Invited Paper

Cultivated Land Changes in China: The Impacts of Urbanization and Industrialization

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ABSTRACT

Debates have persisted on the precise nature and consequence of urbanization on cultivated land in China. The primary goal of this paper is to provide empirical-based evidence on the impacts of urbanization and industrialization on cultivated land. Based on cultivate land data estimated from Landsat Thematic Mapper/Enhanced Thematic Mapper digital images for 1987, 1995 and 2000 and a unique set of county-level socio-economic data, an econometric model on cultivated land change is empirically estimated. The results produce findings that are both expected and those that are fairly surprising. Because of offsetting effects of land expansion in China's northeast and northwest regions, overall there was a small net increase in cultivated land between 1987 and 2000. Although cultivated area decline between 1995 and 2000, the net decline was about 1.2% only. Industrialization and population growth were largely responsible for the fall in 1995-2000. Moreover, contrary to the conventional opinion, after holding constant the effect of industrialization and population growth, regardless of whether urban area expansion occurs in large, medium or small cities or towns, such urbanization is land-saving when compared to leaving rural residents in rural areas. Two of major implications of our analysis are: 1) although the loss of cultivated land imposes a cost on the nation, it appears to be associated with those processes that will lead to the ultimate modernization of China; 2) the nation's policies of town and small city development are not necessarily inefficient in terms of their impact on cultivated land use.

Keywords: Cultivated land, urbanization, industrialization, China

1. INTRODUCTION

China's gross domestic product (GDP) growth has been remarkable and the nation's path toward industrialization has been accelerating since economic reforms initiated in the late 1970s. GDP grew at annual rate of nearly 9% throughout the entire reform period. The nation's real GDP was 6.37 times higher in 2000 than it was in 1980 (Table 1) and by 2004 it was about 9 times greater than it was in 1980 [1,2]. Indeed the rapid pace of growth has made China one of the fastest growth rates of any country in the world during the 1980s and 1990s [3].

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The rapid growth has been accompanied by sharp structural changes in the economy. The highest profile shift has been the rapid progress in industrialization. In the past 25 years, the average growth rate of agricultural production was about 2 to 3 times higher than that of population growth, which resulted in substantial improvement in China food security [4]. Over the same period, however, industrial and service sectors grew even faster, exceeding those of the overall economy. As the growth rates of agriculture have been less than those of the overall economy, China's economy is in the midst of the process of industrialization (and a shift to a service-oriented economy). Agriculture accounted for more than 30 percent of GDP prior to 1980. By 2000 the share of agriculture had fallen to 16% (Table 1) and less than 15% by 2004 [1,2].

As industrialization has progressed, China has also begun to urbanize. Despite observations by a number of scholars that believe that China's urbanization has been limited by its strict *hukou* policy [5,6], in fact, the urban sector has expanded rapidly. The share of the urban population nearly doubled between 1980 and 2000—in part from those registered as urban residents and in part by the unregistered population (Table 1). The number of registered urban residents increased sharply from 152 millions in 1980 to 246 millions in 1990, and 331 million in 2000 (Table 1). During this time the number of unregistered residents also grew and, as their number rose, the gap between the overall urban population share (19% in 1980; 36% in 2000) and registered urban population shares (15% in 1980; 26% in 2000) has grown. Hence, it is clear from the population figures that although the *hukou* policy still is affecting demographic patterns the level of rural to urban migration is becoming increasingly less restricted by policy barriers. Recent policies that are promoting the development of towns and small cities (*xiaochengzhen fazhan*) also have affected and continue to affect the pace of urbanization. According projections by the United Nations [7], more than half of China's population be reside in urban area by 2020.

While transformation of the economy from agriculture to industry and from rural to urban is essential for a country in the process of modernization [8], international experience has shown that rapid economic growth, industrialization and urbanization are often accompanied by large shifts of land from agriculture to industry, infrastructure and residential use[9]. In recent years, as the pace of growth has accelerated in China, the nation's leaders have started to become concerned about the expansion of urban areas and its impact on national food security [10]. There has been enough concern that officials have implemented a number of policies that impose strict limitations on the use of cultivated land for urban expansion [11].

While the data show that there is a strong effect of economic growth on the expansion of urban area, which will necessarily affect the area of cultivated land [12,13], debates persist on the precise nature and consequence of urbanization on cultivated land. Some claim that by promoting the expansion of newly opened cultivated area China has been successful in preventing the fall of its cultivated land during the past two decades [14]. In fact, according to Landsat-based GIS land use data China increased cultivated land by nearly 2% (an increase of 2.65 million hectares) between 1987 and 2000. On the other hand, other scholars claim that huge blocks of cultivated land have been lost to urbanization and it is affecting the nation's ability to produce enough food for itself [10]. Among various factors, the expansion of larger cities has been blamed as one of the primary sources of loss of cultivated area [15]. In part in response to the perception that large cities have been responsible for the loss of much of China's cultivated area over the past two decades, scholars have called for the promotion of alternative land use planning approaches. Some have called for the promotion of small cities and towns [16]; other suggests (either implicitly or explicitly) that the pace of urbanization be slowed and policies that keep farmers in

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rural areas are welcome [17].

Surprisingly, despite the critical and complex nature of the multiple factors that are affecting China's cultivated area, few papers have sought to empirically address the effect of urbanization on cultivated land use. Because, urbanization, industrialization and population growth trends are expected to continue into the future, recent debates on the impacts of urbanization on cultivated land changes may be confusing those policy makers charged with urban development planning. Especially as issues of the degree of and driving forces behind cultivated land change have moved to the top of the national policy making agenda, there is a greater need than ever to create a solid empirical base for decision making.

The overall goal of this paper is to provide empirical-based evidence that will help answer several key questions on the relationship between urbanization and cultivated land use. Specifically, in this paper we will seek to address a number of questions: During the reform era, how much cultivated land has been shifted for non-agricultural use? Of the cultivated area that has been lost, how much has been due to urbanization and industrialization? While most agree that there is causal relationship between cultivated land reduction and economic growth, there are little empirical studies that quantify the effect of different scales of urbanization on the cultivated land changes. Other factors held constant, does the development of large-scale cities require more cultivated land than small city and town development? Since those left in rural areas also tend to use land for non-agricultural uses—e.g., for building houses and for pursuit of non-agricultural uses—will slowing down the rate of shift of the population from rural to urban areas decelerate the loss of cultivated land? Answers to the above questions are critical for China to be able to formulate appropriate policies that can ensure both high growths of economy and urbanization and protection of cultivated land in the coming decades.

In order to achieve these objectives, an econometric model on cultivated land change is developed and is empirically estimated based on Landsat TM/ETM digital images. We use land use information for 1987, 1995 and 2000. In addition, we combine the land use information with a unique set of county-level, socio-economic data that have been assembled by the authors. Such a data set allows us to explain variations in land use across space and over time.

The results of our study produce findings that are both expected and those that are fairly surprising. First, as found in Deng et al. [18], because of offsetting effects of land expansion in China's northeast and northwest regions (and in other areas scattered around the country), overall there was a small net increase in cultivated land between 1987 and 2000, although between 1995 and 2000, cultivated area began to decline. While the overall direction of change in cultivated area may be unexpected, when focusing on the parts of the economy in which cultivated land did fall, we found that industrialization and population growth were largely responsible. Perhaps the most surprising result, however, is the effect of the pattern of growth on cultivated land area, since the pattern of growth may be something policy makers could control—as opposed to a less desirable approach focused on outright limiting the rate of growth of the economy. According to our findings, contrary to the conventional opinion that the expansion of large cities have been the primary source of decline of cultivated land area, when holding all other factors constant we find that in fact, the most cultivated land-using pattern of development occurs when rural resident stay on the farm. Although we do not identify the exact mechanism, our econometric results show that, after holding constant the effect of industrialization and population growth, regardless of whether urban area expansion occurs in large, medium or small cities or towns, such urbanization is land-saving when compared to leaving rural residents in rural areas.

The rest of the paper is organized as the follows. The next section briefly introduces the methodology and data used in this study. Section three reviews the changes in cultivated land and urban area expansion in China. The main analytical results are presented in the fourth section. The final section concludes and discusses the policy implications for the future management of China's cultivated land.

2. METHODOLOGY AND DATA

2.1 Econometric Models of Cultivated Land Changes

There are a number of other studies that have tried to examine the change of cultivated land and its determinants in China [15,19]. The studies that are based on cross section data often find geographic and natural physical conditions are important factors in explaining differences in cultivated land across space inside China [20,21]. Time series analyses normally show industrialization and urbanization are main driving forces for temporal fall of cultivated land [22]. Our study is interested in simultaneously explaining both spatial and intertemporal variations. Hence, the following cultivated land area (Land) function is specified:

(1) $Land_{it} = f\,(BUA_{i(t-5)}, U_{ki(t-5)}, AGDP_{i(t-1)}, NAGDP_{i(t-1)}, RPop_{i(t-5)}, RUPop_{(t-5)}, Land_{i1987}, Slope_i, DistPort_i, DistPorv_i)$

where BUA_{it} is total built-up area in the i^{th} county (or city) in time t (1995 or 2000); $U_{ki(t-5)}$ is area share of the k^{th} type of BUA, which reflect the degree of urbanization.[1] The subscript, t-5 (t-1), means that the variable used in the model is lagged by five (one) years. The model also contains two measures of GDP in order to hold constant the rate of growth of the economy, which should be expected to affect Land. The variable, *RGDP*, is included to measure the agricultural GDP; *NAGDP* measures the non-agricultural GDP (both industry and service). The model also includes measures of the rural population (*RPop*) and officially registered urban population (*RUPop*). While we fully understand that there are many more people living in urban China than represented by RUPop, we include it as a variable that represents China's *hukou* policy.

Beside economic variables, equation (1) also includes several geo-physical variables to control for the impacts of certain non-time varying factors. Specifically, we use cultivated land in 1987 ($Land_{i1987}$) to control for the scale of each county's or city's cultivated land in the beginning period of the study. We also use average level of land slope (*Slope*), the distance to the nearest port city (*DistPort*) and the distance to the provincial capital (*DistProv*) to reflect local land conditions and other locational factors.

Because time and temporally fixed geo-physical factors are often closely associated with economic variables, empirical estimation of equation (1) could be problematic. Hence, in our empirical works, we adopt two approaches in estimating equation (1):

[1] The creation of the degree of urbanization variables are described in the next section.

(2) $Land_{it} = f(D_{2000}, Land_{i1987}, Slope_i, DistPort_i, DistPorv_i)$

(3) $Land_{it} = f(Urb_{i(t-5)}, U_{ki(t-5)}, AGDP_{i(t-1)}, NAGDP_{i(t-1)}, RPop_{i(t-5)}, RUPop_{(t-5)}, CDummy_{ij})$

Equation (2) is designed to measure the impacts of time and temporally fixed geo-physical factors on the distribution of cultivated land across space. This is formulated by replacing all time variable factors (e.g., GDP and population) in equation (1) with a year dummy variable (D_{2000} =1 for the year 2000 and 0 for the year 1995). Equation (2) can be estimated by OLS. Equation (3) is a fixed effect model that includes a county-specific dummy indicator variable for each county or city in the sample (that is, we add 1465 county/city dummy variables in equation 3). In this model, all spatial fixed variables are eliminated since they are captured by the dummy variables, which account for all non-time varying fixed effects. In this way, equation (3) can be used to focus more closely on the effect of time-varying economic factors on cultivated land.

2.2 Estimating Cultivated Land by County

One of the strengths of our study is the quality of data that we use to estimate cultivated land. Satellite remote sensing digital images for our purposes are the most suitable data for detecting and monitoring Land Use Change at global and regional scales [23]. There are a number of choices. Satellite sensors, such as Landsat TM, and the French SPOT system, have been used successfully for measuring deforestation, biomass burning and other land cover changes, including the expansion and contraction of deserts [24]. Remote sensing techniques also have been used widely to monitor the conversion of agricultural land to infrastructure [25,26,27].

In our study we use a land use dataset developed by the Chinese Academy of Sciences (CAS). Based on Landsat TM scenes with a spatial resolution of 30 by 30 meters, our study's data are from satellite remote sensing data derived from the US Landsat TM/ETM images [28]. The database includes three time periods: a.) the late 1980s, including Landsat TM scenes from 1986 to 1989 (henceforth, referred to as 1987 data for simplification purposes); b.) the mid-1990s, including Landsat TM scenes from 1995 and 1996 (henceforth, 1995); and c.) the late 1990s, including Landsat TM scenes were used from 1999 and 2000 (henceforth, 2000). For each time period more than 500 TM scenes to cover the entire country.

The Landsat TM images also are geo-referenced and ortho-rectified. To do so, the data team of CAS used ground control points that were collected during fieldwork as well as high-resolution digital elevation models. Visual interpretation and digitization of TM images at the scale of 1:100,000 were made to generate thematic maps of land cover [21]. A hierarchical classification system of 25 land-cover classes was applied to the data. In this study the 25 classes of land cover were grouped further into six aggregated classes of land cover – cultivated land, forestry area, grassland, water area, built-up area and unused land.

The interpretation of TM images and land-cover classifications were validated against extensive field surveys [28]. The interpretation team from CAS conducted ground truth checks for more than 75,000 kilometers of transects across China. During the ground truthing more than 8,000 photos were taken using cameras equipped with global position system

(GPS). The average interpretative accuracy for land cover classification is 92.9% for 1986, 98.4% for 1995 and 97.5% for 2000. GIS technologies were used to aggregate data to the county levels.

2.3 Urbanization and Other Variables

In order to understand how different patterns of urbanization affect cultivated area changes, we created a set of variables to identify different sizes of cities. We classified the built-up areas into five scales. In the first scale category—which is not true urbanization, we included all the built-up area that appeared in patches less than one square kilometer. In fact, these patches mostly are associated with areas that have been built-up in rural villages. In the second category we included all of the patches that were greater than one square kilometer but less than five square kilometers. The other three scale categories span ranges from 5 to 25 square kilometers, 25 to 50 square kilometers and above 50 square kilometers. Since built-up area that makes up each scale category can exist in each county, we create a set of share variables for each county by dividing the sum of the area within each scale category (which is within each county) by the total built-up area (which is the within-county sum of the area accounted for by the built-up area in the five scale categories). With scale categories so defined we can make a series of assumptions that allow us to identify changes of built-up area that are attributable to rural areas (that is the change in the built-up areas that are in patches of less than one kilometer square) and the changes in built-up are that are due to different forms of urbanization, that is, changes in built-up areas in large townships and towns (henceforth, Urban Scale 1); small- and medium-sized cities (Urban Scale 2); large cities (Urban Scale 3); and mega-cities (Urban Scale 4).[2]

In addition, we tapped several other data sets to generate variables that measure the geo-physical and socio-economic attributes of each county. The average slope of a county is generated from China's digital elevation model data set. The distance of each county (county seat) to the provincial capital and nearest port city were created using data from the Chinese Academy of Science data center, which originally used data from the national mapping bureau. All these data were spatially referenced into the county level using geographic information systems (GIS) geo-coding methods.

Socio-economic variables, unlike the GIS-based data, did not require aggregation from sub-county levels. The GDP data for each county for 1994 and 1999 come from provincial statistical yearbooks [1] and the Socio-economic Statistical Yearbooks for China's Counties [29]. The annual demographic data between 1980 and 2000 are from the population yearbooks at county level which are organized by the Ministry of Public Security of China [30]. The means and other summary statistics for the variables included in the model are in Appendix Table 1.

2.4 Creating the Sample

Because of differences in the jurisdictional areas in China's administrative regions over time, considerable effort was put

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[2] Creating our definition of city sizes required several steps. First, using a comprehensive list of patches of built up area, we created a histogram of patch sizes. From the histogram, we noted the natural break points in the data were near 1, 5, 25 and 50 square kilometers. We then compared these empirically-created categories to the physical size of known rural villages, townships/towns and cities (using data from the China Urban Statistical Yearbook, 2001). As it turns out, in a large majority of the cases, large towns and townships were between 1 and 5 square kilometers; many small and medium-sized cities fell between 5 and 25 square kilometers; many large cities fell between 25 and 50 square kilometers; and mega-cities were all above 50 square kilometers. Hence, although our scale categories are fully based on a criterion based on the size of the built-up patches, there is a high degree of correlation with administratively set town and city sizes (which mostly are based on populations).

into creating a usable data set of county level land use and socio-economic variables over time.[3] In 1987, China had 2156 administrative units at the county level. In 2000, because of the expansion of city-level districts and other new administrative regions, in 2000 the number of county-level administrative units expanded to 2733 [1]. The shifting organization of county-level administrative units is problematic for our study since our data need to be organized into consistent units. In order to overcome this problem, we chose to use the geo-coding system of the National Fundamental Geographic Information System (NFGIS) [31] and a 1995 administrative map of China, which included the most up-to-date county-level borders [31]. Using these tools, if two counties had been subject to border shifts (e.g., one county ceded jurisdictional rights to another), we had no choice but to combine them into a single unit for the entire sample period. In many cases in which the city-core of a county had been removed from the jurisdiction of the original county-level government, we also had to aggregate the municipal administrative zone with the county-proper. In the case of large metropolitan areas (specifically, China's four provincial-level municipalities—Beijing, Tianjin, Shanghai and Chongqing; provincial capitals; and other large cities), multiple city districts were combined into a single, sample period-consistent observational unit. In the end, we ended up with a sample that includes 1465 observational units at the county-level that are consistent in size and jurisdictional coverage over time.

3. URBANIZATION AND CULTIVATED LAND CHANGES

Surprisingly, even after the advent of reform in the early 1980s when many of the factors that should be expected to reduce China's cultivated land, China's cultivated land was rising (Table 2, row 1). According to our data, between 1987 and 2000 in 2348 of China's counties, the total amount of cultivated land rose by 1.92 percent (column 3). Although in most counties (1557) during this period, cultivated land fell (on average by 1.24 percent), in 791 counties there was enough increase (7.68 percent) to lead to a net increase in cultivated land (rows 2 and 3, columns 1 and 3).

The increase in cultivated area, however, did not extend throughout the entire post reform period. Focusing on the 5 year period between 1995 and 2000, we find that cultivated area began to fall (by 2.74 percent, Table 2, last column). The reduction was led by an increase in the counties in which there was a reduction in cultivated land (1925) and an acceleration in the fall in cultivated area in the counties that experienced reductions (a reduction of 3.88 percent between 1995 and 2000). Between 1995 and 2000, there were only 423 counties in which cultivated land increased (and the rate of increase fell to only 1.13 percent). Although our sample counties registered somewhat slower growth between 1987 and 2000—as well as a somewhat lower level of reduction between 1995 and 2000), the patterns of cultivated land change in our sample counties closely mirror those of China, in general. In other words, regardless of whether we use the sample for all of China or for our sub-sample of counties, we see that between 1987 and 1995, on average, cultivated area was rising; after 1995 the trend reversed and cultivated land, on average, began to fall.
According to our data, it is clear that at least one reason why cultivated land began to fall in the late 1990s (or did not increase even more during the late 1980s and 1990s) was due to the rise in built-up area (Table 3). Between 1987 and 2000, the number of patches (rows 1 and 2) and the total area (rows 5 and 6) of built-up area rose for all categories. For example, between 1987 and 2000 the number of patches of built-up area in rural areas rose from 594783 to 595001 and the

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[3] We also dropped counties, such as those in Taiwan, Hong Kong and Macao due to inherent differences across space in the nature of land use and other data. A number of counties (approximately 883), typically those that were in extremely rural, inland areas, were dropped because of lack of GDP and other data in the late 1980s and early 1990s.

size of the built-up area increased by about 1500 kilometers square—from 88564 to 90968 kilometers square (column 1). The average size of the built-up area patch changed only a little bit (it was 0.149 in 1987 and 0.152 kilometer squares in 2000). During the same period, the number of patches and size of the built-up area in China's mega-cities also both increased (column 5). Although the number of patches only increased by 37 (from 81 to 118), since the patches were much larger and growing marginally (rising from 119 kilometers square in 1987 to 123 kilometers square in 2000), the built-up area in mega-cities actually rose much higher than built-up area in rural areas, rising by nearly 5000 kilometers square (from 9650 to 14512). The more rapid rise in the built-up area of mega-cities (as well as other cities—columns 2 to 4) relative to rural areas means that the share of built-up area in rural areas of China has fallen (from 72 to 66.4 percent) and risen elsewhere (rows 7 and 8).

4. RESULTS

In order to understand more precisely the determinants of the change of cultivated land and isolate the importance of level and pattern of urbanization on the loss of cultivated land, we can use our data to estimate the models in equations (2) and (3). Equation (2) is used to examine the importance of cross section differences in geo-physical factors, holding all time varying factors constant (by the inclusion of a year dummy variable). Equation (3) holds all non-time varying factors constant (by the inclusion of a set of county-level fixed effects), and attempts to isolate the effects of industrialization, demographic shifts and urbanization (and changes in built-up area in rural areas). In order to minimize problems of simultaneity, the GDP, population and urbanization variables are all lagged.

The importance of geo-physical variables can be seen from the results of the estimation of equation 2 (Table 4, columns 1 and 2). By holding the size of a county's cultivated land area constant (which is accomplished by the inclusion of a lagged dependent variable) and all time varying factors, the results show that the topography of an area (slope) and its geographical location (distance to provincial capital and distance to port) both matter. The signs on the coefficients are as expected. The positive sign on the slope variable suggests that cultivated land is greater in areas that are more mountainous (it is costlier and there is less demand to convert cultivated land to other uses). The positive signs on both of the location variable suggest the same; the more remote a county is from the coast (or its provincial capital), the greater the amount of cultivated land. Interestingly, the coefficient on the time dummy is negative (and highly significant), suggesting that there are many time-varying factors that are operating jointly to reduce the level of cultivated land. Unfortunately, due to their aggregated nature in equation 2, there is no way disentangle the effects.

In order to better understand the factors that are combining to reduce cultivated land over time, we use the fixed effects model and replace the time dummy with a set of socio-economic variables (Table 4, columns 3 and 4). The results show us the importance of socio-economic factors in the determination of cultivated land. According to the findings, as expected, the growth of agriculture (row 6) and industrialization (the rise of GDP in industrial and service sectors) both lead to a fall in cultivated area (row 7). In addition, the rise in population, both the rural population (row 8) and the official urban population (row 9) both put pressure of cultivate land (as seen through the negative and significant coefficient). Clearly, according to our findings, growth, industrialization and population, the factors that would be expected to contribute to falling cultivated land due to their inherent rise in demand for land as an input into the process underlying their own expansion, are in part responsible for the fall in cultivated land in the late 1990s.

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Unlike the effect of these other socio-economic factors, the pattern of urbanization and expansion of built-up area are somewhat unexpected (Table 4, rows 1 to 5). The change in the overall level of built-up area, of course (by definition), negatively affects the amount of cultivated area (row 1). However, surprisingly, when compared to the effect of increases in built-up area in rural areas (the base category variable that was not explicitly included), all of the other types of urban either save land (large towns; small and medium cities; large cities—rows 2 to 4) or use similar quantities of cultivated land (mega-cities—row 5). While somewhat counter intuitive, frequent visitors to rural areas can understand the basis of findings; in almost any rural area that one visits there is always a considerable building going on—either for housing or for the expansion of small rural enterprises. Although not as apparent—perhaps due to their dispersed nature—as the huge housing projects that are going on in the suburbs of China mega-cities (as well as many other urban areas), our results suggest that policies that intentionally (or unintentionally) keep villagers in rural area actually will end up costing more in cultivated land than policies that encourage urbanization. There are obviously strong economies of scale in the conversion of cultivated land into built up areas in urban areas that are, all other things constant, leading to inefficient use of land when farmers use land in rural areas for housing and other economic activities.

5. DECOMPOSITION RESULTS AND CONCLUDING REMARKS

The decomposition results, however, show that regardless of the pace of urbanization (and the expansion of built-up area in rural areas—row 1) or its pattern (Table 5—rows 2 to 5), other socio-economic variables are more important in determining the magnitude of the change in cultivated land. According to our findings, the rise in overall built-up area (row 1), GDP growth (rows 6 and 7) and changes in the rural and urban registered population (rows 8 and 9—which were all shown to negatively affect cultivated area in Table 4), account for 210 percent (27+24+52+20+87) of the actual change (a fall of 1.21 percent) in cultivated land between 1995 and 2000. In other words, had it not been for other factors, cultivated land between 1995 and 2000 would have fallen by 2.53 percent (2.10 * 1.21). However, in part, because the growth occurred in cities, instead of in rural areas, the decomposition analysis suggests that the loss of cultivated area was 47 percent lower (9+12+7+19 or the sum of the coefficients on the Urban Land Type Category variables—rows 2 to 5).

From this point of view, our analysis has several policy implications. First, at least between 1995 and 2000, all of the change in cultivated land can be explained by economic factors—industrialization and population growth. From one point of view, although the loss of cultivated land imposes a cost on the nation, it appears to be associated with those processes that will lead to the ultimate modernization of China. More specifically, the results also suggest that in an economy like China in which GDP and population are both growing, urbanization is land saving. Moreover, at least during the late 1990s, large towns, small and medium cities and large cities all have almost the same marginal effect on cultivated land. Hence, the nation's policies of town and small city development are not necessarily inefficient in terms of their impact on cultivated land use.

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Table 1. The trends of GDP, population and urbanization in China, 1980 to 2000.

	1980	1985	1990	1995	2000
GDP index (1980=100)	100	166	243	428	637
GDP shares (%)					
Agriculture	30	28	27	20	16
Industry and service	70	72	73	80	84
Population (million)	987	1059	1143	1211	1266
Rural (%)	81	76	74	71	64
Urban (%)	19	24	26	29	36
Registered urban population					
Total residents (million)	152	201	236	284	331
Share in urban population (%)	79	80	78	82	72
Share in total population (%)	15	19	21	23	26

Sources: Data are from NBSC (various years).

Table 2. Cultivated land changes in China's counties, 1987 to 2000.

	Number of Counties		Area changes in percentage (%)	
	1987-2000	1995-2000	1987-2000	1995-2000
Whole China				
Total	2348	2348	1.92	-2.74
County/city with declining cultivated land	1557	1925	-1.24	-3.88
County/city with increasing cultivated land	791	423	7.68	1.13
Sample counties in this study				
Total	1465	1465	1.31	-1.22
County/city with declining cultivated land	1042	1231	-1.16	-2.04
County/city with increasing cultivated land	423	234	6.64	0.82

Sources: Data are computed by authors using remote sensing data.

.Table 3. Urbanization measured by built-up area in sampled counties and cities in China, 1987-2000

	Rural "villages"[a]	Urban Districts[a]					Total
		Scale 1	Scale 2	Scale 3	Scale 4	Sub-total	
Numbers of patches							
1987	594783	7308	812	116	81	8317	603100
2000	595001	8840	1036	153	118	10147	605148
Average size (km^2)							
1987	0.149	1.7	10.3	34.3	119.1	4.1	0.20
2000	0.152	1.7	10.8	35.2	123.0	4.5	0.23
Total areas (km^2)							
1987	88564	12415	8388	3979	9650	34433	122996
2000	90968	15033	11139	5387	14512	46072	137039
Area share (%)							
1987	72.0	10.1	6.8	3.2	7.9	28.0	100
2000	66.4	11.0	8.1	3.9	10.6	33.6	100

[a] Rural "villages" and scales of urbanization are defined in Appendix Table 1. 1465 counties are included each year.

Table 4. Ordinary Least Squares (OLS) and fixed effects estimates of cultivated land by county in China, 1995 to 2000.

	Ln (Cultivated land), hectares			
	(1) OLS		(2) Fixed effect model[a]	
	Parameters	Std error	Parameters	Std error
Built-up Area $_{t-5}$ [b]			-0.078*	0.044
Urban Scale 1 $_{t-5}$ (large towns)			0.323***	0.121
Urban Scale 2 $_{t-5}$			0.281**	0.119
Urban Scale 3 $_{t-5}$			0.311**	0.141
Urban Scale 4 $_{t-5}$ (mega-city)			0.216	0.152
Ln (Agricultural GDP) $_{t-1}$			-0.013**	0.006
Ln (Non-agri GDP) $_{t-1}$			-0.015***	0.005
Ln (Agri population) $_{t-5}$			-0.110***	0.024
Ln (Registered urban pop) $_{t-5}$			-0.052**	0.011
Ln (Cultivated land)$_{1985}$	1.010***	0.002		
Year dummy (2000=1)	-0.027***	0.003		
Ln (Slope)	0.003***	0.001		
Ln (Distance to port)	0.010***	0.001		
Ln (Distance to Prov. capital)	0.028***	0.002		
Constant	-0.277***	0.022	13.219***	0.357

Notes: *, **, and *** indicate that the coefficients are statistically significant at 10%, 5% and 1% levels. Total observations equal 2930. [a] Model (2) includes 1465 county dummy variables to hold constant all non-time varying fixed effects. [b] Built-up area includes Rural Villages and all Urban (Urban scales 1 to 4). Rural Villages are excluded category in the regression.

Variables	Estimated parameter [a] [1]	Change or percentage change [2]	Impact on cultivated land [3]=[1]x[2]	Contribution (%) [4]=[3]/(-1.21)
Urbanization/Built-up area shifts				
Total built-up area (lag 5yrs)	-0.078	4.25	-0.33	27
Built-up area share, rural "villages"				
Urban Scale 1 share (towns)	0.323	0.34	0.11	-9
Urban Scale 2 share	0.281	0.51	0.14	-12
Urban Scale 3 share	0.311	0.27	0.08	-7
Urban Scale 4 share (mega cities)	0.216*	1.07	0.23	-19
Agricultural GDP	-0.014	21.25	-0.29	24
Non-agri GDP	-0.015	41.92	-0.63	52
Agri population (lagged)	-0.110	2.21	-0.24	20
Registered urban resident (lagged)	-0.052	20.34	-1.05	87
Residual			0.77	-63
Cultivated land change (%)		-1.21		100

Table 5. Decomposition of cultivated land changes in China between 1995 and 2000.

[a] Parameters in column [1] are from Table 4 (column 3).

Notes: The symbol, *, denotes that the coefficient on which the decomposition is based is statistically insignificant.

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Appendix 1. Simple means and standard derivations of all variables

Variables	Unit	1995		2000	
		Sample mean	Standard deviation	Sample mean	Standard deviation
Cultivated land (t)	Hectare	67883	55982	67052	57115
Cultivated land (1987)	Hectare	66183	52583	66183	52583
Built-up area (t-5)	Km^2	86.20	95.56	89.87	99.57
Rural "village" share[a]	Ratio	0.704	0.205	0.687	0.205
Urban scale 1 share[a]	Ratio	0.172	0.156	0.176	0.157
Urban scale 2 share[a]	Ratio	0.070	0.111	0.078	0.114
Urban scale 3 share[a]	Ratio	0.024	0.094	0.026	0.094
Urban scale 4 share[a]	Ratio	0.030	0.125	0.034	0.134
Agricultural GDP	Million *yuan*	717	731	856	797
Non-agri GDP	Million *yuan*	2555	9147	4161	13676
Agri population (t-5)	Person	456699	295272	463292	297489
Registered urban resident (t-5)	Person	123005	369899	148132	401628
Slope	Degree	2	2	2	2
Distance to nearest ports	Km	467	342	467	342
Distance to province capital	Km	164	96	164	96
Samples		1465		1465	

Note: Means reported in this table are averages of sample used in this study.

[a] Rural "villages" are those built-up areas from patches less than 1 km^2. Urban districts are those built-up areas from patches more than 1 km^2. Scales of urbanization are defined as: Scale 1: individual patch area between 1-5 km^2 (equivalent to large township); Scale 2: individual patch area between 5-25 km^2 (equivalent to small/middle cities); Scale 3: individual patch area between 25-50 km^2 (equivalent to large cities); Scale 4: individual patch area greater than 50 km^2 (equivalent to super large cities). Numbers of counties and cities included in the samples are 1465 each year.