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Driving Forces of Arable Land Conversion in China

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Abstract

This paper examines the major driving forces behind the conversion of arable land to non-agricultural uses in China during the reform years (1978-1995). Both graphic techniques, based on a Geographic Information System (GIS), and an econometric modeling approach are employed. It is found that industrialization and land losses due to land degradation have played an equally important role in reducing the gross quantity of arable land. The findings suggest that strengthening protection measures for arable land against natural hazards will significantly contribute to maintaining the gross scale of arable land. In order to save high-quality farmland it is necessary to increase the intensity of non-agricultural land uses through both economic incentives and administrative measures.

Key words:
farmland conversion, China, farmland protection, industrialization.

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I. INTRODUCTION

Increasing international attention is being focused on land-use and land-cover changes, due largely to competitive demands for the limited arable land available and the tension between the intensive use of land and the resultant human-induced environment impoverishment (Engelman and LeRoy 1995, Fischer, et al. 1996, Gardner 1996). Scholars place more emphasis on the losses of rainforests and wetlands than on other types of land conversion, because of the significant role these land-cover changes play in the carbon cycle of the earth system, ecological complexity and the conservation of bio-diversity. Another type of land-use change, however, may be more of a threat to the capability of the life support system in a quite direct way. This is the conversion of the limited arable land into other non-agricultural uses. In this regard there seems to be a shortage of formalized and quantitative analysis.

Among many factors that influence food production and supply -- including terms of trade for agriculture, government policies, patterns of land distribution, comparative profitability of agriculture -- the availability of arable land is the most crucial one (Engelman and LeRoy 1995, Sun 1997a, Chap. 4). Arable land is shrinking at a remarkable rate in many countries following the rapid expansion of population and non-agricultural industries as well as due to land degradation. This is especially evident in the case of China. China has experienced a dramatic loss of arable land during her post-reform economic booming period of 1978-1995. In particular, in the eastern part of China there has been an unprecedented conversion of arable land into non-agricultural uses following rapid industrialization.[1]

Food security in China is bound to have a significant global implication. There are controversial arguments about food demand and supply in China for the next 30 years (cf. e.g. Brown 1995, Chen et al. 1996, Huang and Rozelle 1995). But many researchers agree that arable land loss and land degradation are undermining China's food production capacity (Gardner 1996, Rozelle et al. 1997). Considering the fact that primary farmland is mainly located in those areas where the population and major

[1] In this paper, the eastern part of China is defined as the whole area excluding 9 less-developed provinces of Inner Mongolia, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. In these 9 provinces, both the arable land density and population density are relatively quite low, for which please refer to Figures 1 and 5.

economic activities have concentrated as well, the land converted into other uses consists mainly of high-quality primary farmland. In the past 40 years, China has made dramatic progress in food production. This has been the result of technology advances rather than expansion of arable land. Therefore, maintaining the primary farmland will be extremely important for China's future food security.

The Chinese government is anxious to ensure the success of its strategy for food self-reliance. In order to keep farmland losses under control, the central government issued an administrative decree in April 1997. The decree orders local governments to re-examine all the areas of former arable land which were occupied by non-agricultural uses during the period of 1991- 1995, and also to freeze the conversion of additional arable land into non-agricultural uses for one year (CEI, June 3, 1997). Usable land in general and arable land in particular has become a scarce basic resource, and is in high demand by the competing sectors of the economy. Any land-use policy is bound to have a significant impact on all industries, and consequently on the performance of the national economy. This perspective also generates a demand for an in-depth analysis of the causes of arable land conversion in order to design more robust land-use policies.

This research intends to uncover some major driving forces of arable land conversion in China during the reform years (1978-1995). In order to present the findings in an intuitive as well as quantitatively robust way, both graphical techniques based on a Geographic Information System (GIS) and an econometric modeling approach are employed. It is shown that both industrialization and land losses due to land degradation have played an equally important role in reducing the total acreage of arable land. The implications of the findings are twofold. First, it suggests that strengthening the capacities of arable land protection system against natural hazards will make a significant contribution to the maintenance of the gross scale of arable land. Second, for the purpose of saving the farmland with high quality it is important to increase the intensity and scale-efficiency of non-agricultural land uses through both economic and administrative measures. This includes measures that increase the comparative profitability of agriculture, initiatives that attract scattered township and village enterprises (TVEs) into big towns or cities, and policy efforts that promote the transformation of the traditional mode of rural residence into a more land-saving one.

The paper is organized as follows. In the next section we employ the overlay and other map techniques in a GIS, combined with an introductory analysis of national level data, to present an intuitive picture of the distribution and changes of arable land area in the post-reform period. Section 3 presents a pressure-response analysis of arable land conversion. It provides a foundation for the following econometric analysis. In Section 4, an econometric model is established based on the pooled data of the 21 major agricultural provinces in the eastern part of China and across the years of 1989-1995, Section 5 summarizes and discusses the policy implications of the research.

II. DISTRIBUTION AND CHANGES OF ARABLE LAND AREAS, 1978-1995

Although China has a total area of 960 million hectares (9.6 million km^2), which is the third largest in the world, only about 13-15 percent is cultivated, according to the recent estimates (Wu and Guo 1994, Sun et al. 1994). Among China's 1.2 billion population, about one billion is concentrated in less than one-third of the area of the country, where the average population density is higher than that of Belgium (Heilig 1997). The high concentration of population is essentially determined by the highly concentrated distribution of arable land. Figure 1 shows a remarkable and consistent overlap between the population density and farmland density. Figure 1 is generated by using the overlay and spatial data visualization techniques in a GIS and based on county level data, in which the grade shade represents population density and the undulating mesh indicates farmland density. The implication of such an overlap is straightforward: there is a significant positive spatial-correlation between the density distribution of arable land and that of population and between the density distribution of arable land and that of economic and social activities of the population.

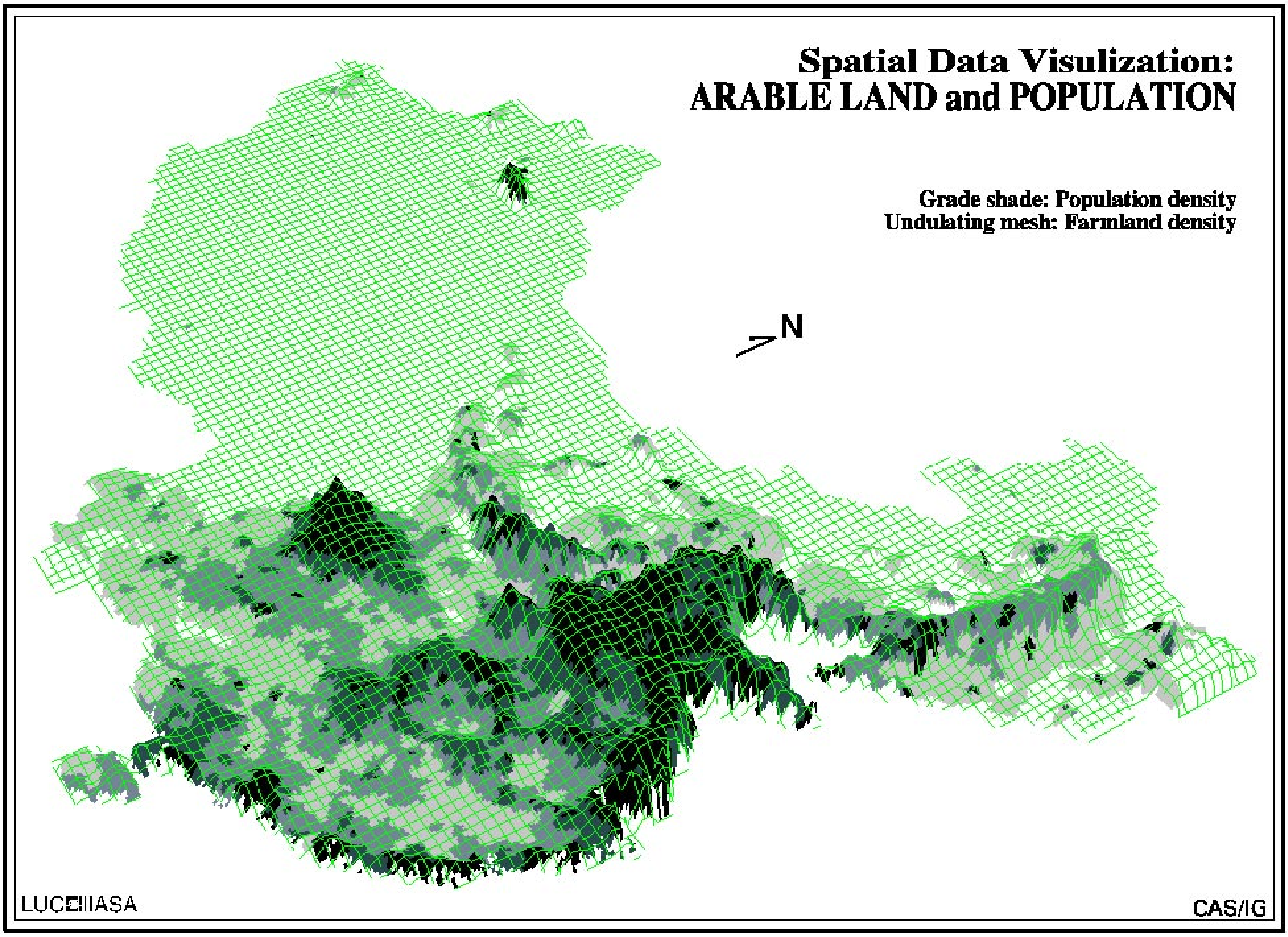

Figure 1. Overlap between Population Density and Farmland Density at County Level
Source: LUC-GIS database, International Institute for Applied Systems Analysis, Laxenburg, Austria and Institute of Geography, Chinese Academy of Sciences, Beijing, China.

It is generally believed that the official statistics of cultivated land significantly underreport the extent. One explanation given is that village authorities intend to reduce their tax base by the underreporting. The possible underreporting, however, does not seriously affect the analysis of this paper, because we focus on estimating the changes of arable land stocks, an indicator that seems has affected by the underreporting. Therefore, in the following analysis we will calculate the changes of arable land stocks based on Chinese official statistics. Another reason for using official statistics is in order to keep data consistency.

China did experience rapid farmland expansion for a short period between 1949 and 1957. According to official statistics, during this period, the cultivated land area increased from 97.9 million hectares to 111.5 million hectares. After the peak year of 1957, the trend of decreasing arable land has been continued. From 1957 to 1995, the net decrease in cultivated land was 16.55 million hectares. As a result, the amount of cultivated land in 1995 as reported by the official statistics was 95 million hectares,[2] about 3 million hectares below the level of 1949. If the farmland losses in the irrational Great Leap Forward period (1958-1959) are taken as an exception, we can see an accelerated decrease in cultivated land since 1980 as shown in Figure 2. During 1980-1995, the net decrease of cultivated land was about 4.4 million hectares (data sources: Xu and Peel 1991, p. 58, *Statistical Yearbook of China*, Yearbook, hereafter, 1996, p. 355).

Farmland reclamation has been emphasized in China's agricultural policy. However, the potential for reclamation seems quite limited and presents a decreasing trend in comparison with the wave of farmland conversion following business cycle in general and rural industrial booming in particular (Figure 3).[3] Another sharp contrast between farmland reclamation and farmland losses is manifested in the differences of their geographic locations. Figure 4 shows this contrast based on county level data for 1990-1993. Farmland losses mainly occurred in the southeastern part of the country, where irrigation conditions are good and the multi-cropping index is high. In other words, those lands that were lost were mainly high quality primary farmlands. In contrast, the reclamation mainly took place in the marginal zones located along the boundary between cropping and non-cropping areas.[4]

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[2] According to the estimates of the State Land Administration Bureau based on survey information, farmland amounts to 125 million hectares (13.2 percent of total land area) and horticultural plantations to 6 million hectares.

[3] Data source of Figure 3: Data base at the Institute of Geography, Chinese Academy of Sciences.

[4] Here, non-cropping area is defined at county level, where the cropping area accounts for less than 5 percent of the total land area of the county.

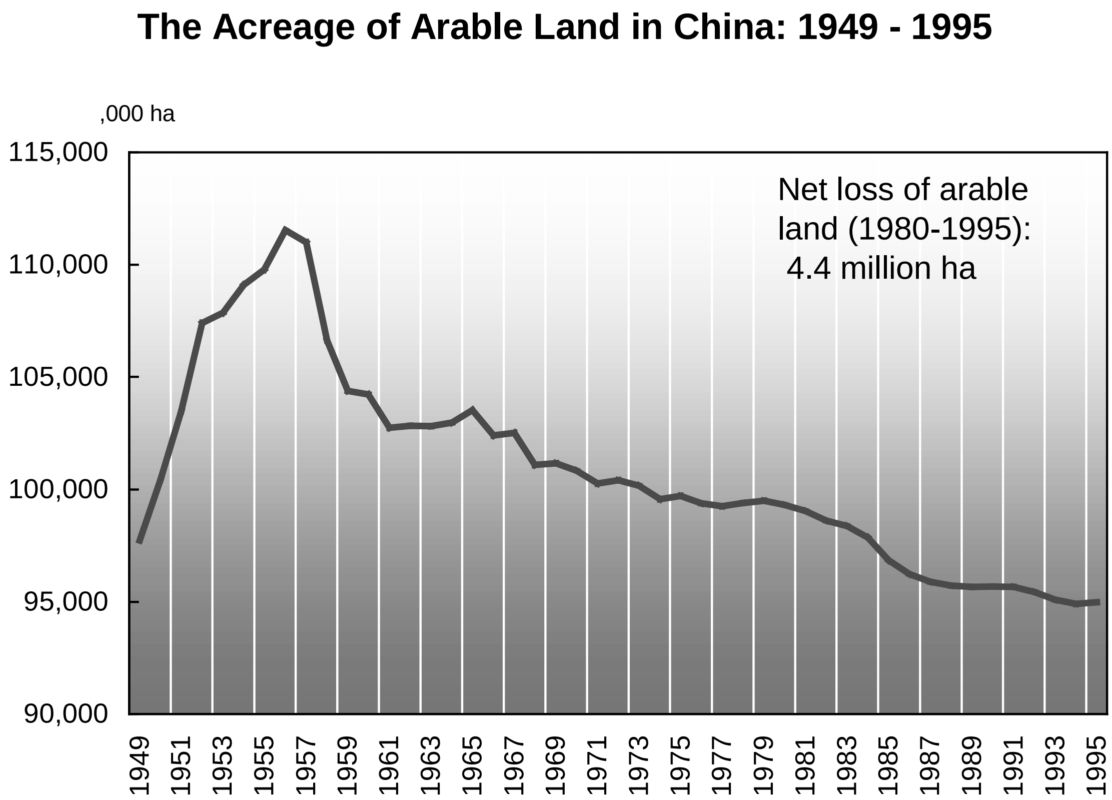


Figure 2. Acreage of Arable Land: 1949-1995
Source: The same as in Figure 1.

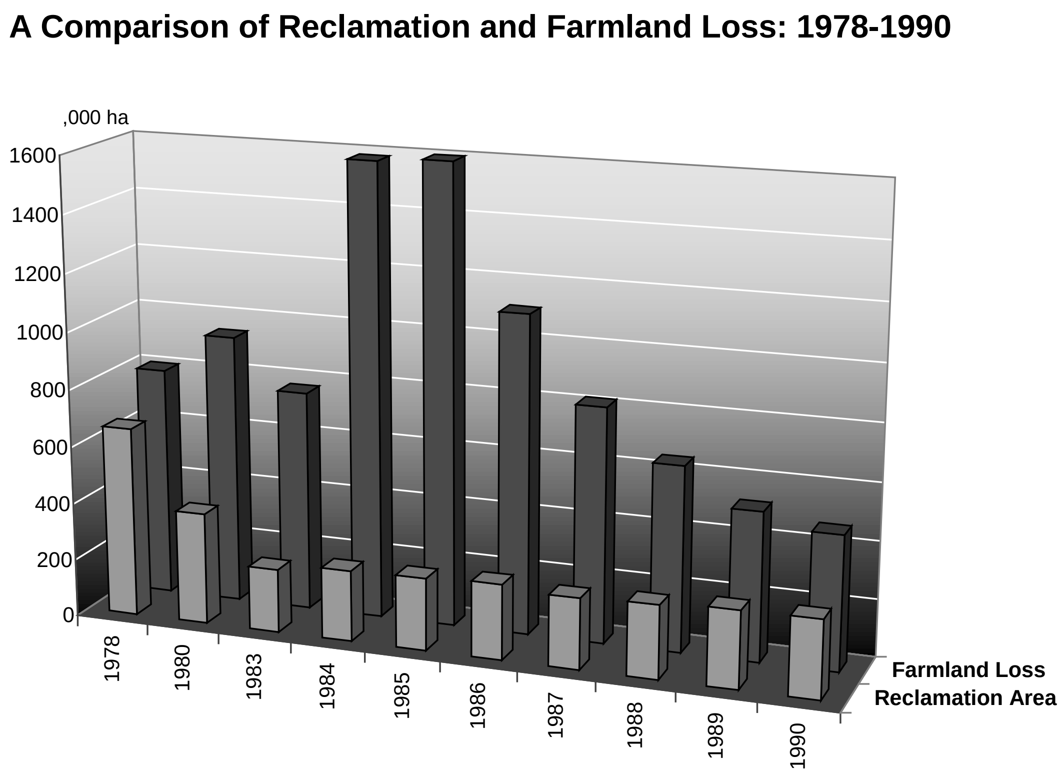


Figure 3. A Comparison of Reclamation and Farmland Loss: 1978-1990
Source: Data base at the Institute of Geography, Chinese Academy of Sciences, Beijing, China.

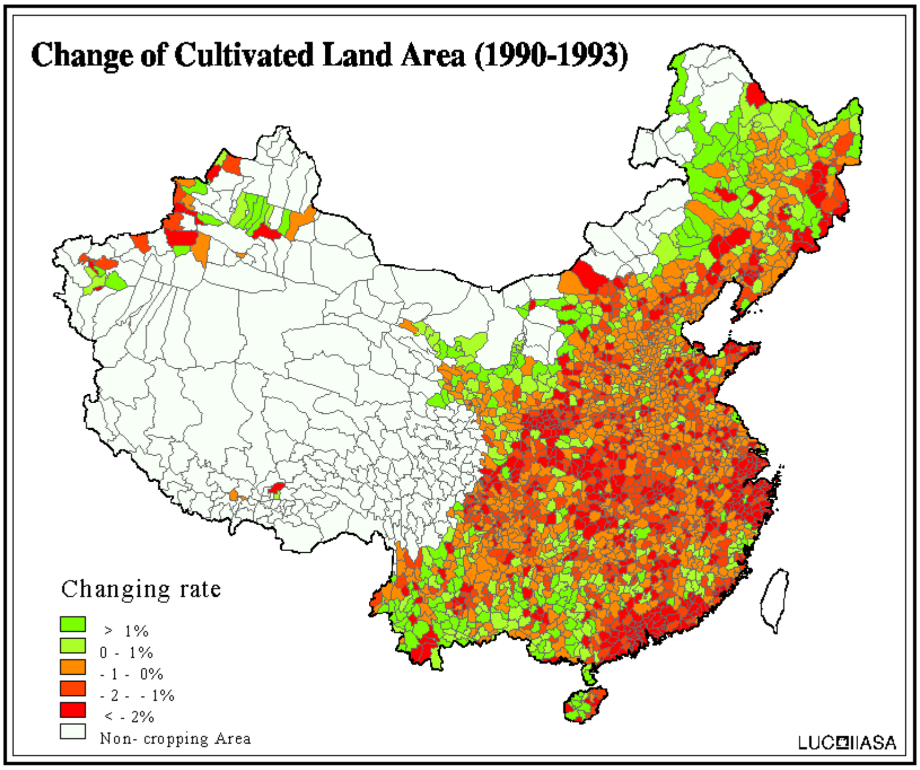


Figure 4. Percentage Change of Cultivated Land Areas at County Level: 1990-1993
Source: The same as in Figure 1.

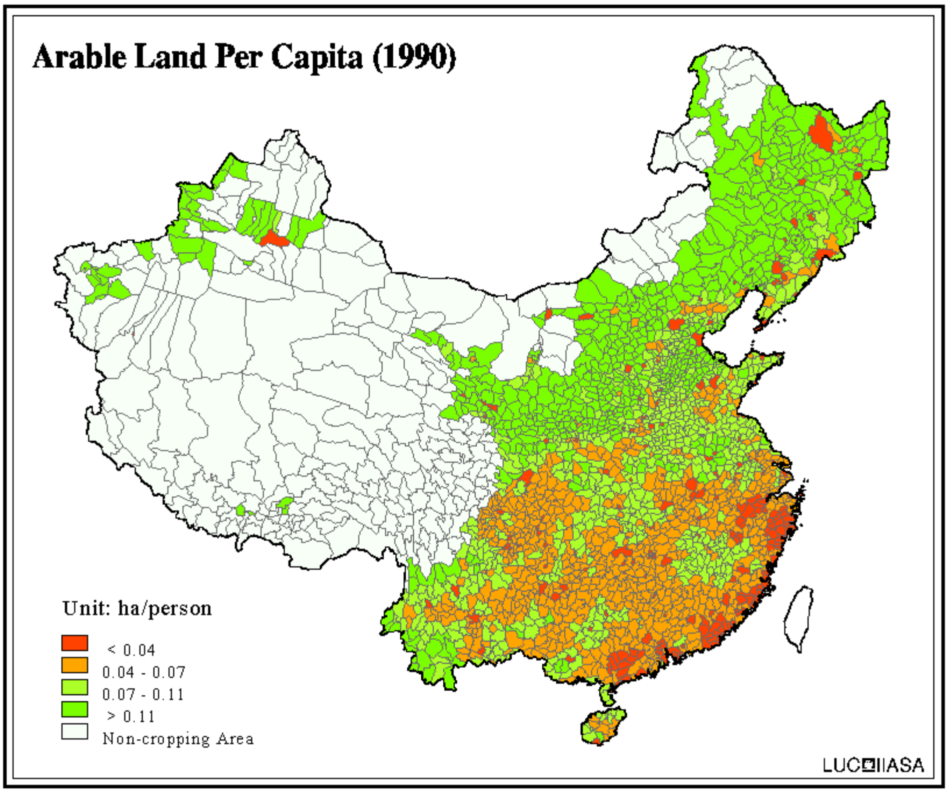


Figure 5. Arable Land Per Capita at County Level: 1990
Source: The same as in Figure 1.

Geographer Vaclav Smil suggests a rough benchmark of 0.07-hectares per person, as a critical level in the agricultural transition to dependence on intensive modern inputs, in other words, as a threshold of arable land scarcity (Engelman and LeRoy 1995, p. 24). If accepting this benchmark,[5] it can be found that a great majority of counties in the southeastern part of China are at the position well below the benchmark (Figure 5). China as a whole is very close to that level according to the statistics or perhaps a little bit above according to other estimates (Wu and Guo 1994; Sun et al. 1994), the benchmark position (Engelman and LeRoy 1995, pp. 24-25). This indicates that the agro-ecosystems must be exploited with increasing intensity. Much modern material input and agricultural technology have to be employed to make up for the losses of farmland. Such intensification may raise the risks of soil degradation, water pollution and scarcity, and other impairments. Thus farmland has become one of the scarcest strategic resources in China. In this view, the value of farmland is much greater than only the economic benefits it provides. Its importance is no less than that of energy reserves or a modern security and national defense system.

III. PRESURES ON ARABLE LAND CONVERSION

Three kinds of pressures on arable land conversion can be directly identified by a primary data analysis or even by casual observations. They are (i) industrialization, (ii) construction of residential buildings, and (iii) land degradation. Table 1 lists some key components for each group of driving forces, together with some instructive figures corresponding to each component. The first panel indicates the very impressive expansion of rural non-agricultural enterprises, with an average annual increase of 1.37 million firms. Although a great majority of them were household-based small-scale enterprises, 1.62 million of them in 1995 were township- and village-run (Yearbook 1996, p. 387). Among both township- and village-run enterprises (TVEs) and private-owned rural enterprises, many were large- or medium-scale. For instance, by the end of 1995, there were 5,824 large TVE corporations, each

[5] The threshold of 0.07 hectares per person is indeed very rough as land productivity and multi-cropping index vary widely between China's southern and northern provinces.

of which created an annual business income over 12 million US$ (CTVEs-Net, 4 Aug. 1997). Furthermore, over 96 percent of the output value of rural non-agricultural enterprises were produced in the eastern part of China (Note 1, Yearbook, 1996, p. 389). When the production scale goes beyond the household yards, all of the rural non-agricultural firms need land for their factory buildings and warehouses at least.

Table 1. Driving Forces of Farmland Conversion: Selected Indicators, 1980-1995

Factors	Unit	1980	1995	Annual increase
Industrialization				
Rural non-agricultural firms	number	1,520,000	22,030,000	1,370,000
State-owned industrial firms	number	83,400	118,000	2,307
Highways	km	883,300	1,157,000	18,246
Express highways	km	0 (1987)	3,250	300
Civil motor vehicles	number	1,780,000	10,400,000	574,667
Railways	km	49,900	54,600	313
New residential buildings				
Urban	m^2/year	92 million	375 million	
Rural	m^2/year	500 million	699 million	
Land degradation				
Wind erosion	km^2		1,6 10,000	2,460
Water erosion	km^2		205,000	
Soil contamination	km^2			
Salinization	km^2		233,000	

Sources: Panels 1 and 2: *Statistical Yearbook of China* (1984, English version, p. 193; 1991, p. 512; 1996, pp. 401, 388, 312, 502, 500). Panel 3: *ASSOD database*, International Soil Reference and Information Center, Wageningen, The Netherlands and International Institute for Applied System Analysis (IIASA), Laxenburg, Austria.

The development of highways was also very impressive, as manifested in the rapid increase of the number of civil motor vehicles, the extension of highways at an annual increment of 18,246 km, and the emergence of express highways. Most of them were developed in the eastern part as well. Although the development pace of state-owned enterprises (SOEs) and railway was less striking, their construction scales are usually very large in comparison with those of TVEs. Particularly, during the reform years, new SOEs were typically set up in the outskirts of large cities and in coastal areas, and new railways were built in the areas experiencing most rapid economic growth so as to reduce the bottlenecks in transportation.

The expansion of residential buildings is not only driven by population growth and urbanization, but also by income-induced improvements of housing standards and residential environments. As a consequence, while the pace of rural new residential buildings increased moderately from 500 million m^2/year in 1980 to 699 million m^2/year in 1995, the rate in urban areas rose dramatically from 92 million m^2/year in 1980 to 375 million m^2/year in 1995. One may argue that the residential buildings in urban areas are typically two or more stories, leading to less land occupation per unit of buildings. In this respect, there is no doubt that land use in urban areas is generally more intensive and efficient than in rural areas. However, there is an important fact which should not be overlooked, namely that each unit of urban residential buildings requires also land for various service facilities such as roads, parks, parking places, shops, schools, etc.

Land degradation in China has been a hot topic among agronomists, geographers, economists, and other scholars (cf. e.g. Smil 1984, 1993, He 1991, Qu 1989, Ross 1988, Rozelle et al. 1995, World Bank 1992). The major types of farmland degradation are soil erosion, salinization, soil nutrient depletion and contamination, and deforestation in areas surrounding arable land or in the upper-reaches of the major rivers. As a consequence of some combination of these factors, the extents of farmland stocks that are prone to natural hazards have increased, and the farmland areas being abandoned due to fertility losses or due to the emergence of severe limiting to farming after natural hazards have increased as well. Figure 6 presents an overall assessment of soil degradation in China. It can be seen that except for some extremely severe degradation taking place within and around desert areas, the major agricultural provinces in the eastern part of the country suffer from land degradation of varying degrees from light to very severe.

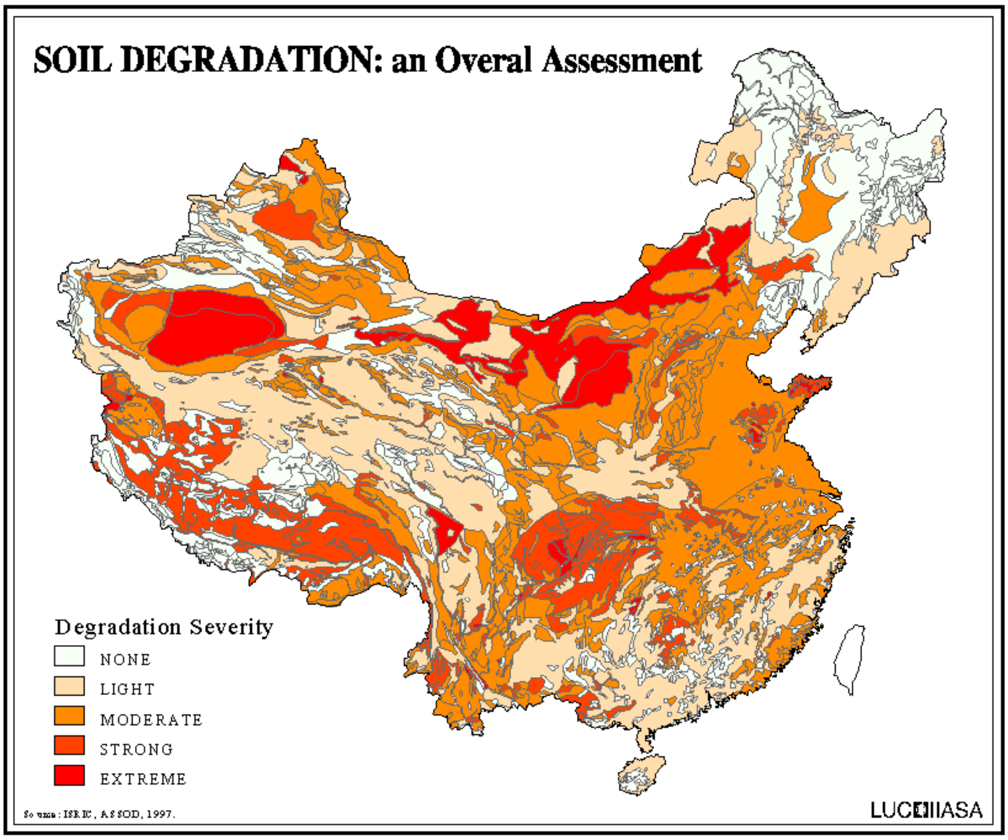


Figure 6. An Overall Assessment of Soil Degradation in China
Source: *ASSOD database*, International Soil Reference and Information Center, Wageningen, The Netherlands and International Institute for Applied System Analysis (IIASA), Laxenburg, Austria.

The principal type of land degradation varies as well among the major agricultural regions. For example, in the Huang-Huai-Hai (Rivers) Plain, located in northern Jiangsu, eastern Anhui, and southern Shandong, soil erosion is not a problem, but salinization is still severe. In the southwest part of China, the opposite is true. While the salinity problem is minimal, the erosion of soil surfaces has been the most serious threat to agriculture (Ministry of Agriculture 1991).

While soil erosion may directly reduce soil fertility, many agricultural experts and officials in China believe that the most serious impact of soil erosion is its harmful effect on irrigation systems (World Bank 1992). It is reported that in some areas the irrigation systems were destroyed or completely silted up by erosion (Liu 1991). Salinization is typically associated with a locally high water table or poorly constructed irrigation systems. The total area officially classified as saline-stressed land increased during the period of 1980-1995. It is worth mentioning that salinization of farmland can cause a significant drop in land productivity long before land is officially classified as "salinized" (Mei 1992). This implies that salinization is increasingly becoming a serious threat to farmland in important agricultural regions such as the North China Plain and the Huang-Huai-Hai (Rivers) Plain, though the official figures on salinized land are certainly not of the same magnitude as those on eroded land.

A common consequence of these land degradation factors is an increase of flood- and drought-prone land areas and a certain amount of abandoned farmland caused by natural disasters. While fluctuating year by year, the areas classified as "easily flooded and drought-damaged" in the official statistics show a significant upward time trend, and rose to about 50 million hectares during the period of 1990-1995 from about 35 million hectares in the early 1980s (Yearbook 1991, p. 372; 1996, p.385). We do not have concrete statistical figures on the amount of farmland areas abandoned after natural disasters. However, it is evident that there is a significant correlation between the "flooded and drought-damaged area" and the "abandoned areas because of natural disasters" with or without time lags.

IV. MODELLING ARABLE LAND CONVERSION BASED ON PROVINCIAL LEVEL DATA

The model aims to establish the quantitative relationship between converted/abandoned farmland (as the dependent variable) and those explanatory factors analyzed in the previous section. There is no direct way to build up the relationship, mainly because the number of observations for the factors listed in Table 1 at national level is too small to make any meaningful regression-analysis, and the corresponding data at provincial level are mostly not available. However, the official statistical data of net farmland losses, which are dominated by areas converted into other uses or abandoned in the present year (cf. Figures 2 and 3), are available at provincial level for years after 1988. We have a subset for the period 1990-1995.[6]

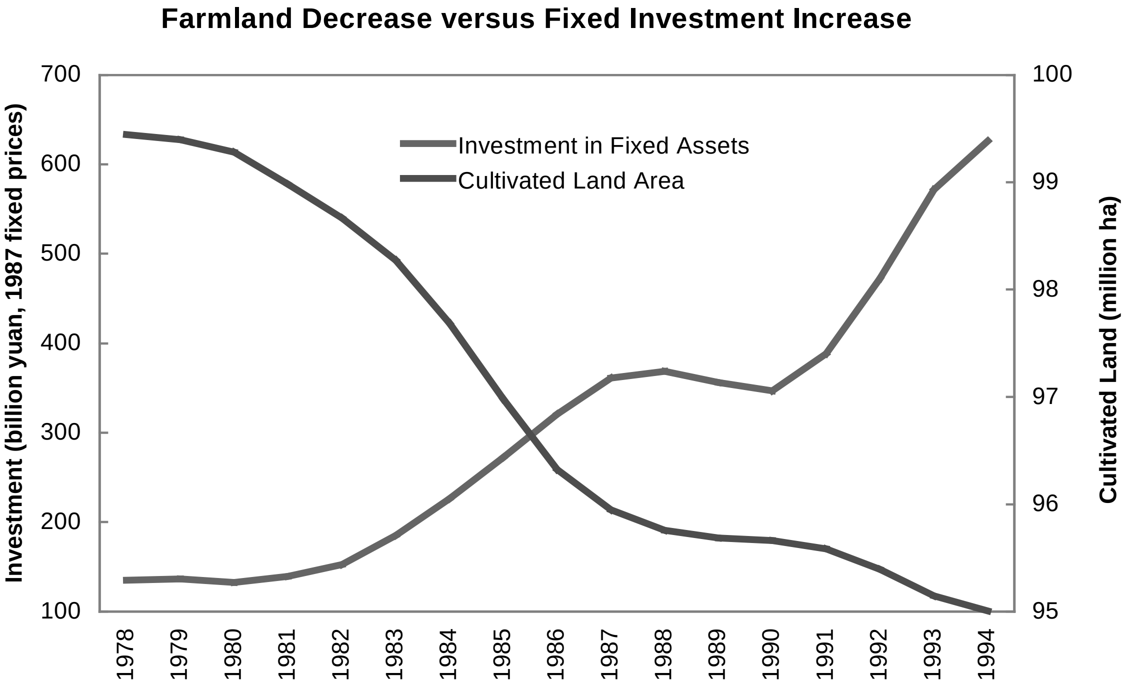
[6] In the case that the relevant data for 1988 and 1989 are also obtained, the estimate period of our model can be directly extended to cover 1988-1995.

Based on this understanding, we are going to look for most appropriate and practical proxies for each factor listed in Table 1 and at provincial level.

1. Total Investment in Fixed Assets at Constant Prices.

It is the most suitable proxy of the state-sector development, urbanization, and construction scale of residential buildings. During the 1980s over 70 percent of fixed investment went to the state sector and the urban collective sector, and during 1990-1995 over 60 percent of fixed investment went to these two urban sectors. For the rest, about half had been used for rural residential buildings (Yearbook, 1984, pp. 299-302; 1986, pp. 365-369; 1989, pp. 404-406; 1991-1996, Tables 5.1-5.2).

The correlation between the decrease in farmland stock and the increase in total fixed investment can be directly observed from national level data. Figure 7 shows the correlation, in which the annual fluctuations were filtered out by taking a three-year moving average. It can be seen from Figure 7 that the accelerated growth of fixed investment (i.e. 1981-1988 and 1991-1995) is accompanied by an accelerated decrease of farmland stocks, and that a slowdown of investment growth (i.e. 1978-1981 and 1988-1990) is followed by a slowdown of farmland decrease. It also needs to be emphasized that there may be a time lag between the payment of land purchase (fixed investment) and the real farmland conversion. In fact a one-year time lag exists between them for a lot of large projects. This lag is also empirically confirmed by our modeling estimates.



Note: The curves were drawn with the three-year moving average values.

Figure 7. Farmland Decrease versus Fixed Investment Increase: 1978-1994
Source: See Data Appendix.

By 1995, TVEs produced about 25 percent of GDP and generated nearly half the national total industrial value-added, profit, and output values. However, the TVE share in the fixed investment was less than 15 percent (*Selections of 1995 National Industrial Census*, in *People's Daily* 19 Feb. 1997; CEI 4 July 1997; Yearbook 1996, pp. 139-141). One of the main reasons for TVEs being able to maintain such a surprisingly low share of fixed investment is that TVEs can use land at a very low cost or even without payment (Chen 1993, Saith 1995). This fact indicates that the total fixed investment at constant prices is not a suitable proxy for representing TVE development and we should look for some other proxy variable.

2. Annual Increment of the Number of Non-Agricultural Employees.

A vast transfer of labor force from the agricultural sector to other sectors took place during the reform years. The proportion of agricultural labor force in the total decreased from 70.5 percent in 1978 to 60 percent in 1990 and 52.9 percent in 1995.

Since 1991, the absolute number of agricultural laborers has continuously decreased as well. From 1991 to 1995, the net decrease of agricultural labor force was 18.6 million, despite a 34.7 million net increase of total labor force. This implies that the non-agricultural sector absorbed about 53.3 million laborers within the 5 years. Among these 53.3 million laborers, 20.8 million (39 percent) were employed by the urban sector, which mainly includes the state sector, the urban collective sector, the urban private sector. The others (32.5 million) were employed by the rural non-agricultural sector, primarily by TVEs (Yearbook 1996, pp. 88, 90-91).

The contribution of TVEs to China's economic growth is characterized not only by their remarkable growth of both output and output share, but also by their excellent capacity to create employment (Sun 1997b). From 1978 to 1995, TVEs created new employment positions for 100 million people. In 1993, the TVE sector started to exceed the state sector in terms of both employment generation and industrial production. It provided employment to 123 million people and produced 44.5 percent of total industrial output, with a fixed investment share of less than 15 percent in the national total. In the same year the state sector employed 109 million people and yielded 43 percent of total industrial output, with a fixed investment share of over 61 percent in the national total (Yearbook 1994, pp. 362-363, 375, 139-141).

One of the major hidden costs behind the TVE miracle of capital-saving and labor-intensive development is a great amount of farmland occupation. Because TVE development has been so closely tied to local initiatives and local conditions, rural industrialization has not yet been accompanied by urbanization, and the distribution of TVEs throughout the country has been scattered and uneven. As a result, land use in the TVE sector is far from intensive and lacks the scale-efficiency. Environmental pollution may go unchecked in certain localities as well (Chen 1993, pp. 207-215; Sun 1997b).

The analyses above indicate that there is a close correlation between TVE labor-intensive development and their scattered occupation of farmland. This justifies that for the purpose of this paper the "annual increment of the number of non-agricultural employees" might be the best proxy for the development of TVEs and other non-state sectors with high labor intensity.

3. Farmland Areas Affected by Natural Disasters.

Each year a certain amount of farmland is abandoned following the natural disasters that occurred in the current or previous year. Abandonment of farmland can be at first sight attributed to natural disasters. However, it is in fact often the accumulated result of land degradation. As analyzed in the previous section, because of various types of land degradation, a certain amount of farmland becomes "easily flooded and drought-damaged" almost every year. After experiencing some natural disasters, a part of this "easily flooded and drought-damaged" farmland becomes non-cultivatable and has to be abandoned. Since the data on abandoned farmland are not available, it is reasonable to use "farmland areas affected by natural disasters" as a proxy for farmland losses due to land degradation.

After all suitable proxies were justified, we directly exercised linear regression based on annual and provincial observations and introducing some lag structures for fixed investment and areas affected by natural disasters. The regression was rejected by mis-specification tests such as the residual normality test (Jarque-Bera statistic) and the residual heteroscedasticity test (White 1980). In addition to the residual heteroscedasticity and non-normality, undetected residual auto-correlation for same province in different years may also be present. To address these problems, we process the data as follows. We take two-year sums of farmland losses (FarmLD2), incremental non-agricultural employees (NAgrLab2), and areas affected by natural disasters (AHazard2) for years of 1990 and 1991, 1992 and 1993, 1994 and 1995, and take three-year sums of total fixed investment at 1987 prices (FInv3) for years of 1989-1991, 1991-1993, and 1993-1995.

The results obtained by linear regression indicate that such a grouping of data successfully removes extreme outliers appearing in certain years and in certain provinces, thus contributing to reducing heteroscedasticity. As there are now only three time periods considered in the derived data set, the temporal residual auto-correlation for some provinces becomes unimportant. Normality of residuals is achieved by applying the natural logarithm-transformation to FarmLD2. The parameter estimates and the results of the statistical tests of the linear regression are presented in Table 2.

Table 2 shows that there is statistically no difference between the usual standard errors and HCSEs. This suggests that there is no significant heteroscedasticity in our estimates. Jarque-Bera's normality χ^2 statistic indicates that the residual normality cannot be rejected. Together these guarantee that our estimates are unbiased, consistent, and efficient. Each estimated coefficient has the expected sign, t-probability indicates that each of them is significantly different from zero, and F-test shows that all estimated coefficients are jointly different from zero. The goodness of fit measured by R^2 and σ is also highly significant.

Table 2. Estimates of Farmland Conversion Equation in China, 1989-1995

Dependent variable: log(FarmLD2); sample size: 63. [a]

Explanatory variable	Coefficient	Elasticity at mean	Standard error	HCSE [b]	t-probability	Partial R^2
Constant	1.999		0.180	0.219	0.0000	
Finv3	0.000588	0.357	0.000221	0.000168	0.0098	0.108
NagrLab2	0.000293	0.308	0.000117	0.000103	0.0149	0.096
Ahazard2	0.000343	0.644	0.000074	0.000088	0.0000	0.268

R^2 = 0.568; F(3, 59) = 25.887 [F-prob. = 0.0000]; σ = 0.649;
Normality χ^2 (2) = 2.175 [χ^2 prob. = 0.337].

Notes: [a] The sample consists of the observations of all dependent and explanatory variables at time points 1990-1991, 1992-1993, and 1994-1995 (for Finv3, 1989-1991, 1991-1993, and 1993-1995) for 21 provinces of the eastern part of China (cf. Note 1).

[b] HCSE represents the "heteroscadasticity consistent standard errors". Large differences between the usual standard errors and HCSEs are indicative of the present of heteroscedasticity, in which case HCSEs provide consistent estimates of the regression coefficients' standard errors, there the name (White, 1980).

Data Sources: See Data Appendix.

To assess the proportional change of farmland loss when the driving forces vary, elasticities of farmland loss with respect to the explanatory variables at means are calculated and reported in Table 2 as well. The sum of elasticities of farmland loss with respect to fixed investment and increase of non-agricultural employees is 0.665, almost the same as the elasticity with respect to areas affected by natural disasters, 0.644. This suggests that industrialization processes and land losses induced by natural disasters played an equally important role in reducing the total acreage of farmland. This conclusion is also supported by the partial R^2 figures. The sum of partial R^2 for fixed investment and increment of non-agricultural employees is 0.204, quite close to that for areas affected by natural disasters, 0.268. The relatively quite large magnitude of the first two elasticities may also imply inefficient occupation and uses of farmland by the non-agricultural sector.

V. SUMMARY AND CONCLUSIONS

China has experienced a net loss of arable land since 1958. During the reform period, i.e. after 1978, there appeared to be an accelerated decrease of farmland stock. This paper examines the major driving forces of arable land conversion during the reform years and assesses the proportional changes of farmland conversion with respect to these driving forces. The major causes are identified as industrialization, construction of residential buildings, and land degradation. We establish a well-specified econometric model of farmland losses and construct the appropriate proxies of these driving forces based on pooled data from 21 provinces of the eastern part of China and across the period of 1990-1995. The model shows that both industrialization/urbanization and land losses induced by land degradation have played an equally important role in reducing the total acreage of cultivated land.

With a population of more than 1.2 billion and despite of very limited farmland resources, China has successfully supplied enough food for its growing and increasingly wealthy population. This accomplishment has been achieved primarily by increasing the intensity of land use in China’s fragile agro-ecosystems and the level of modern material inputs in order to make up for farmland losses. This may enhance the risks of soil degradation, water pollution and scarcity, and other environmental impairments. Farmland has become a scarce strategic resource in China. Its strategic importance would be greatly undervalued if one only takes into account the short-run or medium-run economic benefits obtained from it.

The study shows that the proportional decrease of farmland with respect to the increases of fixed investment, to the increase of non-agricultural employees, and to the areas affected by natural disasters is relatively quite high. In order to maintain the current level of farmland acreage, it is necessary and important to reduce the magnitude of these elasticities by various economic, legal, and administrative means. First, strengthening the capacity of farmland-protection-system against land degradation and natural disasters will certainly reduce the elasticity of farmland loss with respect to natural disasters. This means that marginal land should be restored to earlier, less intensive uses through reforestation and pasture restoration. Erosion-prone areas should be stabilized by means of terracing, contouring, tree planting, and other protection methods. Areas prone to salinization should be properly treated or put to fallow for a sufficient period. Irrigation and drainage infrastructures should be restored, maintained, and renovated in time. All of these measures require larger investments. However, they complementary to economic development and will lead to a higher productivity of land and an improving environment for agriculture in the long run.

Second, in parallel with the improvement of the land protection system, a quantitatively equally but qualitatively more important measure for saving the strategic farmland is to intensify non-agricultural land uses. In most cases non-agricultural industries occupy high-quality farmland around major cities or other economic and transportation centers. For the purpose of saving high-quality farmland, which is more than just reducing the elasticity of farmland loss with respect to industrialization pressures, it is important to increase the intensity of land uses in urban areas and in rural towns. It is crucial to develop a number of central towns by investing in infrastructure construction and service sectors so as to attract the scattered TVEs into these central towns. It is also absolutely necessary to transform the traditional mode of rural housing into a more land-saving one by various incentives and regulations. Such measures would be strengthened by both economic and administrative means that aim to increase the comparative profitability of agriculture.

As China is just in the take-off stage of industrialization, arable land losses to non-agricultural uses cannot be avoided in the next decades, although the proportional decrease of farmland with respect to the industrialization factors may be reduced. In view of the unavoidable farmland losses, apart from the choice to increase productivity per unit of farmland by technical progress and by increasing modern material inputs, a complementary measure would be to gradually increase the share of net grain import in total domestic grain supply. In 1995, China's net import of cereals of 18.7 million tons accounted for about 4 percent of domestic cereal supply and for about 9 percent of world imports of cereals. China's cereal imports were dominated by wheat and maize, which made up more than 80 percent of the total (Yearbook 1996, pp. 371, 589-592; *Food Outlook*, no. 3/4, 1997, p. 31). If China would gradually increase its share of cereal net import to 8 or 10 percent of the domestic supply, the tension between agricultural and non-agricultural land uses could be substantially reduced. In this case, China's share in world cereal imports would rise to 15-20 percent, slightly more than Japan's current share (14 percent). This would only moderately increase the pressure to the international cereal market.

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Data Appendix

1. Farmland areas by province: Yearbook, 1991-1993, Table 9.3; 1994 and 1995, Table 11-3; 1996, Table 11-5.
2. Fixed investment at current prices by province: Yearbook, 1991-1993, Table 5.3; 1994, Table 5-3; 1995-1996, Table 5-2.
3. Deflator of fixed investment: Because the investment deflator and GDP deflator at provincial level are available only for 1991-1995, and because National Income deflator at provincial level was not available after 1993, we decided to use the GDP deflator at the national level as a proxy for fixed investment deflator at provincial level to keep data consistency. GDP deflators are generated based on GDP at current prices and GDP Index at constant prices (Yearbook, 1996, p. 42).
4. Number of employees in the non-agricultural sector by province: Yearbook, 1991-1993, Table 4.7; 1994-1996, Table 4-3.
5. Farmland areas affected by natural disasters in each province: Yearbook, 1991-1993, Table 9.50; 1994-1995, Table 11-26; 1996, Table 11-27.