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Poverty, population and environmental degradation in China

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This paper studies the relationship among population, poverty, and the environmental factors, and the impact they have had on China's land, water, forests and pastures. It does so by examining the extent of environmental degradation and China's success in controlling its environmental problems is reviewed; by investigating how the leadership has tried to develop a legal framework and series of institutions to carry out environmental policy; and by providing empirical evidence demonstrating the determinants of the successes that China has achieved in surmounting (or slowing) some of its environmental problems. Five of China's rural resource concerns are surveyed in this paper: water pollution, deforestation, destruction of the grasslands, soil erosion, and salinization. The paper finds that government policy has not been effective in controlling rural resource degradation primarily because it has limited fiscal resources and poorly trained personnel, and under these constraints the government has delegated responsibility for environmental and resource protection to the ministries of agriculture and forestry, two institutions that have an incentive to favor pro-production policies. Instead, China's efforts to alleviate policy, integrate markets, and control population appear to have helped mitigate a number of adverse environmental consequences of China's development effort of the last 40 years.

Keywords: environmental protection policy, poverty, population, China

Introduction

For longer than any other agrarian civilization, farmers have tilled and tamed China's soil, tapped its water resources and used its forests and pastures. By most international standards, the Chinese government has successfully controlled these elements for the past four decades to meet its food and fiber needs and fuel its modernization drive. Despite a population of more than 1.2 billion, China has harnessed its resource base to produce enough agricultural products to provide its rural citizens with sufficient food, clothing and housing, as well as a wealth of reasonably priced products for its rapidly growing urban and industrial economy.

In the course of this ancient legacy and its contemporary development effort, the natural environment of rural China has become subjected to increasing pressures (He, 1991). In recent years, academicians and policymakers have developed a rising awareness of the environment's fragility and have begun to ask if it is sustaining damage that could affect China's long run welfare (Qu and Li, 1984). The seriousness of the degradation problem and the government's success in addressing adverse environmental impacts has been a source of controversy. Some authors believe China is on a path heading straight towards a full-scale environmental disaster (He, 1991; Smil, 1984, 1993). Others counsel patience before drawing conclusions since existing information sources do not provide reliable indicators (Lindert, 1996). Some blame poor government policy (He, 1991), while others noted the leadership's progress in controlling some of the worst sources of pollution and degradation (Krupnick, 1991; Ross, 1988). The evidence however is piecemeal; most observers have depended largely on anecdotes to infer on the trends and magnitudes of changes in the environment.

The determinants of these adverse environmental trends are even less understood, though in the thin empirical literature existing, wealth and population appear to be the major factors determining protection outcomes. World Bank (1992) has shown that the ownership status (i.e., whether a factory is state-owned or collectively-owned) affects access to resources and, consequently, affects the volume of a factory's wastewater effluents. Rozelle *et al.* (1994) show that progress in controlling water pollution is associated with rising incomes. Lindert (1996) has compelling evidence that long-term soil degradation is mediated in some circumstances by increasing land values and wealth, but adversely affected by population pressures. Tang and Zhang (1990) demonstrate that intensified agricultural production systems in heavily populated watershed areas can have adverse environmental consequences.

What are the trends of China's major ecological problems and what are their fundamental sources? What roles have government programs played in causing or ameliorating them? If China has improved environmental quality (or at least succeeded in slowing down degradation), what factors contributed to this success? The answers to these questions have important implications for future reforms of China's environmental policies, and investments in environmental protection institutions. Institutions that lead to environmental improvements should be strengthened. Otherwise, it may be more realistic to invest the limited fiscal funds in sectors that reinforce environmental-friendly trends, such as poverty alleviation.

This paper studies the relationship among population, poverty and the environment in China, and examines the impact that each has on the country's land, water, forests and pasture resources, as well as those of the decisions made by the country's leaders and producers. Specifically, this paper: (a) reviews the extent of and success in controlling environmental degradation in China; (b) provides empirical evidence demonstrating the determinants of China's successful control of environmental problems; and (c) investigates the legal framework and institutions developed by the Chinese government to carry out environmental policies. In particular, it seeks to answer the question: can the accomplishments (or failures) in environmental protection be accounted for by the leadership's ability (inability) to effectively implement environmental rules and regulations through its environmental protection bureaucracy?

The state of China's rural environment

This paper surveys five of China's natural resource concerns, namely water pollution, deforestation, grassland destruction, soil erosion, and salinization, all of which have immediate and important implications on China's resource productivity. Data on national resource trends and related information used in this paper come from various published reports of academes and government agencies, such as the Ministry of Agriculture and Ministry of Forestry.

Water pollution

In the early 1980s, water pollution of major lakes and rivers was one of the most pressing national environmental concerns in China (Chang, 1987; Smil, 1984, 1993). In the same period, water pollution control significantly reduced the discharge of industrial effluents on a per yuan output basis (Rozelle *et al.*, 1994; *Zhongguo Tongji Nianjian*: ZGTJNJ, 1980–92). Despite this progress, water pollution in China still caused a direct economic loss of about 5 billion yuan in 1990 (World Bank, 1992).

In the rural areas, the rapidly expanding township and village enterprise (TVE) sector, which generates over 25% of China's industrial output on a per yuan of output basis, has become a major source of water pollution (Ministry of Agriculture: MOA, 1991). It contributed an estimated 5–10% of total industrial effluents in the early 1990s (National Environmental Protection Agency: NEPA, 1992; World Bank, 1992), which are in turn projected to more than double by the year 2000 (MOA, 1991). Some officials argue that TVE factories create less, yet significant, pollution than suggested by popular opinion (MOA, 1991). Others explain that lower pollution rates arise not from more effective pollution control, but because of its composition; TVE manufacturing facilities are generally involved in light industry, which is inherently less polluting. The World Bank (1992) reports that after correcting for "industry sector-bias", it is ambiguous which ownership group pollutes more; TVEs outperform their state-owned enterprise (SOE) counterparts in some industrial categories and fare less well in others. The rapid absolute growth of the TVE sector nevertheless suggests continued and increasing pollution problems from rural factories.

Next to industrial effluents, agricultural chemical runoff and leaching also cause serious water pollution concerns and are predicted to grow steadily as observed from past trends and projected increases in their use (Mei, 1992; MOA, 1991).

Deforestation

Deforestation problems have plagued China for hundreds of years, but accelerated more in the late 1950s when Great Leap Forward planners authorized the clear cutting of massive forest areas to fire China's backyard steel furnaces. As a result, China today has less than 10% of the world's average per capita forest area (MOA, 1991).

Long-term (time-series) forestry statistics[1] in China report that forest cover has grown from 13% in the mid-1970s to 12% in the early 1980s, to 13% in the early 1990s (*Quanguo Linye Ziyuan Tongji*: QGLYZYTJ, 1980, 1988, 1995). This trend however hides the degradation experienced during the early reform period, when over a third of China's old-growth timbers were mined, drastically decreasing the stock of high-quality forests (Rozelle *et al.*, 1996). While much of the rampant felling has ceased in the past 10 years, dwellers continue to shift substantial parts of China's natural forests to either orchards, fast-growing paper pulp-bearing trees and shrubs, or other monocrop (Rozelle *et al.*, 1997a). With leaders failing to meet forest

[1]China's forestry statistics may be the most complete of all of the nation's resources due to the intensive national inventory program conducted by the Ministry of Forestry every 5–7 years since the 1950s. However, Smil (1984), Forestier (1989), and He (1991), among others, have questioned China's statistics mainly on the basis of seemingly inconsistent information regarding its forest use data, afforestation numbers and figures on lumber stocks. Forestier (1989), for example, claims that China's current rate of forest cover is overstated by 2–3%, and is possibly below 10%.

regeneration targets since the late 1970s (Liu, 1991), the biostructural shifts may have adverse implications on the diversity of China's forests (Albers *et al.*, 1996).

Three factors contribute to the difficulties in achieving afforestation targets and boosting forest coverage: (a) increasing demand for wood products; (b) timber pricing problems; and (c) management and regulatory shortcomings. First, economic and rapid industrial expansion have increased the general demand for all material inputs, including wood (Rozelle *et al.*, 1997a). Housing investments, a major user of wood products, has grown rapidly since the reforms. China's 900 million rural residents (World Bank, 1992) use fuelwood as a major energy resource. The growth in China's fruit consumption, and in the consequent demand for land to produce it, has surpassed those of nearly all other agricultural products (Rozelle *et al.*, 1997a).

Timber pricing schedules have historically generated the wrong signals, inducing producers and local officials to undervalue forest products relative to other crops, especially grain (Menzies and Peluso, 1990; Ross, 1988). Marketing restrictions on alternative energy sources (e.g., coal cannot be sold in certain communities and regions due to its scarcity) increased the fuel value of wood products, and many rural residents resorted to cutting down forest trees to meet their cooking and heating needs.

Government rules and enforcement programs have provided few incentives to effectively implement reforestation activities. Originally, accounting rules would not allow budget managers to reimburse state forest farms for reforestation expenses (Ross, 1988). Regional afforestation campaign planners have used "planted area", instead of survival rates, as the criterion for success (Smil, 1984), since sufficient technical extension and monitoring of planting does not exist in most areas. More recently, problems with land tenure farm programs—where private, profit-seeking individuals have received contract rights to collective resource and management of tree planting efforts in some areas—appear to have led to a "tragedy of the commons" problem (Menzies and Peluso, 1990; Rozelle *et al.*, 1996).

Grassland destruction

China's grassland covers approximately half of the total land area at approximately 4.0 million km^2 (400 million ha) and over 75% (3.13 million km^2) is classified as agriculturally usable (ZGTJNJ, 1980–92), making it more than three times as large as the nation's total cultivated area. Much of this ecosystem however has come under intense pressure. From the 1950s to the 1970s, desertification ate up 33 million ha of the grasslands, and is proceeding in recent years at a rate of 150,000 ha per year (World Bank, 1992). Degradation has claimed another 30 million ha, or about one-tenth of the usable area, and is estimated to proceed at over 1.3 million ha per year (World Bank, 1992).

Grassland destruction is affected by three important elements: (a) deforestation, as examined above; (b) agricultural expansion; and (c) overgrazing of livestock (Liu *et al.*, 1991). Agricultural expansion onto grasslands create environmental problems when winds and heavy rains cause exposed soil to be lost from recently plowed or harvested land. Poorly designed irrigation facilities also lead to salinization and other drainage-related problems (MOA, 1991). Unfortunately, damaged converted grasslands are difficult to restore to productive pasture land use. A survey on sustainable agricultural policy in 16 counties in 16 provinces in China (hereinafter referred to as the MOA survey) found that agricultural expansion is the main contributor in grassland degradation. Grassland cover in the sample counties declined from 18.2% in 1980 to 16.3% in 1990, mostly due to expanding agriculture, especially in the richer counties that had the resources to invest in agricultural expansion.

Over the past four decades, overgrazing has become an increasingly serious problem in China's grasslands. China's sheep population grew from 37 million in 1952 to 96 million in 1978 (*Zhongguo Nongye Nianjian*: ZGNYNJ, 1981–92), likewise with the goat population, from 16 million in 1949 to 30 million in 1978. These growth trends continued in the later years of the reforms, with sheep count at 99 million in 1984 growing to over 110 million in the early 1990s, and goat population expanding from 35 million to over 40 million in the same periods. Some authors believe that land tenure arrangements may account for the pattern of expansion (Liu *et al.*, 1991). As the tenure system provides individuals incentives to expand their herds and increase their household's profit, these individuals tend to abuse the land in the short run due to factors related to the private use of collective resources. By the late 1980s, over 75% of major livestock raising counties had reached or exceeded their maximum carrying capacities (Wu, 1988).

China responded to this problem by asking regional authorities to emphasize pasture management and to work protective activities into local economic plans. The shelter-belt reforestation projects, that converted fragile cultivated land back into pasture land, helped make a successful rural environment program in China. Interestingly, this successful program was not run by either National Environmental Protection Agency (NEPA) or local forestry bureaus. China's central leadership established independent regional administrative authorities (for example, the "3 Norths Office" to manage North China's shelter belt program), through which budgetary resources are channeled. This administration structure greatly reduced dust pollution in North Asia (NEPA, 1992), and improved, by 1985, up to 100 million ha of grassland (Liu *et al.*, 1991). Recent funding cutbacks, however, reduced the pace of pasture rehabilitation to only about 20,000 ha per year.

Soil erosion

Sixty-five percent of China's total area of 9.6 million km^2 is classified as mountainous, hilly or plateau regions, and, by definition, vulnerable to erosion. Chinese researchers estimated that land with heavy or moderate erosion increased from 13.5% in 1985 to 17% (about 26% of non-plain land) in 1991 (Table 1; World Bank, 1992).[2]

Most of the serious erosion problems in China occur in four regions, namely the Loess Plateau, the Red Soils area, the Northeast China Plain, and the Northwest Grasslands, which

Table 1 Total amount of eroded land and land area on which erosion control programs exist in China

Category	Year 1985	1987	1988	1989	1990	1991
Total eroded area (million km^2)	1.29	1.32	1.33	1.34	1.36	1.62
Land area in erosion control program (million km^2)	0.46	0.49	0.51	0.52	0.53	0.55
Percentage of eroded land in erosion control program	35	37	38	38	39	34

Source: ZGTJNJ (1980–92).

[2]Partly as a result of the biggest flood of the century in 1991, the eroded area increased by 19%. The increase may also be due to the improved reporting system and data collection efforts. See Huang and Rozelle (1994) for a complete description of the data.

together covers 70% of China's land area.[3] The Loess Plateau region located mostly in the provinces of Shanxi, Shaanxi and Gansu, contains the world's largest geological deposits of wind-blown loess soil. The soil, which reaches depths of more than 100 m, is highly erodible because of its finely granulated and undifferentiated nature.

Geologists and hydrologists have shown evidence that within the last several decades the rate of erosion has increased (World Bank, 1992). Among other reasons, experts blame a doubling of the population in the region since 1949 and the resulting agricultural expansion for this trend. Shaanxi province, for example, has increased its cultivated area by 20% since the early 1950s, even though the province's main agricultural areas have been settled and farmed for thousands of years (*Shaanxi Sishi Nian*: SXSSN, 1989).

In contrast, the Red Soils area has a shallow and acidic soil of high clay content that makes it both erodible and unable to hold water (Buck, 1956). The worst problems in these areas are in the hill regions where the densely populated valley-dwellers throughout history and increasingly in recent years have encroached on the easily erodible hills, harvesting trees and brush for fuel, and pushing agricultural activities up off the valley floor. Once the hillside has its natural protective covering removed, unless properly designed and carefully managed, high rainfall levels cause further breakdown of the poor soil base. Even commonly used techniques of erosion control, such as terracing, can lead to significant, long-term soil and fertility losses (World Bank, 1992), and strong economic consequences. In Guangxi province for example, officials claim that more than 20% of their provincial irrigation systems have been damaged, partly or completely by siltation, causing large decreases in provincial grain yields (Liu, 1991).

Recognizing the seriousness of these problems in recent years, China's leaders have begun organizing a national effort to rectify soil erosion. Anti-erosion efforts include afforestation programs, improved pasture management schemes, terracing projects, silt dam construction, and policies that encourage removal of fragile land from cultivation. In 1985, erosion control efforts were undertaken on 465,000 km^2 of China's land, about 35% of the total eroded area (Table 1). Since then, the total area, where erosion control projects are implemented, have increased by almost 4% per year. Although total eroded area also increased until 1991, environmental leaders appeared to be making continuous progress; by 1990, erosion control efforts were undertaken on 39% of China's eroded area.

Salinization

Farmland salinization also can cause significant declines in farm productivity, and can become serious enough to induce producers to remove land from production (Huang and Rozelle, 1994). Poorly-constructed irrigation systems commonly lead to salinization in some environments, either from inadequate application of water or from sub-standard drainage.

Since 1985, salinized area has remained fairly constant at about 7.5 million ha (about 7% of China's total land area), and is mostly concentrated in the flat, water-scarce North China Plain (Table 2). Of this area, government targets for improvement have increased from 59% of the damaged areas in 1985 to 67% in 1991. Rectification and maintenance of salinized land requires substantial infrastructural investment. Some researchers predict that, with increasing water shortages in many northern areas and reduced investment in agriculture, it will be difficult

[3] In this section, only the erosion problems connected with the Loess Plateau and the Red Soils area are discussed. The biggest erosion problem in the Northeast Plains area is deforestation which was discussed in the section on the forest resources. The main factors contributing to soil erosion in the Northwest Grasslands is grassland destruction which was addressed in the previous section.

Table 2 Total amount of salinized land and land area on which salinized improvement programs exist in China

	Year					
Category	**1985**	**1987**	**1988**	**1989**	**1990**	**1991**
Total salinized area (million ha)	7.69	7.63	7.67	7.53	7.53	7.61
Land area in salinized improvement program (million ha)	4.56	4.75	4.83	4.88	4.99	5.11
Percentage of salinized land in salinized improvement program	59	62	63	65	66	67

Source: ZGTJNJ (1992).

for China to maintain this rate of progress in the future, and that salinization will be a chronic problem to sectoral leaders (MOA, 1991).

The state of the environment and impact on production

In general, the trends in controlling environmental degradation in China show an uneven pattern. Success seems to be occurring in reversing water pollution, deforestation and salinization. On the other hand, erosion continues to occur at an apparently unslowing rate. Although no single set of figures is available for assessing the general situation of the pasture lands, it seems safe to say that China's grassland is still a fragile resource.

While beyond the scope of this paper, Rozelle and Jiang (1995) show that behind each of these national trends, the disaggregated figures (based on the same MOA data set used in this paper) show remarkable variability among the regions of China. In their paper trends are presented on an ecosystem-by-ecosystem basis for many of the environmental variables (deforestation, grassland destruction, erosion, and pressure on the land). In almost no case, however, can the direction of the trends be predicted by knowledge of the ecosystem. In other words, there seem to be factors besides purely agro-climatic ones that determine whether an area is experiencing increasing environmental degradation. The next two sections examine some of the regulatory and socioeconomic factors that may explain environmental degradation trends in China's rural area.

At least some of the adverse trends could negatively impact yields and production. Using data from China's Ministry of Water Resources and Electric Power, three papers find that erosion, salinization, and breakdown of the local environment (including local deforestation and grasslands destruction) have affected the nation's grain and cash crop productivity. Huang and Rozelle (1994) found that salinization had the highest impact on grain output, reducing national grain yields by 2% during the reform period. Huang and Rozelle (1996) showed that deterioration of the local environment was the most critical environmental factor affecting the growth of rice yields; without such effects, rice yields would have grown 12% faster in the late 1980s and early 1990s. Huang *et al.* (1996) found the largest effects of erosion to be on maize, wheat, and cash crops in North China, holding back expansion of production by up to 20% during the 1980s and 1990s. In order to reverse these trends in agricultural production losses due to environmental degradation, policymakers need to understand the factors that help improve the environment.

Laws, institutions and the "fox-in-the-chicken-house" syndrome

China's environmental strategy in rural areas is based on three main policy tools: (a) direct regulation (Ross, 1988); (b) targeting and planning clean up and rectification campaigns (Liu, 1991); and (c) reliance on state-mandated technological improvement to reduce the adverse consequences of certain production practices (Sinkule and Ortolano, 1995; Wu, 1987). While noted in the literature (Qu and Li, 1984), economic incentives to combat environmental deterioration is rarely practiced (Ma, 1997; Sinkule and Ortolano, 1995). To implement these largely administrative-based policies, tough regulations and incentive-compatible institutions are seen to be central to any hope of success (MOA, 1991; Ross, 1988; World Bank, 1992).

This section introduces the major laws and institutions that China and its provinces are using to implement environmental policies. To avoid confusion between what leaders and policymakers state to be their institutional goals, and the reality of China's environmental protection infrastructure in rural areas, the findings of this section are as follows. Despite progress on urban China's environmental front, resource constraints have precluded the establishment of strong environment protection agencies in the rural areas. Instead, by default each sector's production-oriented ministry has accepted responsibility for carrying out environmental policies and enforcing regulations (e.g., the forestry ministry is in charge of protecting the forest, etc.).[4] As might be expected, conflicts of interest between those who want to exploit the resource and those who want to preserve it may be underlying the difficulties China has encountered in meeting its environmental protection goals. If there has been success in limiting environmental degradation in rural areas, this section concludes it must lie in other factors beyond the administrative efficacy of rural protection agencies.

Laws

China has had laws covering economic and environmental concerns for many years. Since its first national conference on the environment in 1973, environmental leaders have worked continuously at creating a series of laws to protect the environment. In 1979, on a trial basis, China promulgated its first "Environmental Protection Law (EPL)" (Wu, 1987). Since then, leaders have expanded the law and made it the legal basis for much of China's resource protection work (Smil, 1984, contains a translation of the law).

The EPL is at the apex of a hierarchy of laws covering a broad range of issues (World Bank, 1992 contains an exhaustive listing of the important ones). As designed, the EPL defines the general principles underlying the nation's effort to protect the environment, and contains general clauses describing overall goals, but has few specific regulations. More specific laws to protect China's natural resource base were supposed to be created in subsequent years, and have, in fact, proliferated. Rules and regulations address elements in nearly all sectors of rural areas that directly or indirectly affect the environment.

Some of the most strict laws and regulations issued recently by China's State Council, for example, pertain to forest protection. The comprehensive provisions in these laws address many elements including management practices, property rights, forest protection, as well as strict limitations on any form of exploitation. Recent rules state that timber cutting quotas are to be established exclusively under the national plan, making, in theory, all logging activities in China's forest areas determined by the central authorities.

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[4]An alternative explanation may be that the production ministries have used their influence to keep NEPA from establishing jurisdiction over the relevant resource base. Most likely, the truth lies somewhere in between.

Similar laws have been passed for fisheries and pasture lands (Liu *et al.*, 1991), many of which are aimed at eliminating problems caused by previous policies, and include a number of provisions encouraging soil and water conservation as well as reclaiming wastelands and water areas. In particular, laws (such as one prohibiting cultivation on lands with gradients in excess of 25°) have given high priority to speeding up the conversion of marginal farmland back into more sustainable uses such as forestry or livestock production.

Policymakers also developed one of the newest sets of laws to confront TVE-created wastes (NEPA, 1992). In particular, State Council regulators began to prohibit the discharge of toxic and waste materials from TVEs in 1990 (MOA, 1991). One of the main measures stipulates that sound environmental controls must precede the establishment of the enterprise. Laws also place the responsibility for protecting local resources and the environment on enterprise owners and managers.

Institutions

At the central level, the main institution for environmental management and implementation is the State Environmental Protection Commission (Warren, 1996). The executive arm of this State Council organization is the NEPA, below which are the environmental protection bureaus (EPBs) in all provincial-level administrative regions. Each provincial organization also runs its own network of prefectural and county EPBs. This national environmental protection system is responsible for all environmental affairs of China. At the central level, the main task is to work out general principles for each sectors policies and set national standards for environmental quality (Wu, 1987). The concrete tasks of enforcement and implementation are left to the local agencies (Qu and Li, 1984).

NEPA, however, has chosen not to claim jurisdiction over many of China's environmental and natural resource problems (World Bank, 1992). Interviews with NEPA officials have revealed that its leaders have prioritized the nation's problems, and use its limited budget to address only a subset of them. NEPA leaders admit that they have had to leave implementation of many sector-specific environmental policies to the ministries in charge of the respective systems. In particular, NEPA has decided not to become directly involved with most rural natural resource and environmental problems.

To carry out these protection tasks, each ministry has established its own environmental management hierarchy. For example, MOA officials have delegated the responsibilities for implementing TVE wastewater control and solid waste disposal policies to the Environmental Protection and Rural Energy Division. The Bureau of Fisheries (in the MOA) has jurisdiction over water resources in most rural freshwater lakes and rivers. Ministry of Forestry officials have set up the Division of Environmental Protection and Nature Conservation to watch over the protection effort in the nation's forests. There are also environmental protection divisions in the State Oceanographic Administration, the State Meteorological Administration, and others.

The implementation path for all measures typically starts at the lower levels of the administrative hierarchies (provinces and townships, counties, and farm households), creating a three-tiered Agro-Environmental Protection System (AEPS—Fig. 1).[5] At the top of the system, there is the provincial AEPS station, an office that has been set up under the Bureau of Agriculture in the provincial capital. In the station in Wuhan, the provincial capital of Hubei, for example,

[5]The information in this section is based on a case study of Hubei Province. In cases where variations between Hubei institutions and those of the province are known, these differences are highlighted. it is recognized that considerable regional variation in substance and nomenclature exist.

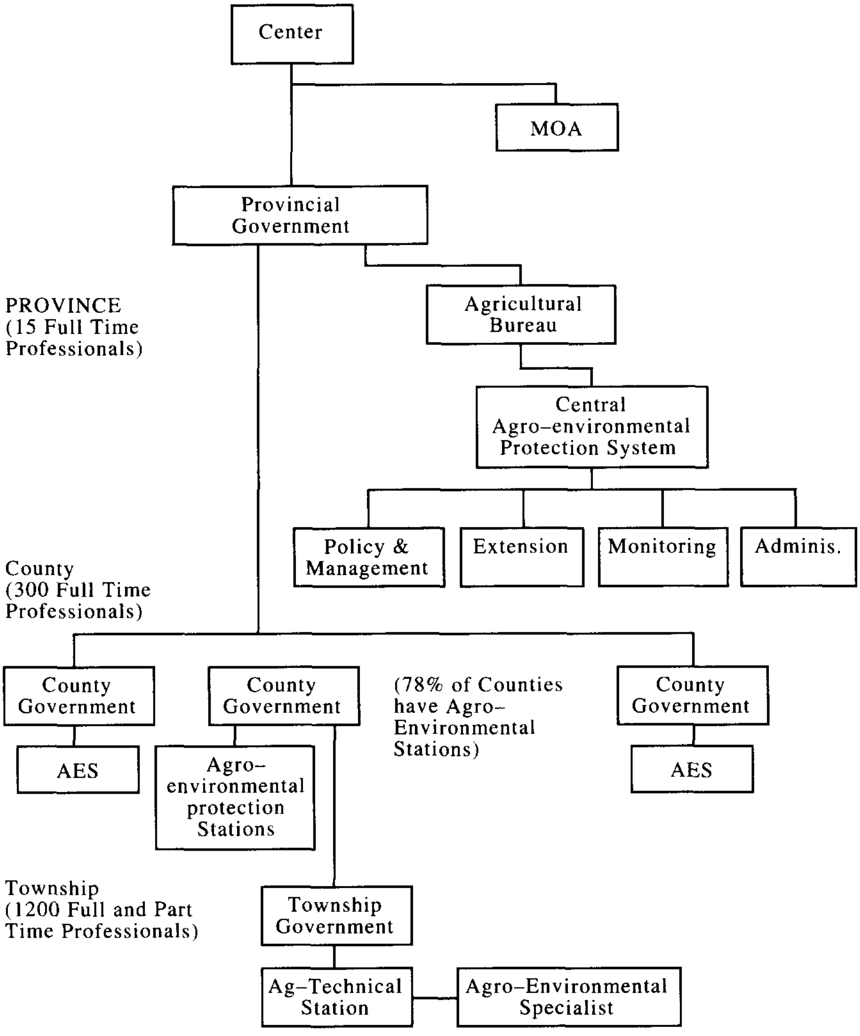

Figure 1 Schematic diagram of Hubei Province's Agro-Environmental Protection System (AEPS), China

there are 15 full-time professionals who are working in four divisions: Policy and Management; Monitoring; Extension; and Administration. The tasks of these four divisions are described in detail in Rozelle and Jiang (1995).

The next level down in the provincial system, most counties have established AEPS offices. For example, 78% of Hubei's 80 counties have created county-level protection stations. Approximately 300 full-time professionals work in Hubei's 60 county-level stations. Although, some counties have not set up protection stations, others have built strong, committed networks to address rural environmental problems. Provincial officials in Hubei have identified 10–15 county AEPS offices as "strong and deserving the study of others". These "model" stations have an average staffing level of about 20 professionals. Each AEPS is also divided into four divisions, with the same responsibilities as their provincial counterparts.

At the lowest rung of the implementation ladder, the township, there is typically an agro-environmental specialist who is in charge of executing environmental rules and regulations at the local level. These technicians belong to the agricultural technical stations which act as the representative office of the agricultural bureau in nearly every township in China. In Hubei, there are over 1200 so-designated personnel at the township level (located mainly in the 60 counties which have AEPS offices). Their work commonly includes: dissemination of information on new environmental regulations and policies; enforcing these new laws and regulations; and periodically monitoring selected resource bases such as critical water sources, soils, and grain and other agricultural products.

Environmental policy implementation problems in China

The array of new regulations in China are designed to provide policy implementation guidance to leaders in specific sectors. The expanded set of laws is also supposed to give more substance to the rating EPL. While impressive in scope, many observers have criticized China's environmental legal framework. Laws are vague (He, 1991; Smil, 1984, 1993), and lack mechanisms to facilitate enforcement (Ma, 1997; World Bank, 1992). The head of NEPA notes that laws in many of the sectors lack coordination (Qu and Li, 1984). Final ordinances do not contain specific standards, fine schedules, or other provisions which facilitate monitoring and enforcement (Ma, 1997; Sinkule and Ortolano, 1995). Wu (1987) and Qu and Li (1984) conclude that since most of China's environmental laws lack substance, effective environmental control relies on the efforts of those charged with its implementation.

However, relying on this system of protecting China's rural environment means that the effectiveness of the entire rural branch of China's institutional structure is suspect, and that many questions remain regarding its long-term efficacy. First, if Hubei is a model province and its implementation network is still as weak as provincial authorities admit, what are the other provinces like? Some are satisfactory, others are poor or nearly non-existent, according to interviews with MOA personnel and Hubei provincial officials (who have been consulted by interested officials of other provinces).

Second, does the system have sufficient resources? National leaders budget less than 1% for environmental protection activities, of which only a small fraction supports rural environmental protection. Localities largely must invest in the creation of their own systems. Since one-quarter of the counties have no local NEPA offices, and many have only several poorly-trained staff members, the answer to the question is obviously no. According to Hubei officials, the worst county offices or the ones without an office are frequently the poorest counties, which are poverty-stricken and suffering from serious environmental problems. Of those Hubei counties that do have offices, each unit has, on average, only four full-time staff members. These four staff members must implement the laws, rules and regulations in all of the rural sub-sectors in areas approximately populated with 500,000 rural residents (the average size of rural population in a Chinese county).

Third, how well trained are China's environmental protection professionals? Sinkule and Ortolano (1995), Warren (1996), and Ma (1997) find that poor training of environmental officials is one of the biggest obstacles to more effective implementation of environmental rules and regulations in the much better funded and more experienced urban and industrial networks. The level of training of their rural, local counterparts is certainly even lower and often inappropriate. In most townships and counties, AEPS personnel have at most a background in agronomy or agricultural management. Most have only high school-level technical training. Even if the leadership was fully behind these environmental policies, such a staff would have difficulty organizing and carrying out systematic monitoring and enforcement.

Finally, one of the biggest questions involves the level of commitment of local leaders to seriously addressing environmental concerns. Under the current system, there is no independent watchdog-type agency. Production-oriented bureaus and agencies have obvious conflicts of interests. For many fairly obvious reasons, sectoral leaders have an incentive to less strictly implement protection efforts. Such production-protection frictions become more visible as one gets closer to the local level, where output and income growth come into the most direct conflict with environmental concerns. Even better laws and a more committed, better funded and trained central environmental protection agency most likely could not overcome the weaknesses of the system that breaks down at this phase of the implementation process.

Why would any one expect local officials to actively push environmental rules and regulations? Local leaders, who have both environmental and production responsibilities, have no incentive to increase the weight of protection goals in their decision-making calculus. Indeed, it is difficult to blame local officials, since they face demanding production targets which offer monetary and promotion bonuses when completed and penalties when not (Rozelle, 1994). Unlike production targets, there are almost no rewards or punishments explicitly tied to success or failure in executing environmental laws. In case of a trade-off between production and the environment, the rational official expectantly will sacrifice environmental goals, or even make decisions that lead to greater environmental degradation, to meet production targets. Given this system, China's rural environmental protection efforts should be expected to be ineffective, since they have, in effect, put the "fox in charge of guarding the chicken house".

In fact, interviews with local officials (in two different surveys) reveal that the consciousness or awareness of key problems in rural environment is quite low. In a set of interviews with 72 local leaders in Jiangsu and Hubei regarding their goals as local leaders (reported in Rozelle and Boisvert, 1994), only two mentioned protection of the community's resource base as being part of their decision-making criteria. A survey taken of participants in a MOA-sponsored conference of sustainable agriculture and rural development revealed that over half failed to explicitly tie together issues of sustainability and obvious actions needed to protect the county's resource base (e.g., that afforestation may positively affect yields and aquatic output through its impact on reducing erosion, increasing moisture retention, and local climate control).[6] In almost every annual report of a set of 16 interviewed model county rural environmental protection chiefs, "sustainability" was described as a state in which the economy grows rapidly year after year.

Pollution, poverty and population

The previous sections demonstrate that while being constrained in their actions sectoral leaders in some areas have taken steps to address China's rural environmental problems. Progress in curbing excessive damage, however, is uneven across different environmental concerns (e.g., there appears to be progress in addressing salinization, but not in erosion control). Additionally, when considering the general contours of geographically disaggregated information, progress

[6]The results are even more surprising since these participants were supposed to be the county officials responsible for overseeing its sustainable agriculture and rural development plan.

is even more variable.[7] This section focuses on answering the question, why does success in controlling environmental degradation differ so much from locality to locality? Are there certain factors aiding local leaders in improving their rural environment, or that encourage better environmental practices regardless of the state of their environmental protection processes? Empirical evidence presented in this section examines the association between environmental improvement and efforts to both alleviate poverty and control population growth. This approach is motivated by recent work relating poverty and environmental degradation, and degradation and population pressure (World Bank, 1992).[8]

Income growth, poverty, and the environment

Real rural income growth patterns in reform China went through two distinct stages. In the early 1980s, income grew extremely fast, and early reform policies made it such that almost every rural resident benefited. Across China, real rural income per capita increased in every province and inequality remained unchanged despite the sharp income rises. Likewise, in the MOA sample, real rural income grew at an annual average rate slightly higher than the national average (about 16% per year from 1980 to 1985 versus about 13% for all of China over the same period). All but one county (in Jiangxi Province) registered high per annum income growth rates. In the late 1980s, however, the growth rates of real rural income declined and then stagnated. Provinces across China (and counties in the MOA sample) began to grow at increasingly unequal rates (Rozelle, 1996). Some continued to grow at high positive rates (in real terms); others suffered annual falls in real income in the late 1980s and early 1990s.

To evaluate the possible relationship between income growth and environmental changes, the sample from the MOA survey was divided into two types: counties that are "well-off" (or those in the upper half of the sample's income distribution), and those that are "poor" (the other counties). The eight "poor" counties had an average income of 249 yuan per capita (in real 1980 prices), an income level making them eligible for the national poverty alleviation program. The "well-off" counties had an average real income level of 514 yuan per capita, which is 47% above the national average.

In the forestry sector, three of the six reporting well-off counties have successfully converted large tracts of marginal cultivated area back into forests (Fig. 2). Conversely, progress in building new forests from farmland in poor counties has declined throughout the 1980s. It may be that richer rural residents and their leaders are more willing and able than their poorer counterparts to forego the immediate benefits from the marginal land's food output, and have begun to invest in forest activities. While having a more lengthy fruition period, residents in these counties can afford to wait to collect higher long-run economic returns as well as enjoy the gains from a better protected environment (including use for lumber, fruit orchards, fuel uses and environmental protection). This result is consistent with those at the national level (Rozelle *et al.*, 1997a). In terms of building up national forest resources, richer provinces

[7]In their review of a wide range of variables, Rozelle and Jiang (1995) demonstrate that there is great variation among the 16 counties in the MOA data set, and that knowing a county's climatic zone does little to increase the predictability of the trends.

[8]While reading the information in this section, a number of cautionary remarks are required. First, we are not claiming our evidence is valid in any formal statistical sense. The number of questions for which these exercises can be performed are limited. Information on some of the most interesting issues is only available for a small subset of an already small sample. Second, the mechanism by which income, population, policy and the environment are connected is complicated. Cause and effect links are frequently either uncertain or two-way. There are often positive and negative pressures simultaneously at work making *a priori* hypotheses difficult.

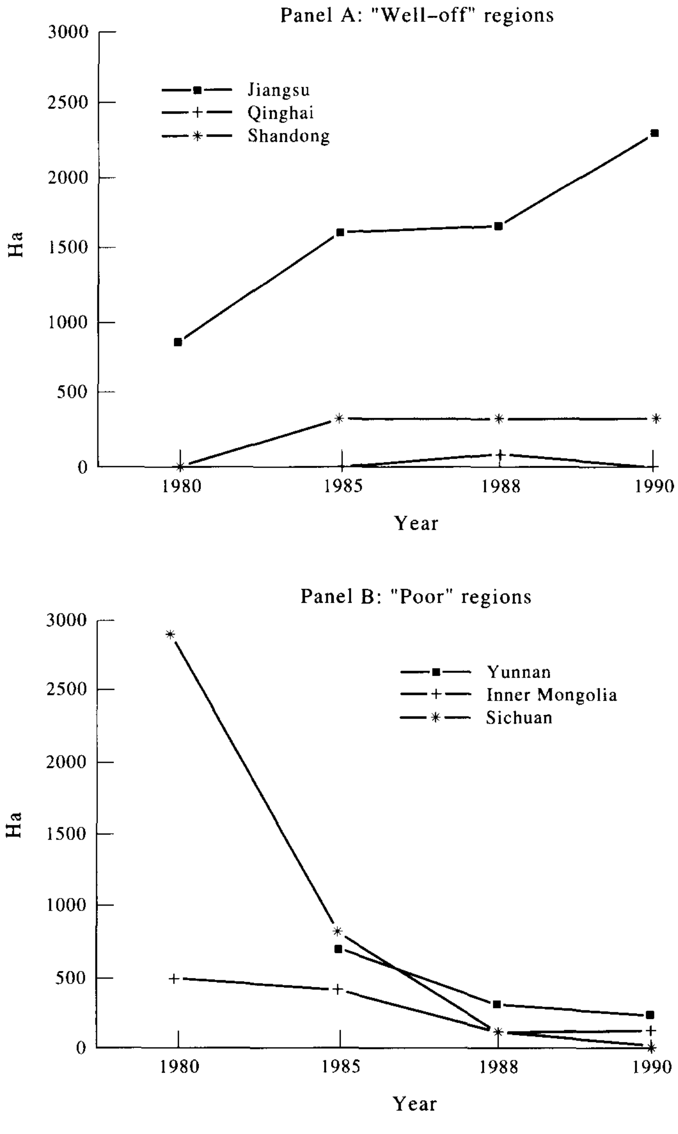

Figure 2 Area converted from cultivated land to forests in "well-off" and "poor" regions, SARD counties, China, 1980–90 (*Source*: SARD Survey, MOA, 1991)

have been able to rely less on cropping, and reduced agricultural expansion has increased forest cover.

Richer counties also have made more substantial progress in cleaning up their rural industrial wastewater (Fig. 3). Both of the two well-off reporting counties recounted that their 1990 level of discharge was less than 20% of their 1980 level (on a volume per yuan of output basis). Only one poor county with TVE production (in Hunan), however, showed significant improvement. The others (albeit only having low levels of discharge to begin with) have either increased their effluent emission or have seen no improvement. Two forces may be at work

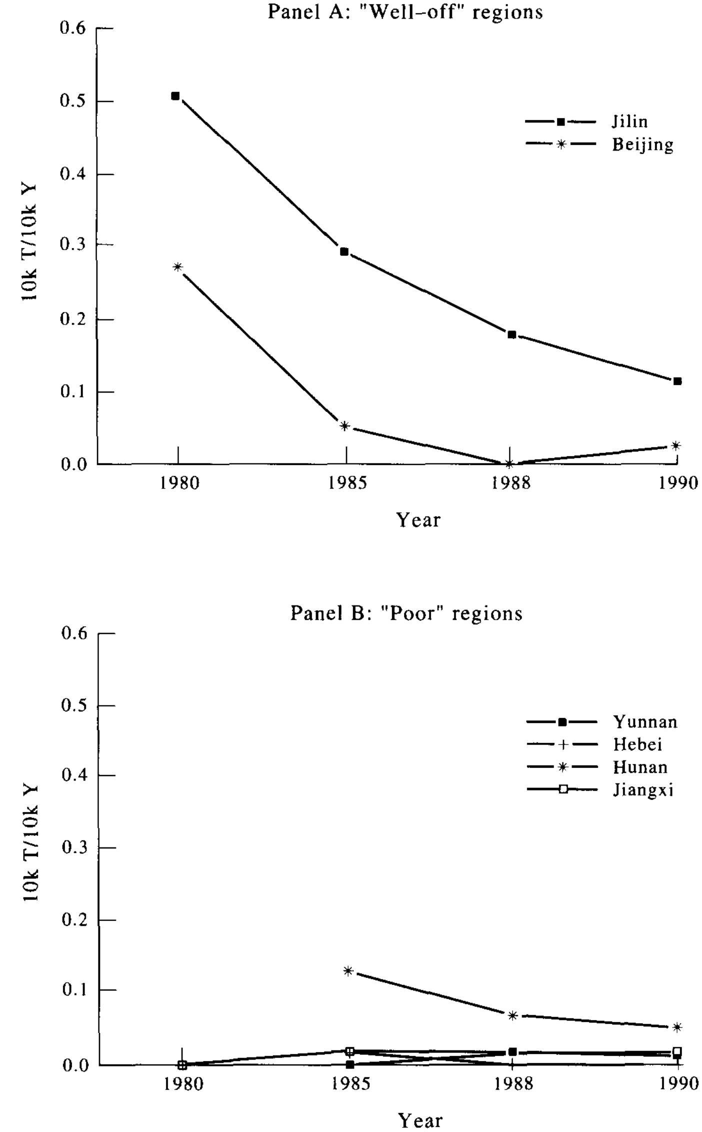

Figure 3 Industrial wastewater discharged from rural industries in "well-off" and "poor" regions, SARD counties, China, 1980–90 (*Source*: SARD Survey, MOA, 1991)

which explain these differentiated trends. First, higher-income areas most likely have relatively better access to capital pools allowing them to either retrofit their production processes with abatement technology, or to a adopt more sophisticated, less polluting production technology in the first place. Poor areas, on the other hand, will likely forego any but the absolutely necessary capital improvements because of their tight budget constraint and capital shortages. Second, there may also be pressure coming from the demand side, as relatively high levels of income lead to higher demand for a clean environment. For example, residents affected by water pollution (either aesthetically or by its impact on other economic enterprises) support the abatement actions taken by local officials (even if it somewhat slows the growth of overall output). Residents can afford to forego current income for future economic and environmental benefits. Moreover, Ma (1997) shows that TVEs in richer areas make greater progress than their urban counterparts, when better-funded local environmental protection bureaus attempt to make them adhere to water pollution rules.

Both of the above examples show that when incomes have reached a certain (high) level, growth may bring about improvements to the environment. These cases demonstrate that rising incomes may be relaxing the capital constraints that are keeping their poverty stricken counterparts from adopting available technology (or creating protection agencies) which in the long run may be both economically superior and environmentally sustainable. However, there are also cases where rich counties are moving away from environmentally sound practices. Fig. 4 shows that income levels are an important determinant of organic manure use. In all but one of the well-off counties (Panel A, that is except for the Henan county, which actually has the lowest per capita income of all "well-off" counties), the level of organic manure is either the same or lower in 1990 than in 1988. The reverse is true for the poorer counties (Fig. 4, Panel B), in which all but one county (the sample county in Sichuan, which is by far the most industrialized of the poor counties, and one that has experienced high levels of out-migration) has increased the use of organic manure.[9]

Population control and the environment

To see if population pressures affect the way rural residents treat the environment, the MOA survey sample was divided into two groups based on the level of population growth rates in the 1980s.[10] The first group of nine counties had high annual population growth rates which increased from 1.32% in 1980 to 2.00% in 1990. The second group had low and fairly steady population growth rates in the 1980s, only rising from 0.3% in 1980 to 0.4% in 1990. Based on these groupings, Figs 5–7 illustrate that rising population pressures seem to be associated with environmentally degrading actions. For example, counties with high population growth rates increased pesticide use in the 1980s (Fig. 5, Panel A). In contrast, three of the five reporting counties in the low population growth group decreased pesticide use, and the other two counties increased their use only marginally (Fig. 5, Panel B). Overall, in 1990 the low population growth counties used less than half the amount of pesticides (8.4 kg per ha) than high growth counties (17.4 kg per ha).

The same trend is true for the use of chemical fertilizers (Fig. 6). In 1980, the high population growth counties (Panel A) and the low growth counties (Panel B) used identical quantities of chemical fertilizer (an average of 80 kg per ha). During the 1980s, the high population growth counties increased chemical fertilizer use by 64 kg per ha, or about 80%. Producers in three of the five counties with low population growth rates, however, maintained or decreased chemical fertilizer use. The group as a whole increased their average use by only around 10% (or less than 10 kg per ha).

[9]As opposed to the former two cases (the forest and water pollution examples), in this latter example the environmentally sound practice being used by farmers in poor areas and abandoned by those in richer areas are labor intensive. In the richer areas where opportunity cost of labor is rising, rural residents are not willing to invest the same amount of time in protecting long-run land productivity as agricultural producers do in poorer areas.

[10]The SARD counties generally reflect national trends. While the national population increased by about 0.5% during 1980–90, the overall population growth rate for the SARD counties rose slightly more (by 0.7%). The variation among the counties in this period also widened, much like the differences among the provinces.

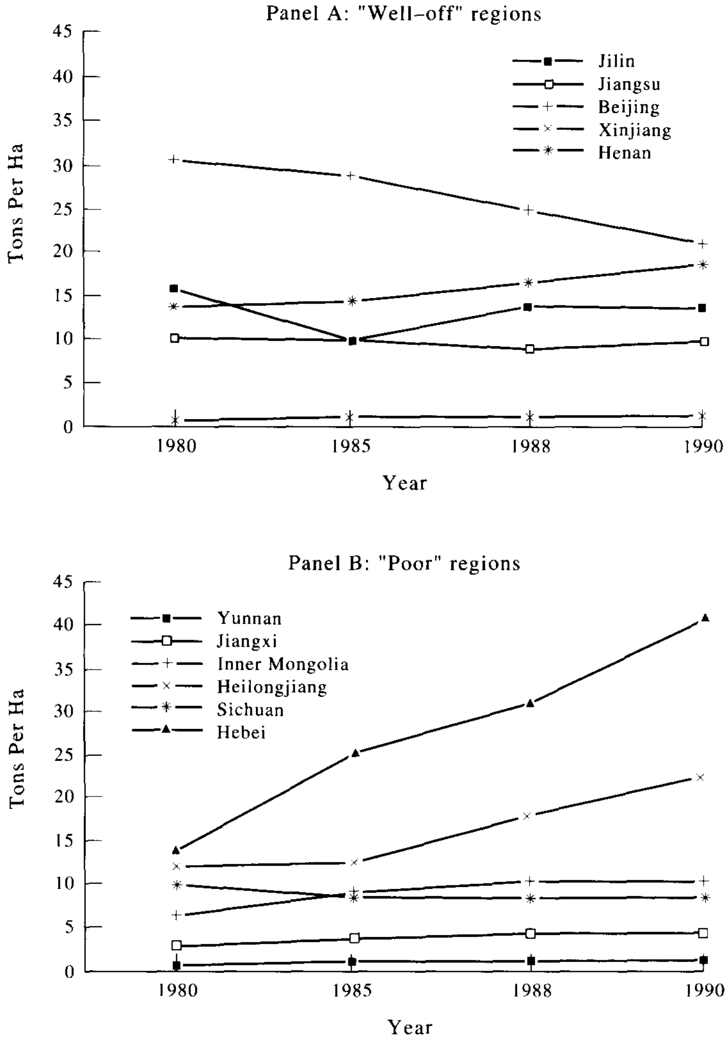

Figure 4 Organic manure application in "well-off" and "poor" regions, SARD counties, China, 1980–90 (*Source*: SARD Survey, MOA, 1991)

Why would these counties with high population growth be using significantly higher levels of agricultural chemicals when, interestingly, there seem to be few noticeable differences when the two groups of counties are compared across other factors? It may be that given the remaining rigidities in interregional markets and continuing barriers to the free flow of goods (e.g., high production quotas), higher population growth rates force farm households to produce, on a fixed land base, increasing amounts of goods for own family consumption. People in areas with high population growth rates apparently adopt increasingly intensive agricultural technologies. While certain domestic policies in China (such as measures encouraging labor migration, more secure land tenure arrangements, and better agricultural markets) could overcome these interregional variations in the short run, the descriptive data here suggests that under

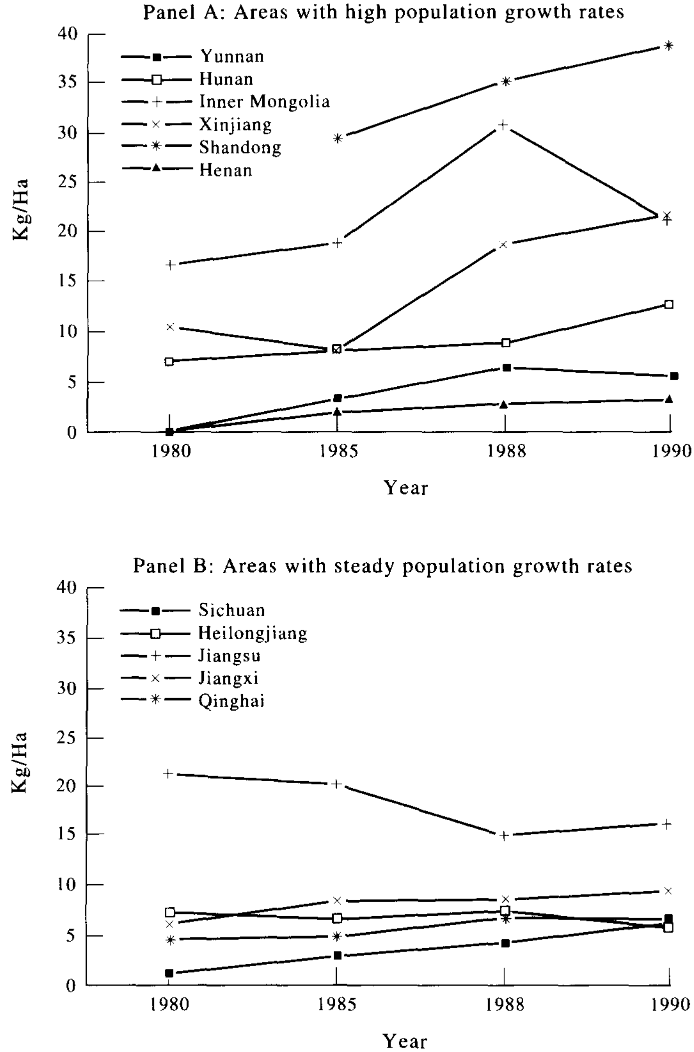

Figure 5 Pesticide use per hectare in SARD counties, by population growth rate, China, 1980–90 (*Source*: SARD Survey, MOA, 1991)

China's current socioeconomic regime, high population growth rates may lead to practices that increase the probability of long-term degradation of land, soil and water resources.

The trends also affect non-cropping activities as shown when examining the livestock stocking rates on pasture lands. During the sample period, pasturalists in high growth rate counties have increased grazing land intensity more than low growth rate ones (Fig. 7). The trends in both panels are not linear, however, and must be interpreted in the light of other policy changes that occurred in rural China. After decollectivization, in the early 1980s there was little systematic attempt at establishing long-term tenure rights to the land, either in cultivated area, the grasslands, or livestock associated with the land. During this time, producers in all areas (Panels A and B) rapidly reduced the size of their herds. Williamson *et al.* (1991) reported that during

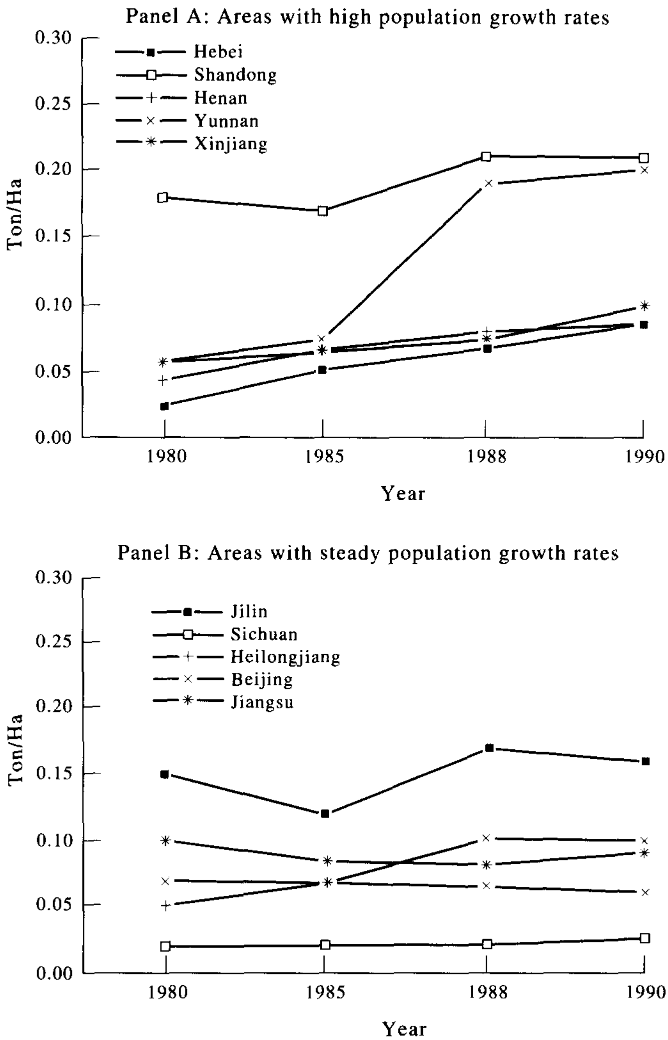

Figure 6 Chemical nitrogen fertilizer use per hectare in SARD counties, by population growth rate, China, 1980–90 (*Source*: SARD Survey, MOA, 1991)

the first years after the reforms, there was little incentive to build up herd sizes, since ownership of many herds was unclear. In fact, in some areas, farmers slaughtered animals for their short run profits (which would accrue to the household at that time but might not if herd control reverts back to the collective). Under these ownership patterns, stocking rates fell in all but one of the reporting counties. In the mid-1980s the situation changed. After contracts were issued clarifying the tenure and ownership rights of livestock producers, the power of the collective was considerably weakened in many areas. At this point, population pressures appear to play another important role. Without a decisive collective manager, areas with rising population pressures appear to have rapidly expanded their livestock holdings. The herds increased dramatically between 1985 and 1988. These rates, however, may have proved to be unsus-

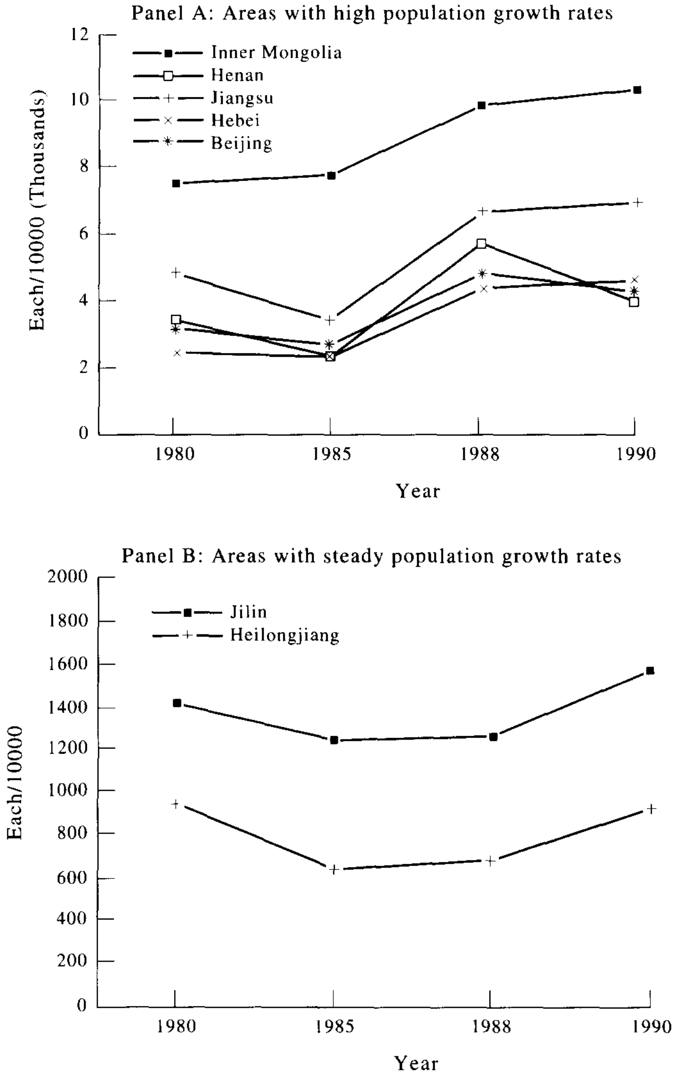

Figure 7 Livestock stocking rates in SARD counties, by population growth rate, China, 1980–90 (*Source*: SARD Survey, MOA, 1991)

tainable. On grasslands of poor quality and maximum carrying capacity (see discussion on grassland destruction in an earlier section), production levels peaked in 1988. In three of the five counties in the high population growth areas, herd sizes contracted by 1990.

The paths taken by the two lower population growth counties show less variability and smoother continuing growth. Herd size gradually recovered in the mid-1980s. Growth did not peak in the late 1980s, as in some high growth rate counties, but continued to increase through 1990. With lower population pressures, livestock managers might not have been forced to adopt such sudden, and possibly unsustainable, measures and may have had the time to increase the quality of their pasture resources.

Rozelle *et al.* (1997b) show econometric evidence that the impact of erosion and salinization systematically is more serious in poorer and more densely populated areas. While it is difficult to determine causality and hold the natural environment constant (i.e., it may be that areas with erodible soils have produced poverty and encouraged high fertility), erosion has kept grain yields from rising in poor areas. In better-off areas, and those with lower population growth rates, reductions in erosion rates have contributed to increased food productivity. Such trends can only increase the rising inequalities among China's region, a problem cited by the State Council as one of the most serious challenges policymakers face in the 21st century.

While not enough information exists (here or in other analyses of China's record on environmental protection) to evaluate all of the institutional changes that occurred in the high and low population growth regions, the evidence is consistent with the following logic. If economic pressures induce institutional change and technology innovation (Lin, 1991), then with less population pressure, there is less immediate exploitation and more time for appropriate institutions to develop. With time and better institutions, good policy and adequate resources lessen the chance of moving onto a sub-optimal, unsustainable development path.

Summary and conclusions

This paper has presented one of the first glimpses at a number of China's environmental problems on a disaggregated basis over time since the reform period. The evidence shows that progress in containing environmental degradation during a time when the nation's leadership is committed to achieving rapid economic growth is mixed. Successes have been enjoyed in some areas (e.g., water pollution, deforestation and salinization), and continued problems have been documented in others (e.g., soil erosion, grassland degradation, and diminishing quantity of prime cultivated land).

Environmental protection accomplishments (and failures) have also varied from locality to locality. Beneath the national trends, a number of widely differing contours appear for many variables, which may be unrelated to an area's natural ecosystem. It is impossible to know if these "random" patterns are related to the environmental awareness and commitment of local leadership. If so, then progress is being achieved *not* because of centrally promulgated policy measures. Despite the development of well-intentioned regulations and institutions to enforce China's environmental ordinances, serious weaknesses exist in rural China's environmental protection administrative framework. Funding shortages have pushed protection duties to local production ministries, who have poor knowledge of the environment, few resources devoted to monitoring or enforcement, and most seriously, little incentive to implement national and regional regulations.

So if China's regulations and institutions have not been effective, why has there been any progress? The paper presents descriptive evidence that successes in some sectors arise with the efforts of leaders to increase incomes (or alleviate poverty) and to control the rate of population growth. If the results are true, they have important implications for how leaders allocate scarce investment funds. Instead of investing in environmental clean-up efforts, it may be that increased attention to the nation's poverty alleviation agenda and its population control programs will have the most positive, albeit indirect, impact on the quality of the environment. Of course, in the longer run, if leaders are serious about their intention to maintain the rural environment, one of the best uses of their time and money may be to strengthen the legal basis for environmental control as well as to invest in the expansion of the national environmental protection agency or some other independent regulatory organization. But, since such an effort is likely to be expensive, in the meantime, hard choices on budget allocations remain.

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