production despite significant increases in technical inputs. This stagnation should be credited to the increasing degradation of agricultural land in these areas.

IV. Concluding Remarks and Suggestions for future research

China is a developing country in the process of transition from a planned economy to a market economy. The environment problems that China faces arise from both its development and transition processes. For environmental sustainability, the direction of future reform is to secure property rights, to liberalize price and market control, to give up self-sufficiency and to reduce government's direct involvement in economic activities. The specific policy recommendations are as follows:

- Abolish the regional grain self-sufficient policy, including the governor's responsibility system for grain production, and encourage domestic trade of agriculture products
- To protect the sustainability of agriculture, government policies should let the resource prices reflect the inter-generation and inter-regional costs of natural resources. The government should not intervene in the price mechanism of natural resources unless the intervention is to compensate for the positive or negative externalities.
- The government needs to continue to secure the ownership of land, forest and other natural resources.
- The government needs to give up the grain self-sufficiency policy and import certain agricultural products which are not worthy of producing domestically.
- The government should reduce subsidy to chemical fertilizers and pesticide.

In terms of areas that may be most relevant for future empirical research on environmental sustainability in China, the followings are our suggestions:

The regional grain self-sufficiency

The topic is extremely important because the regional grain self-sufficiency is still an official policy in China, resulting in many of the environmental impacts, e.g., the over claim of marginal land and the increase in the cropping intensities. The idea is still having great influence on many policy makers in China and other developing countries. Due to the policy, many regions have to produce enough grain for themselves, even though the opportunity costs, for example in the developed eastern provinces, or environmental costs, for example in the arid northwestern provinces, are very high.

This is naturally a regional or cross-sectional research. The researchers could look China as a small world consisting of more than 30 provinces (or less than 10 regions to make the model simple). Each province (or region) has its special resource endowments and the opportunity cost are different for different provinces. For example, the opportunity cost for labor is more expensive

in Guangdong, a eastern province. Each province has two policy choices, trading with each other or being self-sufficient. The researchers can look into the problem by using international comparative advantage theory and relative approaches. The question is which policy increases the national welfare, emphasizing on the cost of natural resources.

The main hypothesis is that regional grain self-sufficiency results in misallocation of natural resources among provinces as well as misallocation of human and capital resources. The policy ignores the relative advantages and different opportunity costs among provinces.

There are two approaches can be used to deal with topic:

- The standard cost-benefit analysis. Researchers can divide China into several areas, according to their levels of development, and calculate the costs and benefits of the policy on environment, using productivity and opportunity cost approaches. The calculation includes the area of farmland, the composition of farmland including portion of the marginal land, the productivity of different farmland, the opportunity cost of farmers to produce agricultural products (the productivity if work in a factory), and the reduction of fertility by increasing yield per ha., etc.
 - CGE model or other regional econometric models. Compare the cost and benefit with or without trade among provinces, including natural resource as a factor of production. Calculate the effects of different policy on environment.

Both approaches should find (1) which regions are hurt and which regions are benefited (or every one is a loser), and (2) the net cost (or benefit) for the whole country. The research will show how large the welfare loss is caused by the regional grain self-sufficiency and how much net benefits will gain if changing to a inter-provincial trade pattern of economy.

Lots of provincial level data are available from official statistical sources for this kind of research. But further data may be needed to be collected by survey performed by the researcher.

The impact of insecure land tenure system

The reforms since 1978 provide a cumulated history of the institutional change from a command economy to a market oriented economy. It involves a dramatic number of reactions between government policy, new institutions and the farmers. The credibility of the policy and the expectations of farmers affect dramatically on farmers' behavior to protect the resource base of agriculture.

The land tenure system was the main result of the rural reform since 1978, which was totally abolished by the collectivization in 1950s. It has great influences on farmers' behavior in using and preserving natural resource, e.g., land, water and forest. The games between government and the farmers in setting the rules of property rights are extremely interesting. The government's policy in setting land tenure system improved gradually according to the reaction of farmers. What we can learn from this game include (1) the importance of commitment of government policies; (2) the role of farmers expectation and reaction; and (3) the timing of implementation of the policy.

The empirical research of land tenure system on natural resources is mainly a research on historical data. The following data are needed: (1) The change in policy, including the length of tenure, whether land is allowed to re-lend, how frequent the land is re-distributed, etc; (2) the history of change in production; (3) the history of change in land resources, e.g., area, quality, and farmers' investment on land.

An econometric model may be used to describe the natural resource preservation and land tenure policy, with other factors being controlled. Models incorporating expectations could be developed.

Researchers may use existing survey data or design and undertake their own survey. Research could focus on some representative regions instead of the whole country. The difficulty in data collecting is how to design questionnaire to collect data of changes in land resources over 10 or 20 years. Cross-sectional data of different regions with different policy may be used instead.

The Impact of Rapid Development of TVEs in Rural Area

The rapid development of TVEs is a major source of environmental degradation as well as a major source of economic development.

There are plenty of existing official or unofficial data on this area. The weakness of previous researches is the policy issues: how to perform pollution control policy to these small-scale dispersed TVEs? How do policies to influence the incentives of TVEs to protect the environment?

The possible research topics include:

- The evaluation of cost and benefit of TVEs in an area or in the whole country.
- The calculation of full value of the pollution charges should be imposed on TVEs, comparing with the current level of pollution charge (may be too low).
 - The comparison of the effects of different policy instruments, e.g., emission standards, charges, and tradable permits.

The policy issue is correlated to the functions of local government and its relation with TVEs. A well-developed local community will consider the long run welfare of the community and make their decision on how severe the environmental restriction on TVEs should be. If free moving is allowed, a geographic equilibrium could be reached in the nation. Otherwise, some kinds of central government's intervention will be needed.

Most of the previous researches on this topic emphasize the shortcomings of TVEs on environment protection. Some positive aspects due to the appropriate policy may be found in a more comprehensive research.

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