Working Paper

Anthropogenic Driving Forces of Land-Use Change in China

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WP-96-011
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Introduction

There are few places in the world where *people* have changed the land so intensely and for such a long time as in China. Much of the country's *habitated* land had been transformed by human intervention already several hundred years ago. The Loess Plateau of northern China, for instance, was completely deforested in pre-industrial times (Fang / Xie, 1994).[1] During the early Han Dynasty, in the fourth and third century BC, the Chinese started *systematic* land reclamation and irrigation schemes, converting large areas of natural land into rice paddies. The process, which was scientifically planned and coordinated by subsequent dynastic bureaucracies, reached a first climax in the eleventh and twelfth century.[2] In the second half of the 18th and first half of the 19th century another period of massive land modification followed.

1. Background

1.2 Some Land-Cover / Land-Use Data

Currently, China has a total land area of about 9.6 million km^2. Some 15% is cultivated, about 20% is forest and woodland, and grassland covers some 35%. More than 22% of China's land area is covered by glaciers and permanent snow, sandy or stony desert (Gobi), and other marginal lands. In other words, far less than 80% of China's land is habitable. Cities, towns, industrial sites, rural settlements and infrastructure cover some 3.4% of the land area (and 4.3% of the habitable land) (see Table 1).

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[1] Fang, J.W. / Xie, Z. (1994): Deforestation in pre-industrial China: The Loess Plateau as an example. In: Chemosphere, Vol. 29, 983-999

[2] Braudel, F. (1990): Sozialgeschichte des 15.-18. Jahrhunderts. Der Alltag. München (Kindler Verlag), p. 159 (Original Edition: Civilisation matérielle, économie et capitalisme, XV.XVIII siécle. Les structures du quotidien: Le Possible et l'impossible.)

Table 1: Land Cover / Land Use in China

No:		Area (in million km2)	Area (in % of Total Land Area)	Area (in % of "Usable" Land)	Area (in % of Cultivated Land)
1	**Total Land Area**	**9.600**	**100.0%**		
2	Cultivated Land	1.364	14.2%		100.0%
3	Horticulture	0.074	0.8%		
4	Forests / Woodland	1.954	20.4%		
5	Grassland	3.386	35.3%		
6	***"Agricultural" Land (Total: 2 - 5)***	***6.778***	***70.6%***		
7	Cities / Towns / Industry	0.019	0.2%	0.2%	1.4%
8	Rural Settlements	0.235	2.4%	3.2%	17.2%
9	Infrastructure	0.071	0.7%	0.9%	5.2%
10	***Non-Agricult. Land (Total: 7- 9)***	***0.324***	***3.4%***	***4.3%***	***23.8%***
11	Inland Water Bodies / Fish Ponds	0.325	3.4%		
12	Beaches	0.022	0.2%		
13	***(Total: 11 - 12)***	***0.347***	***3.6%***		
14	Glacier / Snow	0.069	0.7%		
15	Sandy Desert	0.467	4.9%		
16	Stone / Rock Desert (Gobi)	0.304	3.2%		
17	Other (marginal) Land / Mountains	1.312	13.7%		
18	***(Total: 14 - 17)***	***2.151***	***22.4%***		
19	**"Usable" Land (1 minus 18)**	**7.449**		**100.0%**	

Source: Wu Chuangjun / Guo Huangcheng (1994): Land Use in China. Beijing, Science Press (in Chinese), p. 91

According to a recently published book by Wu Chuangjun and Guo Huangcheng the largest change of land during the past four decades occurred in forestry land: since 1949 it was *extended* by more than 700,000 km^2 (see Table 2). This information is somewhat surprising since most other sources have indicated a *decline* of China's forest and woodland (see also my comments at the end of the chapter). On the other hand, most experts agree that China's marginal land ("other land") and grassland declined. Wu Chuangjun and Guo Huangcheng estimated the decline at almost 600,000 km^2 and more than 500,000 km^2, respectively (see Table 2).

The next largest change in human land-use was the expansion of settlement areas, mining sites and transportation infrastructure. According to Wu Chuangjun and Guo Huangcheng these areas increased by about 260,000 km^2 between 1949 and 1990 (see Table 2). Urban and industry-related land-use change is a major process in China. It is far more widespread than, for instance, the changes in the size of cultivated land which only slightly declined by less than 22 square kilometers. This minor decline is also offset by the significant expansion of horticulture. They were extended by 63 km^2 -- which is three times the size of the decline in cultivated land. Wu Chuangjun's and Guo Huangcheng's data also indicate a significant expansion of water bodies for ponds by 115 square kilometers (see Table 2).

By far the largest *proportional* change of land use in China was the expansion of horticulture; since 1949 it increased by almost 600%. This tremendous increase is mostly due to the small absolute size of the horticulture area in 1949. The area for settlements, mining and transportation increased by almost 390%. This was far more than the 56% increase of forest and woodland or the 51% expansion of inland water bodies (mainly ponds). The cultivated land area declined by about

2% and the grassland shrank by some 14%. Other, mostly marginal, land declined by about 19%.

Table 2: China's Land use Change 1949 - 1990 (in 1000 km^2)

	1949	1990	Change	Change (in %)
Forest & Woodland	1,250	1,954	704	56.3
Settlemens, Mining & Transportation	67	328	261	387.1
Water Bodies	225	341	115	51.2
Horticulture	11	74	63	593.8
Cultivated (Crop) Land	979	957	-22	-2.2
Grass Land	3,919	3,386	-533	-13.6
Other (marginal) Land	3,149	2,561	-588	-18.7
Total Area	**9,600**	**9,600**		

Source: Wu Chuangjun / Guo Huangcheng (1994): Land Use in China. Beijing, Science Press (in Chinese), p. 77

If Wu Chuangjun's and Guo Huangcheng's data are correct than we have to accept that urbanization and industrialization are the major driving forces of land-use change in China. Today, settlements, mining sites and infrastructures not only cover an area which is already about *one third* the size of China's cultivated land (see Table 1), but they are also one of the most rapidly expanding types of land-use (see Table 2).

The Central Statistical Office has also published some more recent land-use data by province. These data indicate a decline of cultivated areas in *all* Chinese provinces in 1993 -- most notably in Shanghai, Guangdong and Zhejiang (see Table 3). For instance, there was a steep 5.3% annual decline of cultivated land in Shanghai and a 4.3% decline in Guangdong. In 1993 the *annual* decline of cultivated land in Guangdong, Xinjiang, and Shaanxi was approximately the same size as the *total* cultivated area of Tibet.

Unfortunately, these statistical data on land-use change in China have several problems. While they are the best we currently could find, their validity is questionable and their level of detail is insufficient. They are highly aggregated on the national or province level and mainly focus on *agricultural* land-use. More specifically we have the following problems:

- There are *gross inconsistencies* between land-use statistics from various sources. In their recent book Wu Chuangjun and Guo Huangcheng published estimates for "cultivated land" which range from 1.364 (page 91) to 0.957 (page 77) million km^2. China's Statistical Yearbook of 1994 reports a cultivated area of 0.951 million km^2 for 1993 (page 329). In its AGROSTAT data base the FAO has estimated China's "arable land & permanent crops" at 0.966 million square kilometers in 1991. The "arable land" alone was estimated to be only 0.933 million km^2. Most experts believe that China has *more* than these 0.96 million km^2 under cultivation, but hard data are not available.
- Land-use statistics in China (as in many other parts of the world) are *heavily biased* towards the *agricultural* sector. While we can easily find most detailed statistical information on the *cultivated* areas by province in China's Statistical Yearbook (such as detailed crop area information reproduced in Table A1 in

Table 3: Recent Trends: Annual Change of Cultivated Area by Province, 1993

	Cultivated Area (in 1000 Ha)		Change (in 1000 Ha)	*Annual* Change (in 1000 Ha)
Province	**1989**	**1993**	**1989 - 93**	**in 1993**
Guangdong	2,524.7	2,356.5	-168.2	-102.3
Shandong	6,867.9	6,758.8	-109.1	-47.0
Hubei	3,486.6	3,392.5	-94.1	-33.0
Shaanxi	3,541.1	3,458.4	-82.7	-52.0
Sichuan	6,307.2	6,231.5	-75.7	-32.0
Henan	6,944.4	6,870.4	-74.0	-17.0
Zhejiang	1,731.1	1,661.2	-69.9	-33.3
Jiangsu	4,562.3	4,495.2	-67.1	-28.8
Anhui	4,373.0	4,317.4	-55.6	-17.8
Hunan	3,318.6	3,272.9	-45.7	-28.0
Liaoning	3,470.4	3,429.7	-40.7	-25.3
Shanxi	3,701.8	3,669.4	-32.4	-15.8
Jiangxi	2,355.5	2,326.1	-29.4	-12.3
Hebei	6,560.5	6,536.0	-24.5	-8.7
Shanghai	324.0	301.8	-22.2	-16.0
Fujian	1,238.5	1,219.4	-19.1	-11.2
Guizhou	1,854.0	1,845.3	-8.7	-10.4
Beijing	414.5	405.8	-8.7	-3.0
Tianjin	432.3	428.8	-3.5	-1.1
Hainan	433.5	431.5	-2.0	-7.9
Tibet	222.3	223.6	1.3	0.0
Jilin	3,935.5	3,937.8	2.3	-11.3
Gansu	3,477.1	3,480.6	3.5	-6.1
Ningxia	795.0	803.1	8.1	-4.0
Qinghai	572.0	581.4	9.4	-2.1
Guangxi	2,578.5	2,606.6	28.1	-34.6
Yunnan	2,822.8	2,854.7	31.9	-46.0
Xinjiang	3,072.9	3,120.2	47.3	-61.3
Heilongjiang	8,826.5	8,913.2	86.7	-19.1
Inner Mongolia	4,911.5	5,171.7	260.2	-45.0
Total	**95,656.0**	**95,101.5**	**-540.1**	**-606.9**

Source: Statistical Yearbook, 1994. People's Republic of China

the Appendix), almost no data are published on land areas used for settlements, industrial sites or infrastructure. This deficit of statistical information on urban and industrial land-use is critical, since these are the sectors where the land-use changes will be most dramatic.

- Finally, there is the problem that some of the most intense land-use changes in China have occurred very recently -- during the past two or three years. Currently available statistical time series, however, usually end in 1992 or 1993. There is reason to believe that especially areas used for urban and industrial purposes significantly expanded during the *most recent* third phase in China's economic transition which started in the early 1990s.

These data problems are widely acknowledged in the literature. The United Nations Food and Agricultural Organization has shied away from publishing *any* land-use estimates for China in its recent study on "World Agriculture: Towards

2010". While there are several tables in this study dealing with the change of global land-use patterns by region between 1961 to 1991 (including projections to 2010) all estimates and projections were made with the exclusion of China.[3]

1.2 Land-use versus Land-cover Change

Land use is an *intentional* human activity. People use land, because they want to extract "resources" (in the widest sense) from the land in order to satisfy their needs for food, water, habitation, energy, fiber, mobility, or recreation. Humans also use land for esthetic and spiritual reasons or political ambitions. Land use activities usually modify the land *cover* -- but sometimes people also reserve land for parks where they try to minimize human interference so that an almost "natural" land cover can remain or re-develop. No matter which type of land *use* we want to study, it is inevitable to *focus the analysis on the human actions and intentions*, because they are the factors which change the land cover. And we have to understand those demographic, economic, political, and social processes which explain human land-use intentions. To restrict a study of land use change to an inventory or bio-physical model of land *cover* changes would go about this problem the wrong way. It would focus the study on the *results* of the process instead on its *causes*.

There is, of course, land cover in China which is changed by bio-chemical and bio-physical processes without significant and direct human intervention, such as land cover which is altered by seismic activities, hydrological processes, or climate change. Very large parts of China are sparsely populated and partly covered by (almost) natural vegetation. *Direct* human intervention in these areas is so minimal that we can probably analyze and model the vegetation cover in a purely bio-physical cause-and-effect framework. This, however, is *not* possible with China's densely habitated and cultivated Eastern provinces, where most of the land cover is a product of century-long human intervention. This land is not just *affected* but *transformed* by human action.

It should also be noted, that even where we have (almost) natural land cover in China, human activities *indirectly* affect the bio-physical process through which it changes. The possible shift of vegetation belts, the migration of plant species or the land-cover effects of hydrological changes can be linked to global climate change, which is (at least partly) caused by human activities.

2. Anthropogenic Factors of Land-use Change

In the future, anthropogenic factors will have a great impact on China's land cover, because the land will be used by a population with massive (absolute) growth. The country also is in a process of rapid *economic development* which will shift the people's primary economic activity from agriculture to industrial production and services. This economic transformation has already triggered a process of *population re-distribution* and *urbanization*. Associated to both trends is a

[3] Alexandratos, N. (Ed.) (1995): World Agriculture: Towards 2010. An FAO Study. Chichester et al. (FAO and John Wiley & Sons)

change in lifestyles: the urban population, working in industries or service sectors, typically will have other food preferences, consumption and mobility patterns, and leisure activities than the peasants of today. To a great extent land use in China, however, will depend on the country's future *political structures, institutions* and *arrangements*.

This puzzle of interwoven demographic, social, economic and political driving forces of land use change makes it inevitable that we identify a small set of **major elements** in order to develop an analytical concept. This is the objective of the following discussion which is based on the assumption that we can only understand future land use change in China if we take into account **five driving factors**:

1. The *unprecedented* and essentially *unpreventable* **increase of population** in modern China;
2. the **rural-urban migration** and the emergence of **urban agglomerates**;
3. an accelerating **economic modernization** and **industrialization;**
4. changes in **lifestyles** among Chinese consumers, such as changes in food preferences, mobility patterns, and leisure activities, which are linked to the urbanization and industrialization of the country; and finally
5. the land-use impact of changing **economic** and **political arrangements** and **institutions** (such as the emergence of land markets).

2.1 The (unprecedented and essentially unpreventable) further increase of population in China

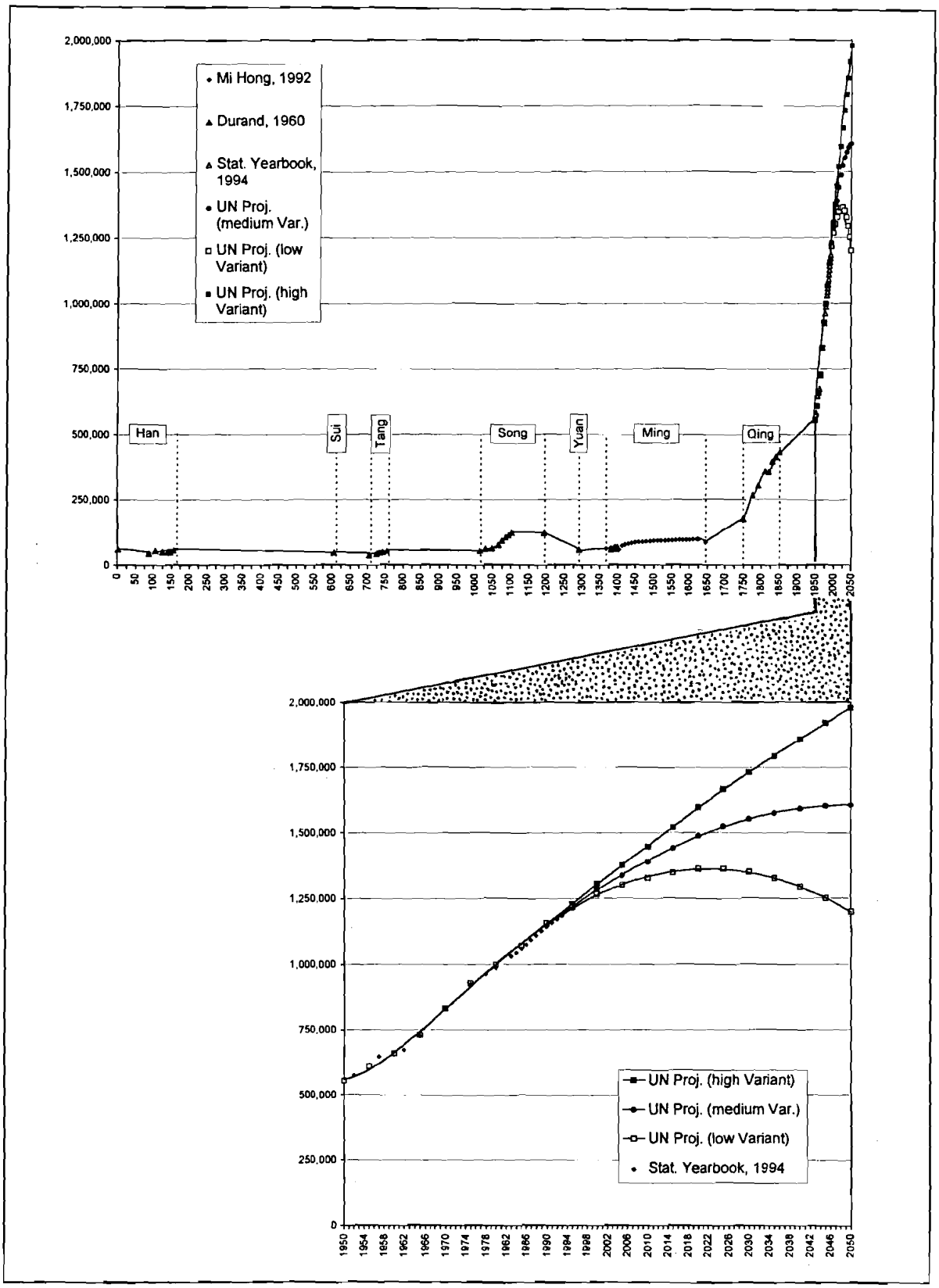
Land *use* in China certainly cannot be analyzed, modeled, projected or planned without a deeper understanding of the country's demographic trends. Since people -- *not* bio-physical processes -- have transformed the habitated land, their *number* is a critical factor. There are two characteristics of the Chinese population we have to keep in mind when analyzing land-use changes: First, its enormous increase during the past four-and-a-half *decades* -- which is without historical precedence -- and, second, its extremely uneven spatial distribution.

For more than 1400 years -- during the Han, Sui, Tang, Song, Yuan and Ming dynasties -- the Chinese empires had an almost stable population which fluctuated between only 37 and 60 million. There were periods of growth, such as during the last half of the eleventh century (Song dynasty), but they were reversed by subsequent population decline.[4] The first period of *sustained* population growth in China was recorded between 1749 and 1851, when the population more than doubled from about 177 to some 430 million. The increasing food demand made it necessary to expand the cropland by a factor of more than four and to improve irrigation. Also, new food crops and high yield rice varieties were introduced.[5] This growth, however, was followed by a century of relative population stagnation due to the decline and collapse of the dynastic system, the Japanese invasion and the outbreak of civil war (see Figure 1).

[4] Ge Jianxiong (1993): An estimate of the population size of the Ming dynasty in early 17th century. Paper presented at the XXII nd IUSSP General Conference, Session 40, Montreal, Canada

[5] Banister, J. (1987): China's Changing Population. Stanford (Stanford University Press)

Figure 1: China's Population, AD 0 - 2050



Source: (a) Mi Hong (1992): The Quantitative Analysis about Evolution of Historical Population on Ming Dynasty in China. In: Population History of East Asia, No. 2. (Papers presented to the XXII nd IUSSP General Conference, Session 40, August 28, 1993); (b) Durand, J.D. (1960): The Population Statistics of China, A.D. 2 - 1953. In: Population Studies, Vol. 13, No. 3, 209-256; (c) Statistical Yearbook, 1994. People's Republic of China; (d) United Nations Population Division (1995): World Population Prospects, 1950 - 1990, the 1994 Revision. New York

Note: Only the data points represent empirical (or projected) data; the lines between the points were added to facilitate visual inspection. The dotted lines do not represent the dynastic periods, but indicate during which dynasty the data were collected.

From 17th to the first half of the 20th century China and Europe had remarkably similar population size: in 1650 China had a population of about 89 million, while Europe's population was about 103 million.[6] Three centuries later, in 1950, China and Europe, again, had almost the same population: 555 million people as compared to 549 million (see). But then a significant diversity of trends occurred: While China's population more than doubled since 1950, Europe's population only moderately increased to 727 million. The really dramatic divergence, however, will emerge during the next few decades: By 2050 the Asian country will most likely have more than 1.6 billion inhabitants, while Europe's population size will stagnate at 678 million (see Figure 2).[7] Thus, within only *one* century, the population will most likely *triple* in China. There are even higher projections. Lutz and colleagues have estimated that in a "worst case" scenario China's population could increase to 1.93 billion by 2030.[8] The International Programmes Center of the US Bureau of the Census, on the other hand, has estimated China's population to increase to only 1.41 billion by 2050.[9] I cannot go into the details of the various projections, but I consider the UN projection of 1.61 billion (medium variant, 1994 edition) the most plausible -- a projection which, by the way, seems to be accepted by most Chinese demographers.[10]

The second basic characteristic of China's demographic situation is the compression of its large population into the eastern part of the country -- especially its coastal zones (see Figure 3). Much of China's land is virtually uninhabited: the Gobi Desert, the steep slopes of the Himalayan and the vast dry grasslands of North-Central China. 50% of the Chinese population lives on only 13% of the country's land area; two thirds of the population are concentrated in just 20% of the land. On the other hand: 50% of the Chinese land mass is *extremely* sparsely populated -- with a density ranging between 2 people per km^2 in Tibet to 19 people per km^2 in the Inner Mongolia. Only 3.6% of the Chinese population live in these huge areas (seeTable 4). The highly uneven population distribution of China not only reflects the concentration of arable land resources in the East, but also the transportation problems of a continental scale country. Chinese civilization spread along the coastal zones, using sea transport as a backbone of colonization (see Figure 3).

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[6] Please note that from the 17th to the 19th century the population of Europe includes the *western* part of Russia. The 1950, 1995 and 2050 popuation data are from the 1994 UN projection which includes *all* of the Russian Federation; plus Belarus, Bulgaria, Czech Republic, Hungary, Poland, Republic of Molodova, Romania, Russian Federation, Slovakia, Ukraine, Denmark, Estonia, Finland, Iceland, Ireland, Latvia, Lithuania, Norway, Sweden, United Kingdom, Channel Islands, Faeroe Islands, Isle of Man, Albania, Bosnia & Croatia, Herzegovina, Greece, Italy, Malta, Portugal, Slovenia, Spain, TFYR Macedonia, Yugoslavia, Andorra, Gibraltar, Holy See, San Marino, Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland, Lichtenstein, Monaco.

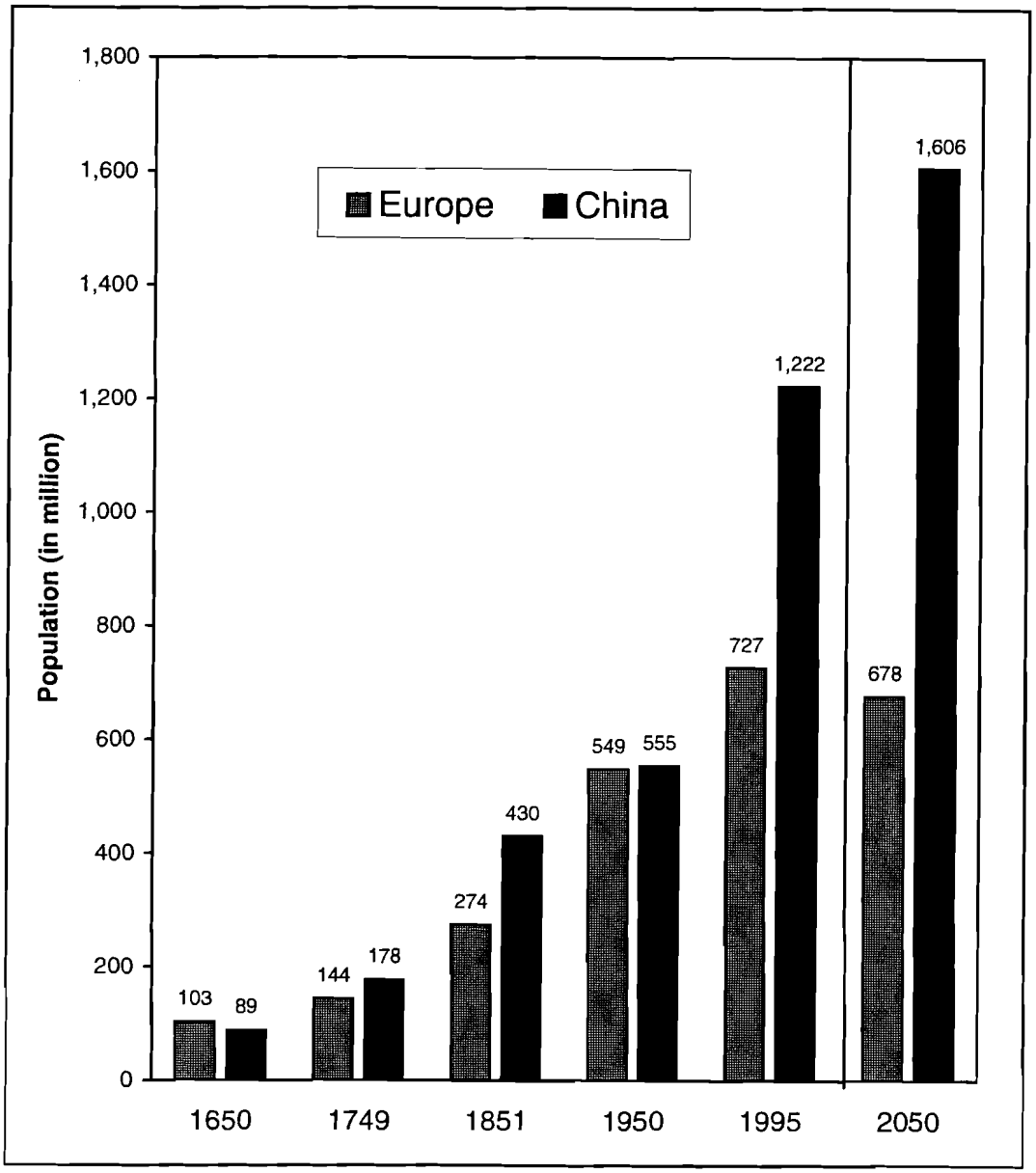
[7] United Nations (1995): World Population, 1950 - 2050. 1994 Revision. UN Population Division, New York

[8] Lutz, W. / Prinz, C. / Langgassner, J. (1994): The IIASA World Population Scenarios to 2030. In: Lutz, w. (Ed.): The Future Population of the World. What can we assume today. London (Earthscan).

[9] Johnson, P.D. (1995): International Data Base. Washington. (International Programmes Center of the US Bureau of the Census)

[10] The State Science and Technology Commission, People's Republic of China is using the 1.6 billion population projection for 2050 in its assessments. See: State Science and Technology Commission, People's Republic of China(1995): Population, Resource and Environment in China. Special Issue of the China Science and Technology Newsletter, No. 49, July 20, 1995

Figure 2: China's and Europe's Population, AD 1650, 1749, 1851, 1950, 1995, 2050

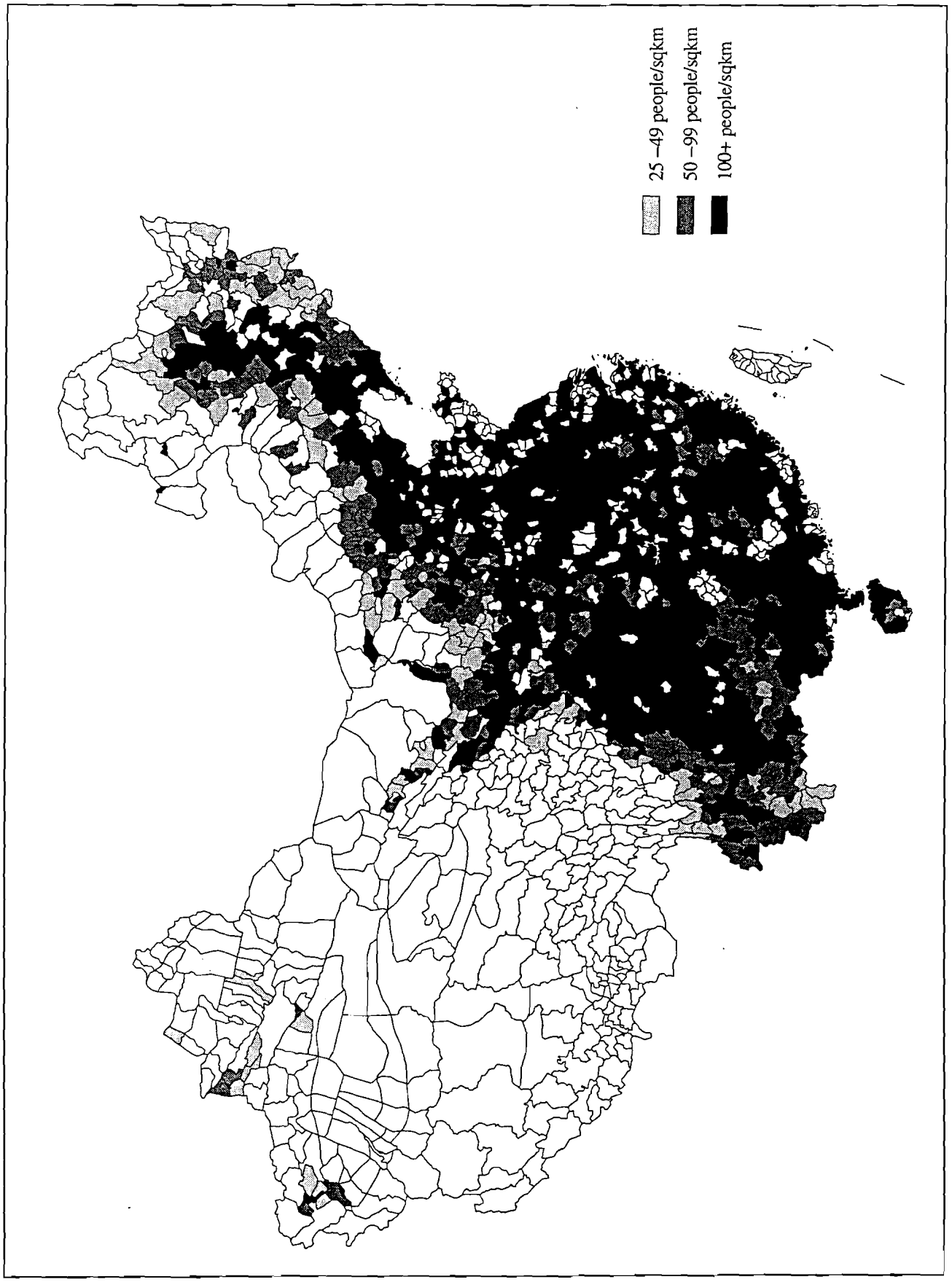


Source: As in figure 3; in addition: Braudel, F. (1990): Sozialgeschichte des 15.-18. Jahrhunderts. Der Alltag. München (Kindler Verlag), p. 159 (Original Edition: Civilisation matérielle, économie et capitalisme, XV.XVIII siécle. Les structures du quotidien: Le Possible et l'impossible.)

Note: In 1650, 1749, and 1851 Europe includes the western part of Russia. The UN population estimates and projections for 1950, 1995 and 2050 are based on the UN definition of Europe which includes *all* of the Russian Federation.

The compression of China's large (rural) population into the Eastern provinces has resulted in a unique demo-ecological situation: If we compare Chinese provinces with (industrialized) countries of similar population size, we can see that these Chinese provinces are typically twice or three times more densely populated than typical industrialized countries (see Figure 3).

Figure 3: Chinese Counties with a Population Density of 25, People per km^2 and higher.



Source: People's Republic of China, State Statistical Office, 1992

Table 4: Land Area, Population and Population Density of China's provinces, 1993

Province	Total Area (in km²)	Total Population 1993 (in million)	Population Density (People / km²)	Cumulative Percentage of Land	Cumulative Percentage of Population
Shanghai	6,186	12.9	2,093	0.1	1.1
Tianjin	11,305	8.9	787	0.2	1.8
Jiangsu	102,600	68.0	663	1.3	7.3
Beijing	16,807	10.6	629	1.4	8.2
Jiangxi	166,600	98.6	592	3.2	16.3
Shandong	153,300	86.2	562	4.8	23.3
Henan	167,000	89.1	534	6.5	30.6
Zhejiang	101,800	43.1	424	7.6	34.1
Anhui	139,900	58.7	420	9.0	38.9
Guangdong + Hainan	212,000	72.6	343	11.2	44.9
Hebei	187,700	63.1	336	13.2	**50.0**
Hunan	204,000	62.5	306	15.3	55.2
Hubei	185,900	55.9	301	17.2	59.7
Liaoning	145,700	39.8	273	18.8	63.0
Fujian	123,100	31.0	252	20.0	**65.5**
Sichuan	569,000	110.0	193	26.0	74.5
Shanxi	156,300	29.6	189	27.6	76.9
Guizhou	176,300	33.3	189	29.4	79.7
Guangxi	236,200	44.1	187	31.9	83.3
Shaanxi	205,600	33.7	164	34.0	86.0
Jilin	187,400	25.0	133	36.0	88.1
Yunnan	394,000	38.0	97	40.1	91.2
Ningxia	60,000	4.9	82	40.7	91.6
Heilongjiang	453,300	35.4	78	45.5	94.5
Gansu	454,000	23.2	51	**50.2**	96.4
Inner Mongolia	1,183,000	22.0	19	62.5	98.2
Xinjiang	1,646,800	15.8	10	79.7	99.4
Qinghai	721,500	4.5	6	87.2	99.8
Xizang (Tibet)	1,228,400	2.3	2	100.0	100.0
Total	9,595,698	1,222.8			

Source: People's Republic of China, State Statistical Office, 1994

The Chinese province of Anhui, for instance, has the same population as Italy; its density, however, is more than twice that of Italy -- 420 as compared to 189 people per km². Spain has a population of 39 million, and so has the Chinese province of Liaoning; but Spain's population density is 78 people per km² while it is 273 people per km² in Liaoning. Inner Mongolia, arguably a very sparsely populated province of China, has a population comparable in size to that of Australia -- some 19 million as compared to 17 million. Population density in the Inner Mongolia, however, is almost 10 times higher than in Australia. The "densely" settled Germany had a population of about 80 million in 1990 -- somewhat more than Guangdong (combined with Hainan) or Jiangsu, and a little less than Shandong. All these Chinese provinces, however, have a much higher population density, ranging from 343 in Guangdong + Hainan to 663 people per km2 in Jiangsu. A last example: both Mexico and the Chinese province of Shandong have a population of some 85 million inhabitants; the Chinese province, however, has a density which is 13 times higher than that of Mexico. The high density of its very large (rural) population is a critical factor of China's future development.

Within the next five decades China has to provide food, labor, energy, resources, housing to an *additional* 400 million people -- an *increase* of population, which

is more than twice the current total population of Western Europe (which includes the *combined* total population of Austria, Belgium, France, Germany, Luxembourg, Netherlands and Switzerland). And China has to deal with this massive population increase predominantly in the East of the country and its coastal zones which are already extremely densely populated and probably close to the carrying capacity of their arable land.

Table 5: Population Density of Selected Chinese *Provinces* and *Countries* of Comparable Population Size

Selected Chinese *Provinces*			***Countries* of comparable population size**		
	Total Population 1993 (in million)	**Population Density** (People / km2)		**Total Population 1990** (in million)	**Population Density** (People / km2)
Jiangxi	98.6	**592**			
Henan	89.1	**534**			
Shandong	86.2	**562**	Mexico	84.5	**43**
Guangdong + Hainan	72.6	**343**	Germany	79.4	**222**
Jiangsu	68.0	**663**			
Hebei	63.1	**336**			
Hunan	62.5	**306**	Iran	58.9	**36**
Anhui	58.7	**420**	Italy	57.0	**189**
Hubei	55.9	**301**	France	56.7	**103**
Guangxi	44.1	**187**			
Zhejiang	43.1	**424**			
Liaoning	39.8	**273**	Spain	39.3	**78**
Shaanxi	33.7	**164**			
Guizhou	33.3	**189**			
Fujian	31.0	**252**			
Shanxi	29.6	**189**	Canada	27.8	**3**
Inner Mongolia	22.0	**19**	Australia	16.9	**2**
Tianjin	8.9	**787**	Sweden	8.6	**19**
Ningxia	4.9	**82**	Finland	5.0	**15**
Qinghai	4.5	**6**	Norway	4.2	**13**

Source: People's Republic of China, State Statistical Office, 1994; UN Population Assessments and Projections, 1994

This task is without historic precedence; and there can be no doubt that it will affect land use in multiple ways:

- The task of providing **food** for another 400 million people will undoubtedly change the land. The State Science and Technology Commission believes that by 2040 the production of food crops, pork, beef, and mutton must be doubled, as well as the production of soybean, sugar and vegetable oils. The production of aqua-cultures must be tripled.[11] Since China has almost exhausted its arable land -- significant reserves of farmland can only be found in the Northeastern provinces of Lianoning, Jilin and Heilongjiang[12] -- much of the increase in food production will have to come from agricultural *intensification* and moderniza-

[11] The State Science and Technology Commission, People's Republic of China (1995): Population, Resource and Environment in China. Special Issue of the China Science and Technology Newsletter, No. 49, July 20, 1995

[12] Hook, B. / Twitchett, D. (1991): The Cambridge Encyclopedia of China. New York (Cambridge University Press)

tion. In addition, food imports will probably have to increase considerably. There is concern that international markets might be unable to supply future Chinese demand; but this is probably just a matter of price. If China can afford to pay *higher* prices, farmers in Canada and Northern America would probably be more than happy and capable of providing the additional amounts. However, this is only possible if China's industrial exports will generate enough foreign currency to pay for the country's food imports.

- Second, 400 million people will need additional **space** for housing and urban infrastructures. The eastern part of the country however, is already densely populated and the rest -- which is covered by sand, rock surfaces, grasslands and mountain ranges with very little rainfall and/or extreme cold in the winter -- is not very attractive for human settlements. Rural counties in the habitated part of the country have population densities which are among the highest in the world. Additional space for housing and infrastructure can often only be taken from cultivated areas.
- Third, even without any improvement in living standards additional **energy** has to be provided for hundreds of millions of people. Assuming further economic growth Chinese researchers have estimated that the energy production has to be expanded by at least 3 to 5 times. Most of this energy will come from coal and (in rural areas) firewood, but there are also concrete plans to expand hydropower. Increasing firewood collection will put China's forests under additional stress and the construction of reservoirs will directly affect the land use in river valleys. Work on the "Three Gorges" project, a massive scheme to dam the Yankees river, was started only recently.

In addition to these *direct* land-use consequences of population growth numerous *indirect* effects exist, which we will discuss below. The most important is a process of rural-urban migration and urbanization.

2.2 Urbanization[13]

China has long been the prototype of a rural society. The government's closed city policy effectively prevented rapid urbanization and 72% of the population is still classified as *rural.*[14] This will almost certainly change in the near future. Attracted by the rapidly growing industrial and commercial sectors in towns and urban areas and pushed by rural un(der)employment millions of Chinese peasants will go urban. According to Chinese sources the number of cities is projected to almost double within the next 15 years (from currently 570 to about 1000).

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[13] Parts of the "Urbanization" paragraph have been previously published in: Heilig, G.K. (1995): Lifestyles and Global Land-use Change: Data and Theses. Laxenburg (International Institute for Applied Systems Analysis, Working Paper WP-95-91) and in: Heilig, G.K. (1995): Who is Changing the Land. Data and Concepts. In: Population and Environmental Issues. Rene Dubos Center (Ed.), New York (Greenwood Publishing Group) (in press)

[14] State Statistical Bureau (1994): Statistical Yearbook of China. Beijing, p. 33

Table 6: UN Estimates and Projections: Population of the largest 51 Cities in China, 1950, 1995, 2015

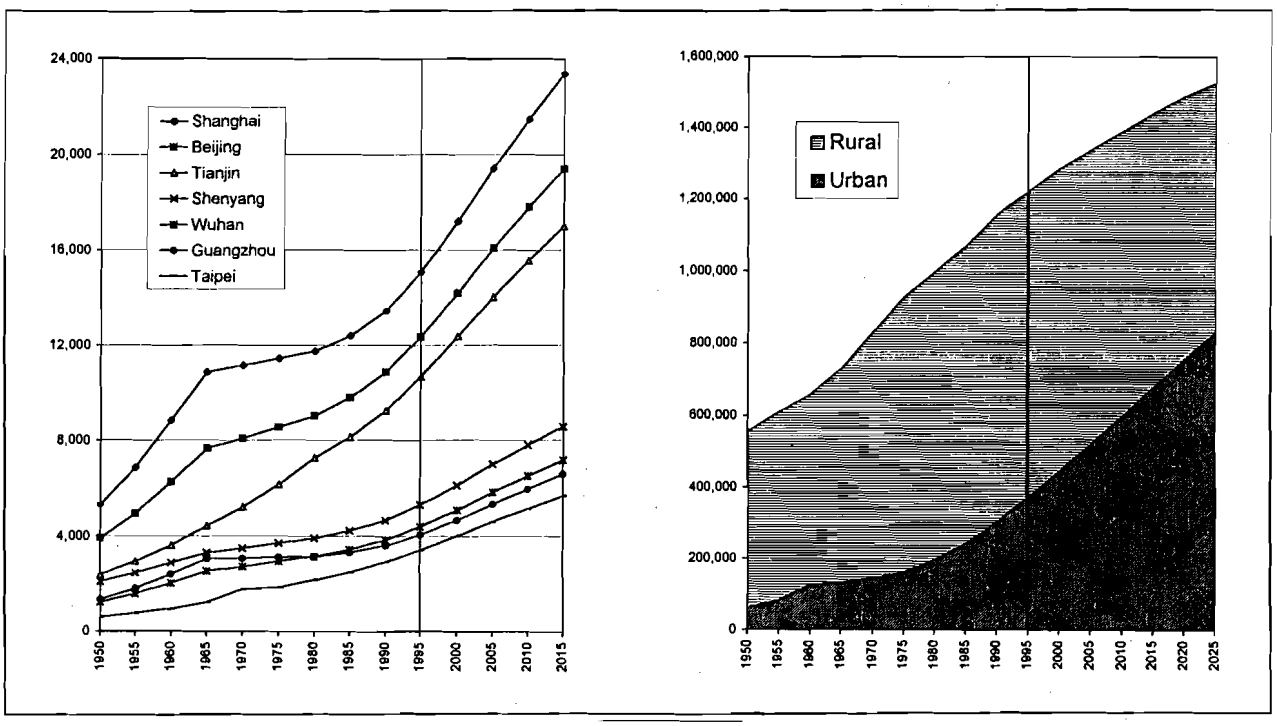
	Population (in 1000)			Population Growth 1950 - 1995		Projected Population Growth 1995 - 2015	
	1950	1995	2015	Total	Av. Annual Pop. Growth in %	Total	Av. Annual Pop. Growth in %
Urumqi	102	1,643	2,857	1,541	6.4	1,214	2.2
Baotou	97	1,414	2,400	1,317	6.1	986	2.1
Luoyang	123	1,411	2,420	1,288	5.6	1,009	2.2
Hohhot	109	1,067	1,847	958	5.2	780	2.2
Handan	136	1,323	2,270	1,187	5.2	947	2.2
Nanning	157	1,498	2,609	1,341	5.1	1,111	2.2
Guiyang	195	1,792	3,025	1,597	5.1	1,233	2.1
Yichun	134	1,051	1,803	917	4.7	752	2.2
Datong	165	1,275	2,168	1,110	4.6	893	2.1
Liuzhou	131	905	1,589	774	4.4	684	2.3
Kaohsiung	255	1,726	2,932	1,471	4.3	1,206	2.1
Jixi	157	1,034	1,779	877	4.3	745	2.2
Qiqihar	265	1,642	2,774	1,377	4.1	1,132	2.1
Fuxin	147	880	1,523	733	4.1	643	2.2
Taipei	604	3,417	5,700	2,813	3.9	2,283	2.1
Lanzhou	315	1,747	2,935	1,432	3.9	1,188	2.1
Xian	650	3,283	5,472	2,633	3.7	2,189	2.1
Jinan	598	3,019	5,250	2,421	3.7	2,231	2.2
Shijiazhuang	307	1,547	2,639	1,240	3.7	1,092	2.2
Nanchang	343	1,646	2,825	1,303	3.5	1,179	2.2
Chengdu	725	3,401	5,623	2,676	3.5	2,222	2.0
Dalian	678	3,132	5,402	2,454	3.5	2,270	2.2
Tianjin	2,374	10,687	16,998	8,313	3.4	6,311	1.9
Jilin	371	1,506	2,563	1,135	3.2	1,057	2.1
Taiyuan	629	2,502	4,189	1,873	3.1	1,687	2.1
Zhengzhou	521	1,999	3,371	1,478	3.0	1,372	2.1
Daqing	310	1,151	1,997	841	3.0	846	2.2
Wuhan	1,228	4,399	7,182	3,171	2.9	2,783	2.0
Anshan	479	1,648	2,788	1,169	2.8	1,140	2.1
Jinzhou	326	1,090	1,932	764	2.7	842	2.3
Changchun	765	2,523	4,228	1,758	2.7	1,705	2.1
Harbin	1,012	3,303	5,425	2,291	2.7	2,122	2.0
Xuzhou	341	1,084	1,867	743	2.6	783	2.2
Beijing	3,913	12,362	19,423	8,449	2.6	7,061	1.8
Fuzhou	492	1,535	2,602	1,043	2.6	1,067	2.1
Nanjing	973	2,965	4,919	1,992	2.5	1,954	2.0
Kunming	641	1,942	3,270	1,301	2.5	1,328	2.1
Guangzhou	1,343	4,056	6,591	2,713	2.5	2,535	2.0
Shanghai	5,333	15,082	23,382	9,749	2.3	8,300	1.8
Tangshan	640	1,767	2,962	1,127	2.3	1,195	2.1
Hefei	437	1,143	1,965	706	2.2	822	2.2
Benxi	414	1,063	1,823	649	2.1	760	2.2
Shenyang	2,091	5,310	8,588	3,219	2.1	3,278	1.9
Fushun	634	1,595	2,694	961	2.1	1,099	2.1
Changsha	623	1,559	2,660	936	2.1	1,101	2.2
Hangzhou	638	1,581	2,670	943	2.0	1,089	2.1
Shantou	420	981	1,689	561	1.9	708	2.2
Chongqing	1,680	3,525	5,788	1,845	1.7	2,263	2.0
Suzhou	457	908	1,567	451	1.5	659	2.2
Wuxi	572	1,086	1,861	514	1.4	775	2.2
Qingdao	894	1,585	2,679	691	1.3	1,094	2.1
Total	38,894	133,785	219,530	94,891	2.8	85,745	2.0

Source: United Nations (1995): Urban Agglomerations, 1950-2015. The 1994 Revision. Machine-readable Data Sets. UN Population Division, New York

The United Nations Population Division is monitoring the population of 51 Chinese cities and urban agglomerates.[15] According to their estimates, which are based on Chinese reports, these cities had a total population of about 39 million in 1950. Today, their population is almost 134 million. The UN recently projected that within only twenty years their combined population will further increase to about 220 million. China's 51 largest cities, in other words, will have twice the total population of Japan. Shanghai, for instance, is projected to increase to 23 million by 2015 -- mainly due to rural-urban migration; Beijing could be 19 million and Tianjin almost 17 million (see Table 6).

Could this projection of urban growth in China be an exaggeration? I don't think so. In fact, the UN projections cited above are actually quite conservative, as compared to the actual historical trends. Between 1950 and 1995 China's largest city populations had an average *annual* growth rate of 2.8%. The UN projections imply that this growth will slow down to an annual growth rate of 2.0% between 1995 and 2015.

Figure 4: (a) Population of Selected Chinese Cities: 1950 - 2050
(b) Urban and Rural Population in China: 1950 - 2050



Source: (a) United Nations (1995): Urban Agglomerations, 1950-2015. The 1994 Revision. Machine-readable Data Sets. UN Population Division, New York. (b) United Nations (1995): Urban and Rural Areas, 1950-2025. The 1994 Revision. Machine-readable Data Sets. UN Population Division, New York

Are there any other *obvious* patterns of migration in China? A first attempt to answer this question is shown in Table 7. It is based on a county/city level data base of birth and death rates in 1993. These two rates can be used to calculate the "natural growth rate" of the population. We also have the "total annual growth rate" of the population. The difference between *total* and *natural* population

[15] United Nations (1995): Urban Agglomerations, 1950-2015. The 1994 Revision. Machine-readable Data Sets. UN Population Division, New York

growth must be due to migration. Thus we can estimate the annual growth or decline due to net migration.

Table 7: Counties and Cities with Highest Population Growth or Decline due to Migration (based on the differences between *natural* and *actual* population growth)

Counties / Cities with Highest In-Migration

County / City	Birth Rate	Death Rate	*Natural Annual* Growth Rate	Total Annual Population Growth Rate	Estimated Annual Growth *due to Net-Migration*
Shenzen City	12.51	0.95	1.16	29.07	27.91
Baoan	12.47	1.88	1.06	16.20	15.14
Zhuhai City	15.68	2.66	1.30	12.19	10.89
Huolinguoli	18.16	2.42	1.57	11.51	9.94
Daxian City	14.37	4.02	1.04	7.08	6.05
Zhumadian City	17.16	3.88	1.33	7.28	5.95
Mohe	18.28	2.66	1.56	7.48	5.92
Shufu	39.31	7.94	3.14	8.69	5.55
Huizhou City	17.50	5.10	1.24	6.45	5.21
Qitaihe City	21.51	2.86	1.87	6.96	5.10
Foshan City	13.81	4.38	0.94	5.23	4.29
Yanji	16.11	5.24	1.09	5.33	4.24
Erlianhaote	22.85	1.66	2.12	6.09	3.97
Panjin City	14.56	2.56	1.20	5.16	3.96
Tongshi	19.99	3.94	1.61	5.54	3.94
Fuyuan	22.34	3.23	1.91	5.75	3.84
Rangfan City	14.40	3.48	1.09	4.82	3.73
Gujiao	25.48	3.52	2.20	5.88	3.68
Shashi	15.33	4.53	1.08	4.62	3.54
Tahe	16.74	3.16	1.36	4.66	3.30

Counties / Cities with Highest Out-Migration

County / City	Birth Rate	Death Rate	*Natural Annual* Growth Rate	Total Annual Population Growth Rate	Estimated Annual Decline *due to Net-Migration*
Hetian City	30.95	5.23	2.57	-8.47	-11.04
Hetian County	37.83	7.85	3.00	-3.16	-6.16
Jixian	17.24	4.28	1.30	-3.83	-5.13
Kashi City	25.82	6.40	1.94	-2.97	-4.91
Yongshun	36.94	9.27	2.77	-1.42	-4.19
Fushun	25.70	8.10	1.76	-1.43	-3.19
Yanqi	18.63	3.58	1.51	-1.38	-2.89
Dulan	24.06	5.95	1.81	-1.04	-2.85
Huanglong	23.68	5.83	1.79	-0.78	-2.57
Gangcha	24.78	4.86	1.99	-0.43	-2.42
Puyang County	27.97	5.56	2.24	-0.12	-2.36
Jiaohe	19.17	6.13	1.30	-0.98	-2.28
Qinggang	19.86	5.17	1.47	-0.77	-2.24
Wangkui	18.61	5.10	1.35	-0.86	-2.21
Baiquan	21.50	5.20	1.63	-0.49	-2.12
Fuhai	26.08	4.03	2.21	0.16	-2.05
Bomi	27.31	7.92	1.94	-0.06	-2.00
Hailun	18.72	5.13	1.36	-0.64	-2.00
Queshan	20.06	6.52	1.35	-0.62	-1.97
Bin	18.78	4.95	1.38	-0.58	-1.96

Source: People's Republic of China (1993): Population by County and City. Beijing (Ministry of Public Security)
Note: The "Estimated Annual Growth / Decline due to Net-Migration" was calculated as the difference between the reported "Total Population Growth Rate" (in % per year) and the "Natural Growth Rate" (which is the Birth Rate minus Death Rate divided by 10). Please note that birth and death rates by county might not be very reliable, so that the estimated net-migration should be considered only as a rough approximation.

We have ranked more than 2000 Chinese counties and cities for which we have data according to their estimated population change due to net migration. The first part of Table 7 gives the 20 counties or cities with the highest population *growth* due to in-migration, the second part reports the counties/cities with the highest population *decline*. Using a map we can easily see that both types of counties and cities are distributed all over China. This seems to indicate that migration in China is probably governed by local or regional conditions. There seem to be cities or counties all over the country which attract farmers from surrounding areas. China apparently does not (yet) experience some kind of a long-distance "gold rush" to the prosperous counties and cities in the East, but a more distributed process of urbanization. Clearly, this is just an impression from a very limited set of statistical data. More detailed investigation of migration statistics is necessary (and planned) to confirm or reject this observation.

The State Statistical Bureau (PRC) has estimated that the total *urban* population of China will increase from 28% (in 1995) to 50% in 2010.[16] In its most recent assessment the United Nations Population Division has estimated a 1 *billion urban* population for China in 2050 -- *two thirds* of the total population. For comparison: In 1950 China's *urban* population was 61 million (see).[17] Quite frankly—it is very hard to believe that this 940 million increase in city dwellers would *not* cause a major urban land-use expansion.

The growth of China's cities and urban agglomerates, of course, depends on future political and economic conditions. In the 1970s and 1980s, the government had strictly regulated migration and basically closed the cities for rural-urban migrants. However, there are good (economic) reasons to believe, that even if China's government will try to maintain some restriction of mobility, massive rural-urban migration and city growth cannot be stopped. Beijing and Shanghai already have so-called "floating" populations of between 1 and 2 million each -- the Chinese version of "illegal" rural-urban migrants. There are powerful pull and push factors for -- if necessary, illegal -- rural-urban migration:

- First, there is a huge demand for cheap rural labor in China's cities and urban areas, due to the accelerating economic boom. Many construction companies already hire their unskilled workers directly in rural areas. In the booming towns and cities, there are also numerous opportunities for starting a small private business -- from selling self-made household items to running a food stall or street restaurant. Jobs and business opportunities, however, are not the only attractions of town and cities. As everywhere else in the world rural people realize that cities provide better facilities for education, health care, and entertainment than the villages. Only strict control of mobility has so far prevented the young and energetic from (at least temporary) migrating to the urban areas. Without these controls a tidal wave of farmers would check out the urban opportunities.
- Second, there is a large reservoir of (hidden) rural unemployment which will significantly increase in the next decades. We have already mentioned that

[16] State Statistical Bureau (1994): Statistical Yearbook of China. Beijing, p. 33

[17] United Nations (1995): Urban and Rural Areas, 1950-2025. The 1994 Revision. Machine-readable Data Sets. UN Population Division, New York

between today and the year 2050 the country population will grow by about 400 million -- most of it will be born in rural areas. It is very unlikely that these additional people can be absorbed in the agricultural sector. There is already hidden unemployment and the mechanization and modernization of agriculture will further reduce labor demand. Since 1978 China's farmers have increased agricultural machinery by a factor of 10; nitrogen fertilizer input grew even twelve-fold. *Labor* intensity in the agricultural sector will probably stagnate or even *decline,* as China moves further towards modern agricultural production methods. Population growth and stagnating agricultural labor demand will cause a multi-million *rural* excess population. According to official Chinese estimates the country may have some 100 million idle farmers.[18] Other Chinese experts believe that the surplus of rural labor is more in the range of 150 million and could increase to 190 million by the end of 2000.[19]

Direct effects of urbanization on land-use patterns

The growth of cities and towns usually leads to a conversion of arable land into built-up areas for housing and commercial purposes. It can also cause a modification of built-up land without expansion of the area ("vertical growth" of high-rise buildings). In both cases the conversion of land is significant -- if not in size, then certainly in its *temporal* dimension. While agricultural land-use changes often affect large areas, they are usually reversible (even deforestation can be reversed by a reforestation program). The transformation of arable land into built-up areas, such as highways or settlements, however, is often not reversible (or only with extremely high costs).

Table 8: Structure of Lost Cultivated Land in China: 1988 and 1989

	1988		1989	
	(in 1000 ha)	(in %)	(in 1000 ha)	(in %)
State Construction City, towns, factories, railway, highway, hydroelectic projects, other.	71.2	10.5	51.2	12.3
Collective Construction Roads, irrigation, TVEs, farmer housing, other	29	4.3	22.7	5.4
Agricultural Restructuring For fruit trees, forests, grassland, fishponds.	394.8	58.4	231.1	55.4
Natural Disaster Related	159.4	23.6	97	23.2
Total Loss of Cultivated Land	**676.3**	**100**	**417.3**	**100**

Source: World Bank (1993): China. Urban Land Management in an Emerging Market Economy. Washington, DC. p. 95

[18] Li Huiming (1994): Rural Workers Tiding in Urban Areas. Special Report 1.14. In: China Development Report, 1994. People's Republic of China (China Statistical Publishing House), p.168-169

[19] Zhenghua, Jiang / Feldman, M.W. / Zhang, Lingguang (1995): Population and Development in China. Paper presented at the 1995 Summer Session of the Aspen Global Change Institute.

In 1988/89 China lost more than 1 million hectares of its cultivated land. Most of it was due to agricultural restructuring (about 55%) and natural disasters (some 23%); but some 18 percent of the losses were due to urban growth and infrastructure construction (see Table 8). This was seven years ago, when the current infrastructure boom had barely started. More recent statistics are not available to me, but the losses of cultivated land due to urban and infrastructure expansion must have multiplied.

Of course, not all land in urban areas is sealed off by houses or roads. There is often a high proportion of land which looks rather "natural", such as parks, gardens, or vegetation belts between highway lanes. People are often surprised, how "green" and "untouched" the land appears from an airplane—even within (or close to) urban agglomerates. This, of course, is a misleading impression. It is not the *appearance* of land, but the *purpose* of its use, which determines how it has to be classified. The purpose of agricultural land is the *production* of food and other agricultural products, it serves the rural population as a source of food and income. *Urban* land, on the other hand, no matter how "green" it appears, provides space for housing, consumption, mobility, recreation, education or entertainment to people who earn their income in ***non***-agricultural sectors (even if they grow some tomatoes in their cottage garden).

Indirect effects of urbanization on land-use patterns

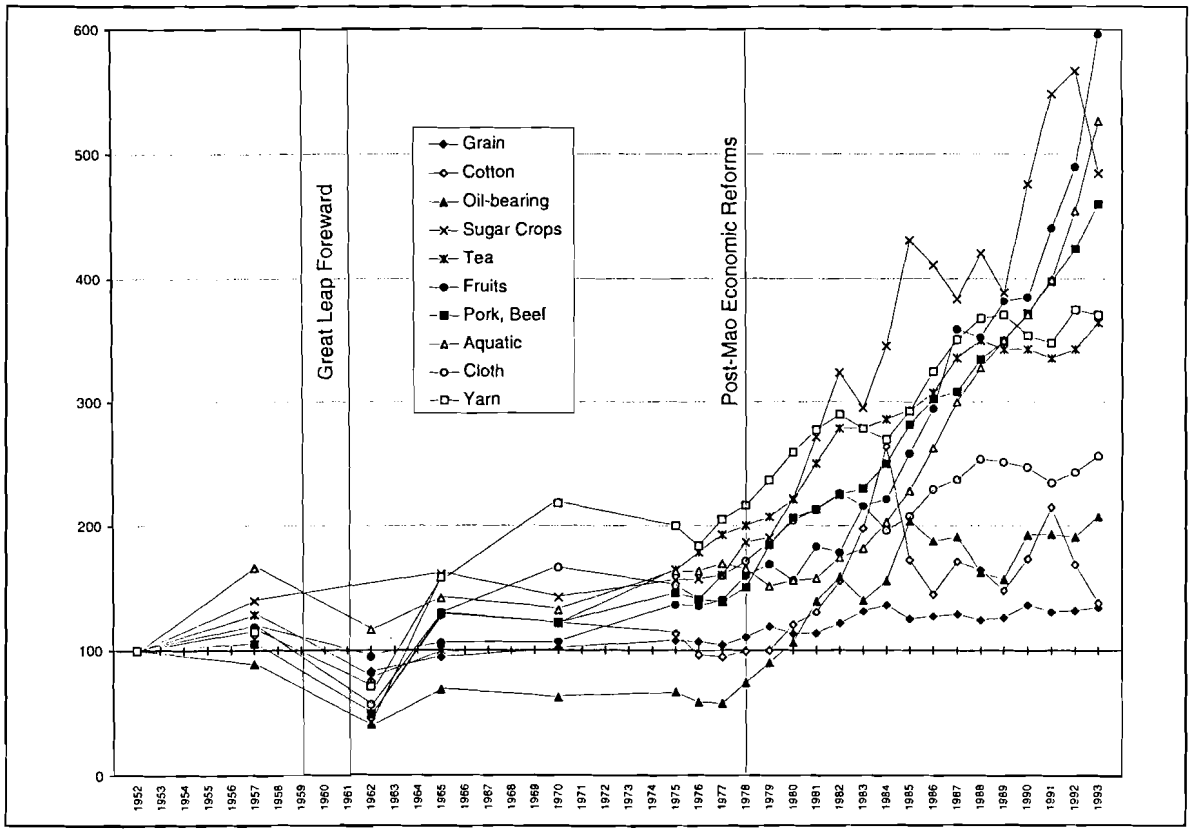
Urbanization not only causes an *expansion* of built-up areas -- which is certainly only a *minor* change in terms of the *size* of land affected -- but has also far-reaching effects on *indirect* land-use change. City dwellers need a much broader supply and service infrastructure than rural populations—from shopping centers to water reservoirs. They usually cannot build their houses with local products, such as clay or wood -- steel mills and cement factories are necessary for urban construction. They cannot collect firewood for cooking and heating, but depend on the production and distribution of *commercial* energy. The high *per capita* consumption of energy and material in urban areas affects the urban hinterland in many ways. Cities also need special areas for sewage treatment and waste disposal—in a village this is often done by reserving a certain spot behind the house. This is why a process of urbanization usually triggers off the growth of specific commercial sectors, supply infrastructures and city-specific land-use forms (such as parks, recreation areas, sport stadions, etc.). In addition, city people prefer *processed* food. They do not grow and mill wheat to bake their bread, but leave this job to farmers, mills and bakery shops. A large city population is the major factor for the emergence of *commercial* farming and food processing. This urban demand can change *agricultural* land-use in areas far away from the city.

2.3 Economic modernization, accelerating industrialization, and resource exploitation

The economic reforms of 1978 were probably more important to China's future land-use change than any other single event in recent history. A decade after the trauma of a Cultural Revolution and two years after Mao's death, China's leaders decided to gradually abandon the system of *collective* land ownership and centra-

lized command economy. Family farming was re-introduced together with a limited system of agricultural markets. The impact couldn't have been greater. Almost instantly agricultural output began to increase. Within only 10 years China's peasants almost *doubled* the production of rice. But the growth was not only in volume -- the decentralized planning favored diversification and farmers began to concentrate on products where they had a comparative advantage. Before the liberalization the central planners had often forced them to grow rice where it would have been better to grow wheat, or to keep pigs where they should have been raising cattle. The new flexibility broadened the range of agricultural production to non-rice crops, aqua cultures, and various livestock. Meat consumption in China -- an extremely rare food in the 1950s and 1960s -- began to soar. Available statistics clearly indicate the new diversity of agricultural production after 1978 (see Figure 5).

Figure 5: Indices of Per Capita Output (in kg) of Major Agricultural Products, 1952 - 1993, (1952 = 100)



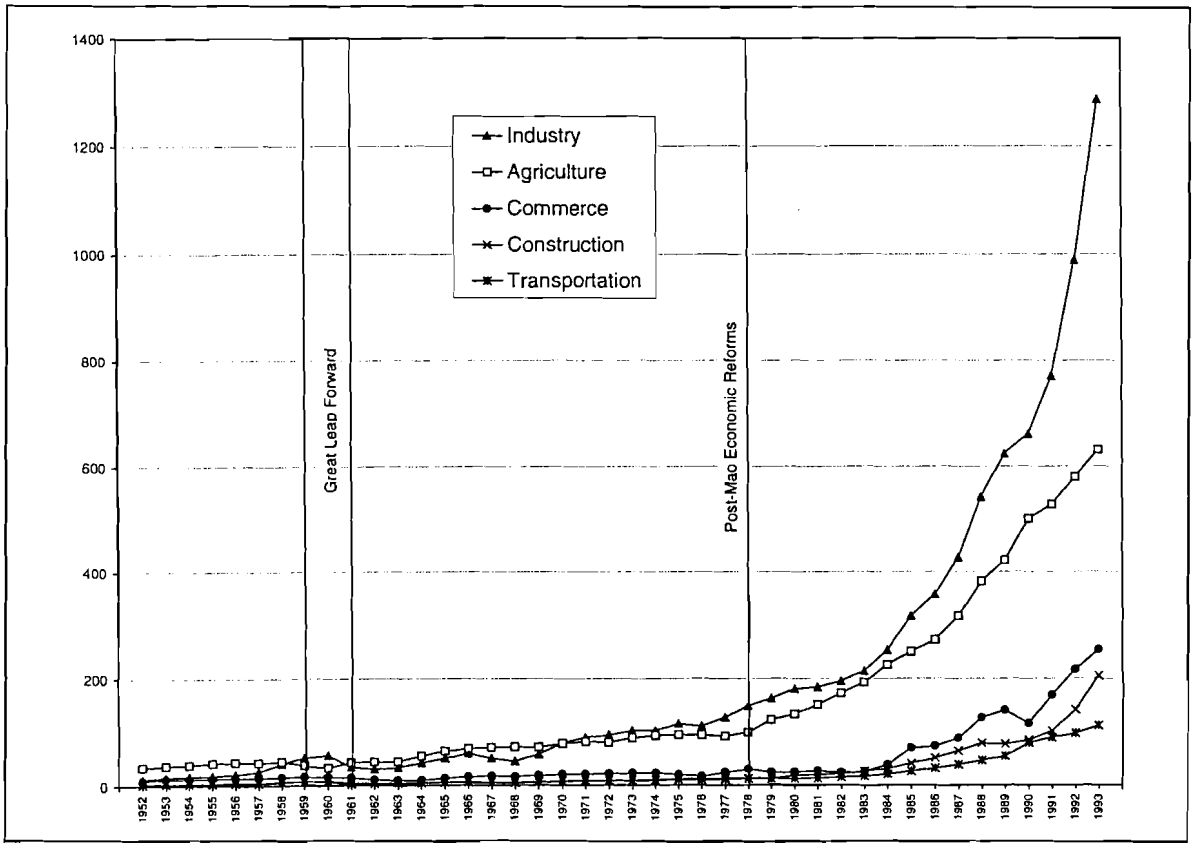
Source: Statistical Yearbook, 1994 (Beijing, People's Republic of China), p.31

The growth of agricultural production in China from 1978 to the mid 1980s was far more rapid than most observers believed possible (see Figure 5). It was driven -- as Barnett noted -- by the "deep-rooted entrepreneurial impulses among China's peasants that long have been suppressed".[20] The explosion in agricultural productivity eliminated the biggest risk for the Chinese peasants: famine. Less than a generation after at least 23 million people had died in the famine of the

[20] Barnett, A.D. (1986): China's Modernization: Development and Reform in the 1980s. In: Joint Economic Committee of the Congress: China's Economy Looks Toward the Year 2000. Volume 1. Washington, D.C. (U.S. Government Printing Office), p.7-8

"Great Leap Forward", the farmers could not only feed their children, but actually expand their diets to meat, fish, sugar and fruits. More than that -- for the first time farmers could generate enough money to buy consumer goods like bicycles, TV-sets, and watches. National income statistics clearly show the trigger effect of these 1978 reforms.

Figure 6: National Income by Sector, 1952 - 1993 (in 100 million yuan)



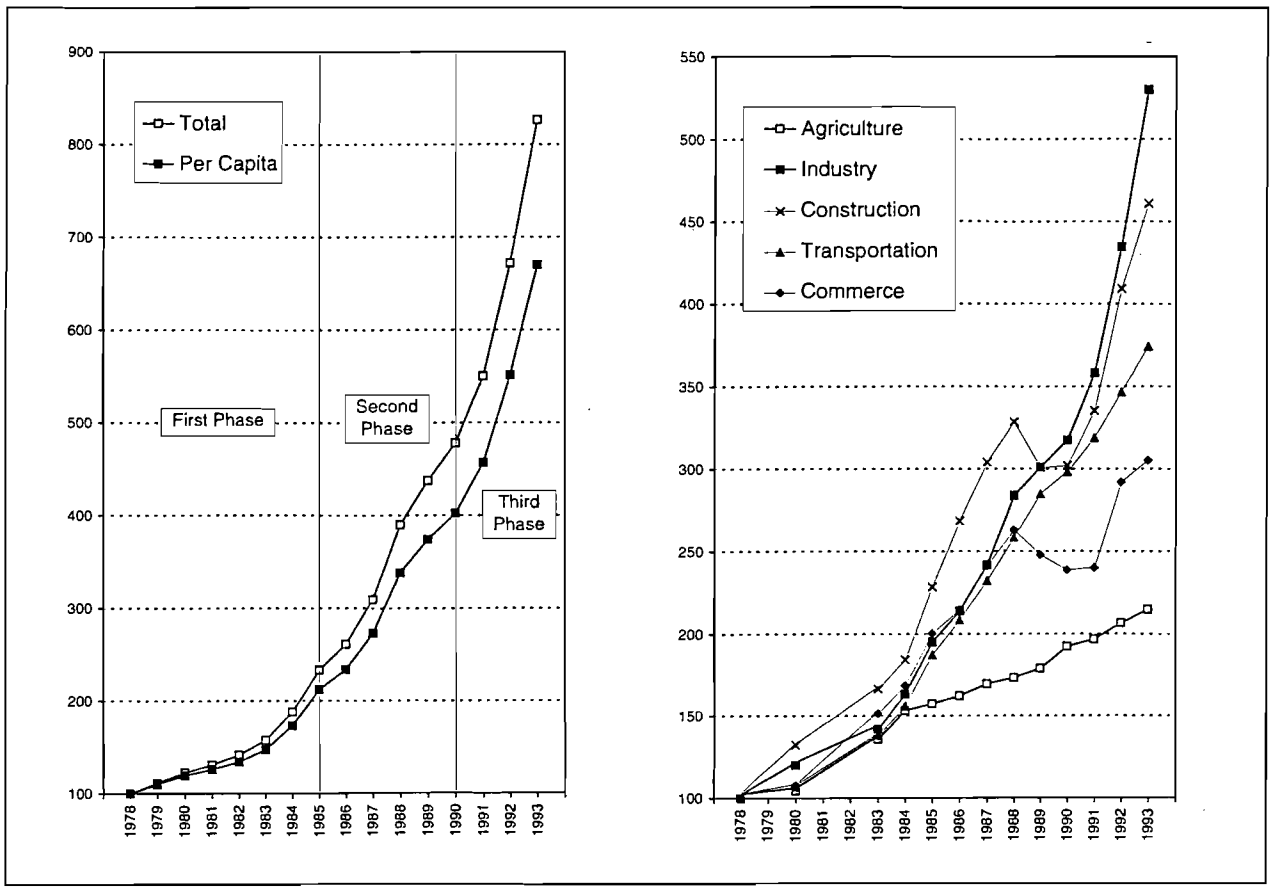
Source: Statistical Yearbook, 1993, 1994 (Beijing, People's Republic of China), p.33
Note: The figure is based on *current* prices. Due to inflation this leads to an overestimation of the national income. The key issue, however, is not the absolute level of *real* national income, but the temporal pattern of change. Since inflation has not changed dramatically in China, the figure indicates that the spectacular economic development in agriculture and industry only started in 1978.

The talent for business showed up with even greater clarity as the first wave of economic modernization in China began to level off in the mid 1980s (see Figure 7). Fortunately, a second wave of economic reform was ready to take off. In 1978 Deng Xiaoping not only had returned the farmland to the peasants, but with remarkable foresight had introduced small-scale *rural* industries. These village and township enterprises became a phenomenal success. Their number increased more than twelve-fold from 1.5 in 1978 to 19 million in 1991, at which time they generated about 30 percent of China's Gross National Product -- *exceeding* the share of agricultural output.[21] In the early-1990s Deng Xiaoping further encouraged the peasants' engagement in the "xiangshen qiye" as the countryside enterprises are called in China. Within only two years, from 1991 to 1993, their number further increased from 19 to almost 25 million.[22]

[21] Kristof, N.D. / Wudunn, S. (1994): China Wakes. The struggle for the soul of a rising power. New York (Vintage), p.172

[22] Statistical Yearbook, 1994. People's Republic of China. p. 361

Figure 7: (a) Three Phases of Economic Modernization: Indices of Total and Per Capita National Income, 1978 - 1993 (1978 = 100)
(b) Indices of National Income generated by Agriculture, Industry, Construction, Transportation, and Commerce, 1978 - 1993 (1978 = 100)

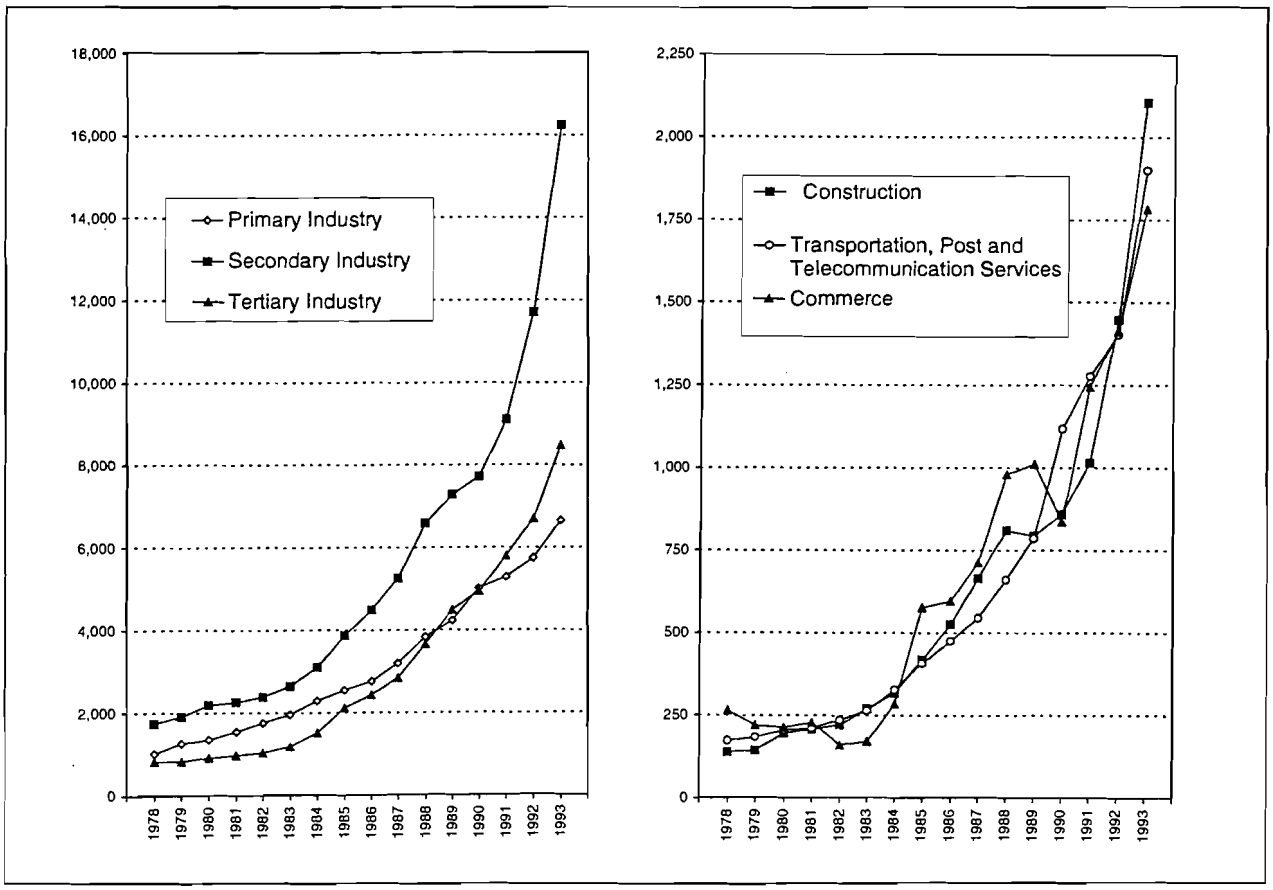


Source: Statistical Yearbook, 1993, 1994 (Beijing, People's Republic of China), p.33
Note: Figure is based on *current* prices.

With this clever move Deng succeeded to solve three fundamental problems of any developing economy: he reduced the power of the *central* bureaucracy, stopped the farmers from *migrating* to the big industries and the cities and gave them an opportunity to *learn* about modern technology and business. Contrary to the state-run heavy industry the town and village enterprises are owned by the *local* governments; their management is far more independent from national plans and regulations -- partly because they employ only from a few dozen to a few hundred people. The decentralized planning facilitated innovation. While most enterprises started with the production of crude consumer goods for the regional demand, some of them quickly switched to more profitable products for urban and international consumers. Today these rural industries put out many of the teddy bears, jigsaw puzzles, and plastic toys which populate the shelves of US toy warehouses. Some of the rural enterprises are heavy polluters of agricultural land and most are still far from western standards of efficiency, but they have helped to absorb agricultural excess population -- which is estimated from between 100 to 200 million. The greatest potential benefit of the rural enterprises, however, is that they generate a *broad base* of managers and skilled laborers who are familiar with market mechanisms, understand technology and have learned the discipline of the assembly line.

This broad base of trained human resources will be needed in the *third phase* of economic modernization in China which started in the early 1990s and is in full swing today. It is characterized by a massive growth of the industrial, transportation and construction sectors (see Figure). China's leaders have realized that a *fundamental modernization of the infrastructure* is essential to make the country the third largest economy in the world. An enormous amount of capital is currently being invested into the construction of urban housing and business buildings, roads and railways, power plants and networks.

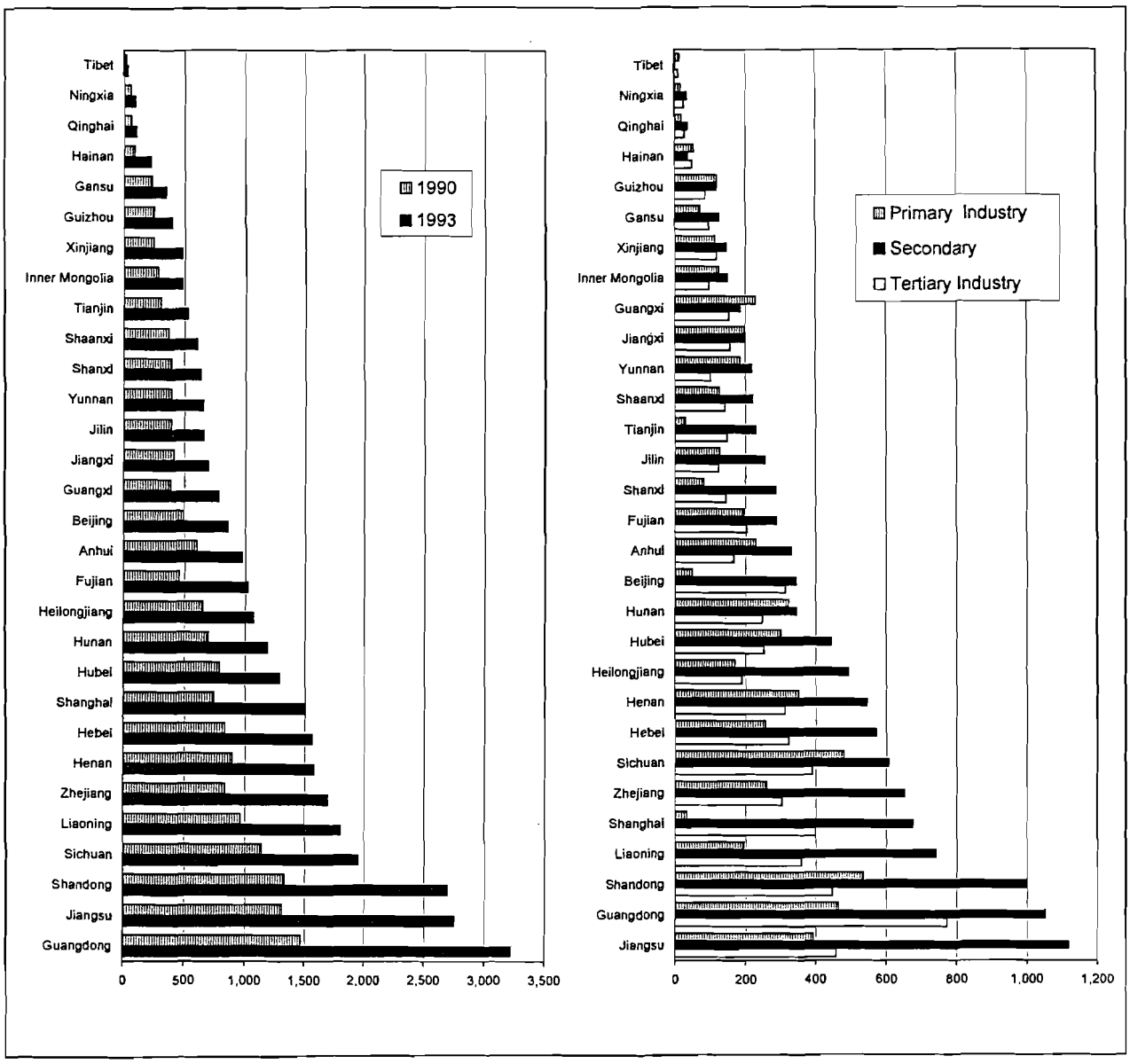
Figure 8: (a) Gross Domestic Product by Sector, 1978 - 1993 (in 100 million yuan)
(b) Gross Domestic Product generated in Construction, Transportation etc. and Commerce, 1978 - 1993, (in million yuan)



Source: Statistical Yearbook, 1993, 1994 (Beijing, People's Republic of China), p.33
Note: Figure is based on *current* prices.

The geographical focus of China's economic modernization is easy to detect: the highest growth rates, by far, are reported from the coastal provinces of Guangdong, Jiangsu, Shandong, Lianoing, and Shanghai, where in 1993 the GDP was up to 87 times higher than in the Western part of the country (see Figure 9). In fact, the Gross Domestic Product of Guangdong in 1993 was equivalent to the *total* GDP of Xinjiang, Tibet, Qinghai, Gansu, Yunnan, Inner Mongolia and Heilongjiang provinces *combined.* In other words, on 2.23% of China's total land area the province of Guangdong generates the same GDP as the seven other provinces mentioned above, which cover almost 63% of the country's land area. This indicates an *extreme* spatial concentration of economic activity in China.

Figure 9: (a) Gross Domestic Product by Province, 1990 - 1993 (in 100 million yuan)
(b) Gross Domestic Product by Province in Primary, Secondary, and Tertiary Industry, 1990 - 1993, (in 100 million yuan)



Source: Statistical Yearbook, 1993, 1994 (Beijing, People's Republic of China), p.35
Note: Figure is based on *current* prices.

While western scholars still dream of a country where transportation problems should be solved (for the sake of global carbon dioxide mitigation) by a mixture of bicycles and public transport facilities, China's economic planners have already decided that *road* transport will be a backbone of the country's economy. And *private* car ownership will be the growth engine for these ambitious plans. In late 1994, He Guangyuan, China's minister of industry, announced that "to increase car sales the state will introduce incentives to car buyers to boost market demand".[23] And in the summer of 1995 the Chinese government declared that the automotive sector will be the "pillar industry" of the economy. In the meantime the Chinese automobile industry, which was fragmented into some 125 state-run car manufactures, is in a process of consolidation. Before long it will be trans-

[23] China to Subsidize Car Purchases. International Herald Tribune, Sept. 23, 1994.

formed into three or four gigantic producers which will emerge from joint ventures with Germany's Volkswagen AG (in Shanghai and Changchun), PSA Peugeot Citroen from France (in Wuhan), Japan's Daihatsu Motor Co. (in Tianjin) and others.[24] Within the next five years they are expected to *double* annual car production from today's 1.5 to 3 million in the year 2000. By 2010 they should produce at least 4 million cars a year.

How will these economic trends affect the use of land in China? Three major trends can be anticipated:

- Facilities for energy generation (water reservoirs), transportation infrastructures and commercial buildings will eat up valuable cropland in China. Highways, such as the six-lane superhighway recently built from Guangshou to Shenshen, will be cut through former rice paddies to connect the industrial and urban centers in China's Eastern provinces. Between 1980 and 1993 the area of paved roads in urban areas quadrupled from 252 to 1075 km^2. Gigantic dams are built or planned to meet the growing demand for electricity, such as the "Three Gorges Dam" which will drown 113,000 acres of fertile land.[25] And all large cities in China will expand their perimeter due to an uncurbed construction boom. But there are land-use effects which will go far beyond.
- The car industry (which, by the way, was also the growth engine of Germany's "economic miracle" in the 1950s and 60s) will not only boost China's economy, but will also transform its economic structure. Private trucks will stimulate economic flexibility and expand markets. What a car or a truck means to an entrepreneur can easily be seen from Beijing's taxi drivers. Those who managed to get a car of their own have not only often become Yuan-millionaires -- they have also significantly changed the commercial and private transportation and collaboration patterns in the city. It is no longer bicycles which cause the usual traffic congestion. Commercial road transport will accelerate the transition from an agricultural to an industrial and service economy. Small-scale producers and service enterprises will be able to reach distant markets and consumers.
- The car will also -- as everywhere else in the world -- change everyday life in China. With a "people's car" (the Chinese actually use the same term as the most popular German automobile "Volkswagen") individual mobility[26] will *explode*. A growing number of citizens will experience the "freedom of the road" which can only be truly appreciated by those who were -- as the Chinese people -- controlled and restricted all their life. The experience of free individual mobility will change people's lifestyle -- in much the same way as it has transformed Western societies. Many of these new lifestyles which we will discuss below, are highly land-use related.

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[24] "Mercedes-Benz Seals $1 Billion China Deal. Chrysler and Ford Are Beaten Out For Joint Venture to Build Minivans". In: International Herald Tribune, July 13, 1995, p. 1: "China to Churn out Personal Cars. Can Its Infrastructure and Ecology Stand the Weight?" International Harald Tribune, Sept. 23, 1994.

[25] Topping, A.R. (1995): Ecological Roulette: Damming the Yangtze. In: Foreign Affairs, Vol. 74, No. 5, 132-146

[26] The term "individual" in this context should not mean "one person", but rather "one family". It is, however, the opposite of "collective" which is still a dominating principle of social organization in China.

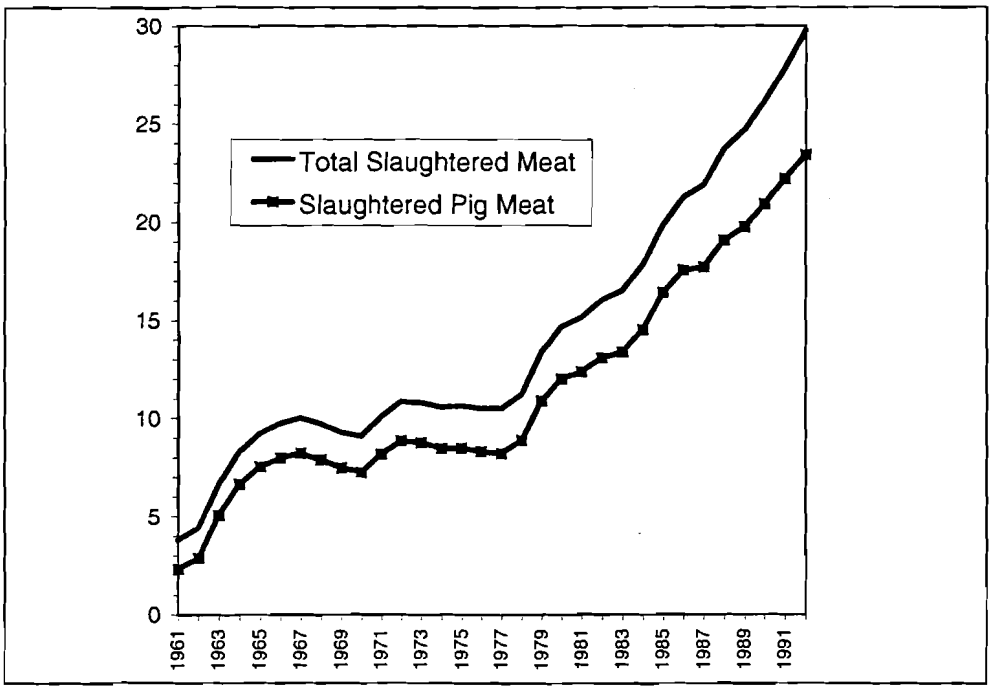
The rapid industrialization of China, which generated spectacular economic growth rates for more than a decade will significantly transform the country's land use patterns. Economic experts have argued that the urban parts of the Yangzi delta which are the centers of China's economic growth will become one big metropolitan sprawl like the one along America's east coast, from Boston, through New York, to Washington.[27]

2.4 Changes in Lifestyles

Food Preferences

Diets and food preferences can have a great impact on agriculture. It certainly makes a big difference in terms of land-use and -- by the way -- input energy efficiency whether 2000 kcal are consumed as a T-bone steak, a bunch of candy bars, or a bowl of rice. Unfortunately, it is not easy to predict trends in food preferences -- especially for a country like China. Much depends on the future level of income available for food -- a parameter very difficult to project. But there are also *cultural* factors, that have to be taken into account. Food consumption isn't just the supply of carbohydrates, protein, fat, vitamins, and fiber. As we know from the French, it is a way of life. Chinese cuisine may resist western dietary trends.

Figure 10: Per Capita Meat Production in China (in kg)



Source: FAO (1994): AGROSTAT. Rome (Electronic Data Base)

On the other hand we know that urban populations usually prefer different kinds of food than peasants. An increase in the proportion of urban population will thus automatically change China's overall composition of food demand. We

[27] The Economist, Sept. 9, 1995, p. 63

also have time-series data which indicate that a change in food preferences already occurred in China during the last decades. These trends can be extrapolated. Cross-country comparison is another possibility to determine future trends of food preferences in China. Other Asian countries, such as Japan or South Korea have experienced a change in dietary preferences during the last decades which could be seen as a prototype to model the Chinese transition. And finally, there is reason to believe that Western influence on Chinese food preferences may be more rapid and profound than expected. For the moment, the following trends seem to be most relevant for detailed research:

China's meat consumption significantly increased during the past 30 years. Per capita production of animals slaughtered, for instance, grew from about 4 kg per year in 1961 to almost 30 kg per year in 1992 (see Figure 10). The increase of meat consumption in China was mainly due to the consumption of pig meat (see Figure 10). Mutton, veal and beef are not very popular in China.

It is quite likely that the consumption of animal-based food (meat, dairy products, eggs) will further increase in China. Other Asian countries, such as Japan already have a much higher consumption of animal-based food (see Table 9). The most "Western" dietary pattern is probably represented by the United Sates. It could be considered an upper limit for the consumption of meat and dairy products.

What would be the land-use consequences of an accelerated trend towards animal based food in China? A further increase of pig meat consumption would probably boost the demand for feed crops, such as soybeans. In fact, the Chinese soybean areas increased significantly during the last few years. While soybean has its origin in China and was already cultivated there some 2800 years B.C.,[28] not much of it was grown before the late 1980s. The 1994 Statistical Yearbook begins to report production areas for soybeans in the year 1992 with 8 million ha. By 1993 the total sown area of soybeans had increased to over 12 million ha. This is equivalent in size to the *combined* areas for the production of vegetables, tobacco, sugar, and tea (!). In Heilongjiang one third of all cropland is already used for the cultivation of soybeans; in provinces with large extent of arable land, such as Henan or Sichuan, the soybean cultivation has increased to between 4% to 6% of the cropland area (see table A1 in the Appendix). A further trend towards meat-rich diets in China would also trigger a corresponding (per capita) decline in areas for cereal and roots and tubers production.

Parts of China's grasslands *might* be suitable for ranging additional cattle. Beef is not unknown to the Chinese cuisine so it might be reasonable to consider the vast grasslands as one of the underutilized resources for the production of food. The main problem, however, is water. Large numbers of cattle would require the drilling of wells in these dry areas. Even if there is enough water underground, massive ecological problems, which we know from the African Sahel, could follow. It seems to be more reasonable to think about an expansion of pastoral systems based on animals better adapted to draught, such as camels, mules, sheep and goats.[29] Obviously, any expansion of pastoral systems in China has to take

[28] Cheng Chunshu (Ed.) (1993): Climate and Agriculture in China. Beijing, China Meteorological Press, p.179

[29] Cheng Peilieu (1984): Livestock breeds of China. Rome (FAO Animal Production and Health Paper, 46)

into account the close relationship between the productivity of livestock and their ecological conditions. Pastoral systems can only increase their production when they are adapted to the climatic conditions (temperature), the topography, the availability of water, and the kind of vegetation and topsoil of the specific grassland area.

Table 9: Patterns of Food Consumption in the USA, Europe, the former USSR, Japan and China: Average Calorie Consumption per Capita per Day, 1990

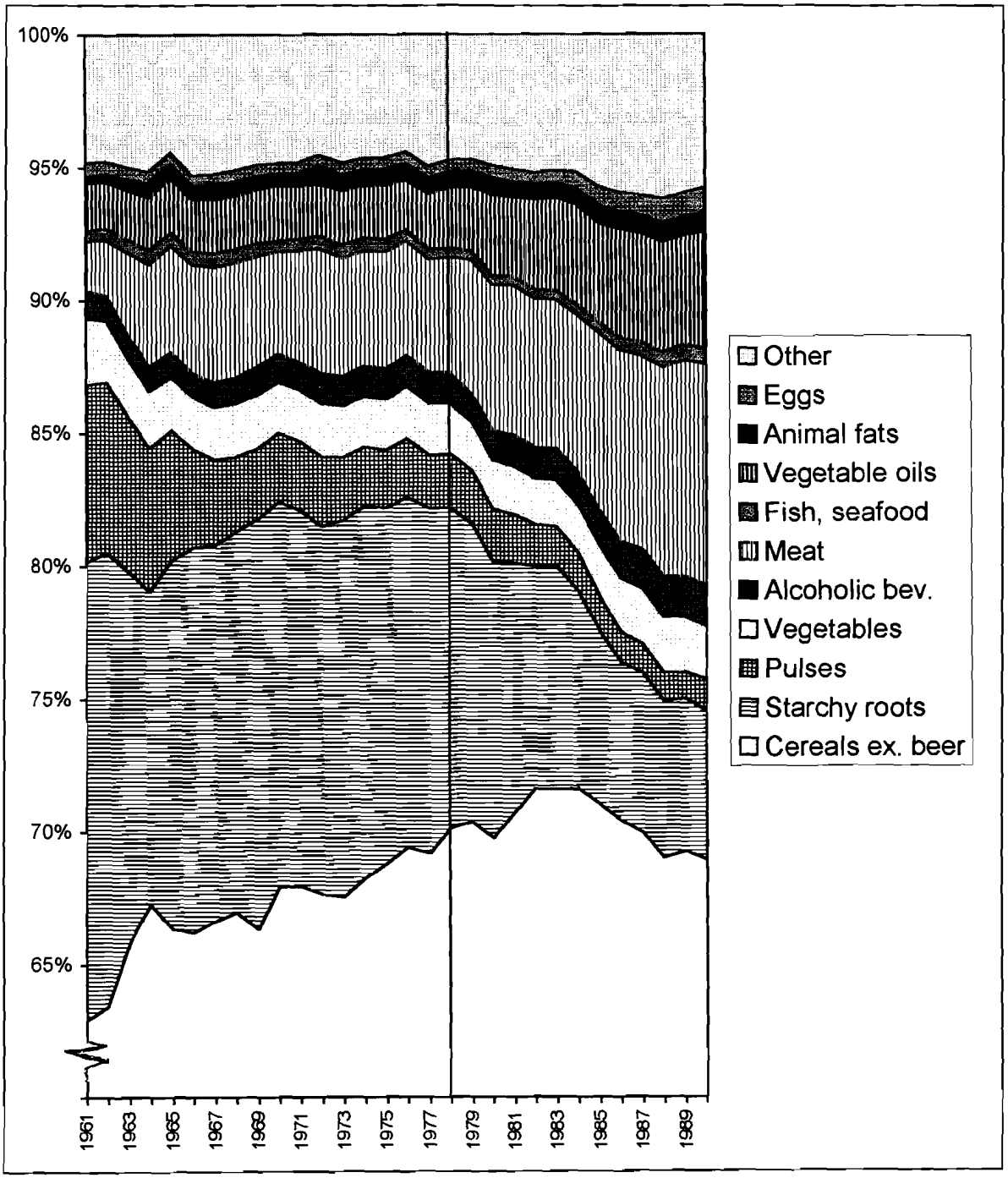
Calories per Cap./Day (in kcal)					
	USA	Europe	USSR	Japan	China
Grand total	3680	3439	3391	2926	2706
Vegetable products	2568	2310	2426	2304	2401
Animal products	1112	1130	965	622	305
Cereals ex. beer	822	931	1254	1164	1865
Starchy roots	98	146	178	77	151
Sweeeteners	610	371	475	300	66
Pulses	32	31	21	22	32
Vegetable oils	528	374	236	270	119
Vegetables	80	77	53	75	54
Stimulants	18	19	3	18	1
Meat	531	474	357	165	226
Animal fats	116	252	213	57	19
Eggs	52	50	57	74	26
Fish, seafood	30	35	72	200	16
Other	763	679	472	504	131
Calories per Cap./Day (in Percent)					
	USA	Europe	USSR	Japan	China
Grand total	100.0	100.0	100.0	100.0	100.0
Vegetable products	69.8	67.2	71.5	78.7	88.7
Animal products	30.2	32.9	28.5	21.3	11.3
Cereals ex. beer	22.3	27.1	37.0	39.8	68.9
Starchy roots	2.7	4.2	5.2	2.6	5.6
Sweeeteners	16.6	10.8	14.0	10.3	2.4
Pulses	0.9	0.9	0.6	0.8	1.2
Vegetable oils	14.3	10.9	7.0	9.2	4.4
Vegetables	2.2	2.2	1.6	2.6	2.0
Stimulants	0.5	0.6	0.1	0.6	0.0
Meat	14.4	13.8	10.5	5.6	8.4
Animal fats	3.2	7.3	6.3	1.9	0.7
Eggs	1.4	1.5	1.7	2.5	1.0
Fish, seafood	0.8	1.0	2.1	6.8	0.6
Other	20.7	19.7	13.9	17.2	4.8

Source: FAO (1994): AGROSTAT. Rome (Electronic Data Base)

During the last 30 years worldwide sugar consumption multiplied, as the availability of soft drinks (Coca Cola) and manufactured candy bars expanded to almost every part of the world. Industrially manufactured soft drinks and the enormous range of "sweet "products produced from cocoa and sugar were extremely rare only 50 years ago. Today their marketing has expanded to even the most remote village on earth. There is a high probability -- if economic and

political conditions allow for it -- that in a few years young Chinese will also drink Coca Cola (or Pepsi), have a Hamburger and enjoy a milkshake or ice-cream (full of sugar). There is no reason why the expansion of some 14,000 McDonald's restaurants should stop at the Chinese boarder (when one can find them easily in Guatemala City, Moscow or Jakarta). If only a *fraction* of the 1.6 billion projected Chinese consumers in 2050 will begin to prefer such a "western" diet, it will have a significant impact on the (worldwide) sugar (and meat) demand.

Figure 11: Changes of Food Consumption Patterns in China: Average Calorie Consumption per Capita per Day, 1961-1990



Source: FAO (1994): AGROSTAT. Rome (Electronic Data Base)

Note: Cereals (mainly rice and wheat) account for between 63% and 69% of the average Chinese calorie supply. Changes in the proportion of other food commodities are much smaller. To make these visible we have rescaled the y-axis. Please note that it starts at 60%.

Experience from Northern America and Europe suggests that there will not only be a trend towards animal-based food in China, but also a trend for increased vegetable oil consumption (see Table 9). As people prefer more meat, they often switch from animal fat to vegetable oil in order to avoid over-consumption of cholesterol. Recently, the Chinese government set up a commission to study how *over*-consumption of pig-meat could be stopped in order to prevent cholesterol-related diseases.

Other land-use related lifestyle changes

There are many lifestyles which directly or indirectly affect land-use patterns. Most of these lifestyles are related to the level of wealth in a society. As people become more affluent they usually prefer larger flats or move to suburban houses with gardens. This certainly affects land-use patterns, as one can easily observe in the sub-urban sprawl of Southern California and many other highly developed places. Of course, there is a long way (of economic growth) before Chinese cities might expand into space-consuming suburbs. But even a very modest increase in the demand of improved housing, and the most likely split-up of the large multi-generation Chinese households into core-family households, will boost land demand for (urban) housing.

Even if some scientists believe otherwise, further economic growth in China will probably require a *massive* expansion of the private transportation sector.[30] There can be no doubt that this expansion of transportation infrastructure is well on its way. Between 1980 and 1993 total fright traffic in China more than tripled, from 9.8 to 30.5 billion t km^2. The area of paved roads increased by 326%; the per capita area of paved roads more than doubled (see Table 10). The modernization and commercialization of agriculture and the further expansion of industry just need a much larger transportation capacity than traditional (subsistence) farming or small-scale industries. Farmers have to supply *distant* markets within (and possibly also outside) the country. They need inputs (fertilizer, pesticides) which are produced in industrial areas and must be transported into the rural areas. Export-oriented industrial production which is rapidly expanding in China obviously has a much higher transportation volume than traditional small-scale industries which supplied local markets.

China's economic growth also generates income which will eventually make motor bikes and cars affordable to private owners. Indonesia, Thailand, Malaysia already had their "Honda-Revolution" as can be easily observed in the traffic jams of Bangkok, Jakarta or Kuala Lumpur. The *explosion of mobility* is typical for all industrial societies around the globe. Why should China be an exception?

It is very difficult to estimate the direct and -- even more important -- indirect impact of increasing mobility on land-use patterns. Transportation infrastructures (roads, railways, airports) will expand; more space will be needed for the servicing and supply infrastructure (car factories, service stations, etc.). But this direct impact on land-use will be minor compared to the indirect effects of increasing mobility, such as tourism, commuting, short-term migration flows, etc.

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[30] The lack of transportation infrastructure in various African countries South of the Sahara is a major cause of its economic development disaster.

Table 10: Selected Consumption and Lifestyle-related Statistics

Consumer Goods (in 1000)	1978	1985	1993	Increase 1985-1993 (in 1000)	Increase 1985-1993 (in %)
Casette Recorders	47	13,931	36,479	22,548	162
Household Refrigerators	28	1,448	5,967	4,519	312
TV Sets	517	16,677	30,329	13,652	82
Household Washing Machines	0	8,872	8,959	87	**
Mobility-related Statistics					
Number of Tourists	5,703	17,833	41,527	23,694	133
Total Passenger Traffic (100,000,000 person km)	1,743	4,437	7,858	3,421	77
Civil Aviation	28	117	478	361	309
Highways	521	1,725	3,701	1,976	115
Railways	1,093	2,416	3,483	1,067	44
Total Freight Traffic (100,000,000 t km)	9,829	18,126	30,510	12,384	68
Civil Aviation	1	4	17	13	325
Highways	274	1,693	4,071	2,378	140
Railways	5,345	8,126	11,955	3,829	47
Food-related Statistics					
Output of Major Farm Products (in 10,000 t)					
Tea	27	43	60	17	39
Fruits	657	1,163	3,011	1,848	159
Pork, Beef, Mutton	856	1,761	3,225	1,465	83
Aquatic Products	466	705	1,823	1,118	159
Oil Crops	521	1578.4	1803.9	226	14
Sugar Cane	2111.6	5154.9	6419.4	1,265	25
Sugar Beets (Beet Roots)	270.2	891.9	1204.8	313	35
Wealth / Income					
Per Capita Average Annual Wage of Staff and Laborers (in yuan)	615	1,148	3,371	2,223	194
Per Capita Average Annual Consumption (in yuan)					
Agricultural Population	132	324	774	450	139
Non-Agricultural Population	383	727	2480	1,753	241
Urban Public Utilities	**1980**	**1985**	**1993**	**Increase 1980-1993**	**Increase 1980-1993 (in %)**
Per Capita Residential Consumption of Water (in t)	46.8	55.1	68.8	22	47
Area of Paved Road (10,000 m^2)	25,255	35,872	107,471	82,216	326
Area of Paved Road (10,000 m^2) per 10,000 of Population	2.8	3.1	6.5	4	132
Public Green Areas (in m^2)	85,543	159,291	576,832	491,289	574
Public Green Areas (in m^2) per 10,000 of Population	9.6	13.7	34.9	25	264

Source: Statistical Yearbook, 1994 (Beijing, People's Republic of China), p. 20-23

Recently, China has reduced the number of working days per week from six to five. This immediately sparked a small-scale vacation boom. Public parks and beaches are now crowded on the "long weekends" -- a first step toward domestic tourism. Recreational land use might be still minimal in China, but with an increase of wealth this will change. Official statistics already indicate a more than three-fold increase in the per capita size of "public green areas" since 1980 (see Table 10).

Total passenger traffic in China has increased tremendously from 1.7 billion person km^2 in 1978 to 7.9 billion person km^2 in 1993 (see Table 10). It is not *completely* impossible that sometime in the future a few hundred million Chinese *will use their cars* to visit friends and family members during the "Spring Festival" or go on vacation (something the present generation not even dreams of). What this will do to China's land can be observed in the most densely populated countries of Europe, where the remaining "natural" land is sliced by roads and highways and where coastal areas are covered by the semi-urban sprawl of tourist centers (such as the "Costa del Sol").

In 1995 almost five million foreigners visited China -- expatriate Chinese *not* counted. This invasion of foreigners will inevitably change attitudes and lifestyles. One can already observe western-style weddings, beauty contests, gambling halls, cellular phones, busy MacDonald's restaurants, numerous luxury limousines, and Coca Cola drinkers everywhere.

2.5 Future Political and Economic Conditions

Future land-use in China, of course, heavily depends on how the country's leaders will pursue reform. But what does the future hold for China?[31] Will the country experience political and economic stability?[32] Will its provinces and special economic zones gain even greater economic and political independence from the center? Could there be a violent power struggle after Deng Xiaoping's death? Will corruption paralyze economic reforms? Is further economic modernization possible without political change? No one knows the answers -- and those who pretend they do, have not learned the lesson of radical political changes in this century. All we can do is speculate.

Let us envision three scenarios; one, in which China will experience further economic liberalization and gradual progress towards democracy; another, in which the country would sink into the chaos of a full-blown civil conflict sparked by regional diversities and people's discontent with political and civil repression; and third, a country in which a post-Deng "strong men" or power elite puts the brakes on economic and political reforms to re-centralize authority.

Scenario 1: Market economy and socio-political liberalization

Many people inside and outside China hope that the country can achieve what would be a *unique* development among the communist states of the 20th century:

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[31] Segal, G. (1994): The Muddle Kingdom? China's Changing Shape. In: Foreign Affairs, Vol. 73, No. 3, 43-58

[32] Lieberthal, K. (1995): A New China Strategy. In: Foreign Affairs, Vol. 74, No. 6, 35-49

a smooth transition from command to market economy, a gradual liberalization of society and a peaceful transition to democracy. In this scenario the China of the 21st century would be more open to the outside world, wealthier, and more regionally diverse. There would be more individual freedom, greater political participation and economic flexibility, but probably also more corruption and income disparities. [33]

In this political scenario land-use would be increasingly dominated by market mechanisms. Private owners would make the decisions about land-use -- not a central bureaucracy far away. The *price* of land would determine to a great extent for which purpose the land would be used. It is not difficult to predict that in this scenario private farmland in close neighborhood to large booming cities and towns would be quickly converted into suburbs and commercial sites. Few farmers prefer to cultivate their land when they can sell it and become millionaires. Land-use change around urban areas of Europe or Northern America was usually associated to the emergence of rather opulent wealth among the original land owners.

The use of land in rural areas would very much depend on producer prices for agricultural products and, if they are introduced, state subsidies. Europe is a showcase of how quickly land use can change with consecutive waves of state subsidies and market conditions: the farmers plant whatever generates more income. For instance, changing food preferences (and various subsidies) have made oil crops in Europe often more profitable than roots and tubers. Hence, the soybean area harvested increased 50 times between 1961 and 1981 from 21,000 to 1,331,000 ha, the rape seed area expanded almost 6 times and sunflower seed areas almost 5 times. The area for roots and tubers production, however, was reduced by 50% between 1961 and 1992 (from 8.9 to 4.2 million ha).[34]

Bio-physical conditions, such as the quality of the soil, the amount of rainfall or the level and distribution of temperature are certainly not irrelevant for the land-use patterns of a *market-oriented* agriculture, but they are often less important than socio-economic incentives (and subsidies). Finland is a good example: the country's soils and climate is certainly not optimal for the production of rape seed. Yet even in this cold and rainy climate the country's farmers expanded the rape seed area between 1961 and 1992 by a factor of 12 -- from 6,000 to 73,000 ha. And they even managed to increase the area of sugar beet cultivation from 18,000 to 32,000 ha.

If China's agriculture moves towards a market system, *consumer demand* will primarily determine how the arable land is used. This is a clear lesson from Europe and Northern America. Thus, food preferences and other socio-economic conditions are not just interesting side aspects. They are major driving forces of land use.

In conclusion, we can assume that in an "economic growth scenario" China's agricultural land use patterns would be rather fragmented, highly variable and regionally diverse, due to individual decision making of land owners and changing consumer demands. Much land would be transformed into urban areas

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[33] Lieberthal, K. (1995): Governing China: From Revolution through Reform. New York (W.W. Norton)

[34] FAO (1994): AGROSTAT. Rome (Electronic Data Base)

or industrial sites. The rapidly growing industrial economy would require a significant expansion of (road) infrastructure, which would not only cut through cultivated areas, but also open up previously remote areas to colonization or resource exploitation. Much more land than today would be needed as parks and recreation areas for the "exploding" urban population.

Scenario 2: Chaos and conflict

While most of the professional China observers seem to predict a more or less linear, continuous economic and political development for the country, far more radical and violent alternatives cannot be excluded. As Arthur Waldron has pointed out "substantial -- and not evolutionary or gradual -- changes are not only possible but likely".[35] The biggest threat to China's economic and political stability comes from *within* the system: it is the contradiction between economic liberalization and ongoing political control. The situation is like a horse race in which the animal storms forward at the spurs of the jockey who simultaneously draws in the reins. It is hard to believe that China's still very small but growing middle class of successful managers, entrepreneurs, and professionals will much longer accept the top-down control of a communist bureaucracy. It is also hard to believe that the students and intellectuals can be kept quiet for all times. The economy needs smart managers who know the world -- how could they otherwise compete in international markets? But those who are sent abroad have seen individual and political freedom they will demand back home.

Equally explosive might be the rapidly growing regional diversity which is also a result of China's economic success. How long will a powerful local politician or economic leader accept interference from center which is a continental distance away? China's vast size has always been a threat to its unity, but it will be even greater as the provinces further drift apart in their economic performance.

Finally, we have to realize that Deng Xiaoping's 1978 reforms have not only transformed the country economically, but also socially. The threat of famine and poverty had been greatly reduced; millions more Chinese have learned how to read and write; TV sets and radios have given peasants a glimpse of the world; and people, for the first time in communist China, could travel relatively unrestricted. Every year, during the "Spring Festival" China's train stations are clogged for several days as *millions* of peasants are on their way to see friends or look for a (temporary) job in a city. There is a saying in Europe that "a serf becomes a freeman if he stayed in a town for a year and a day". In China, millions of peasants will go urban. It might not have been his intention, but Deng has triggered a "cultural revolution" with his reforms which could easily spark a real upheaval. Those who believe a civil revolution impossible in China, should think twice: no one had thought a few years ago that the disciplined East Germans would use crowbars and hammers to break down the "Berlin Wall" and that the Soviet flag would be lowered over the Kremlin. A civil revolution, however, could easily result in chaos and conflict. The ruling power elite might not grant

[35] Waldron, A. (1995): After Deng the Deluge. China's Next Leap Forward. In: Foreign Affairs, Vol. 74, No. 5, 148-153

greater freedom and participation, but use the military to restore order. The protest might expand to the regions and get out of control. There might be divergent interests between political leaders of wealthy regions and the central government. It would not be the first time of civil war in China.

What would all this mean to land use in China? We have some recent experience with African countries that have drowned in political conflict and civil war, such as Ethiopia, Angola or Mozambique. Usually, these conflicts have caused a serious decline of agriculture, followed by widespread food deficits and famine. Africa's food disasters during the last decades are almost all associated to war and civil conflict. In a long period of civil war farmers usually switch back to *subsistence* farming, since transport routes are unsafe and markets often inaccessible. Areas of market production fall fallow. Therefore, a paradox consequence of political conflict and agricultural decline can be the recovery of "natural" land. The most important land-use consequence of a civil conflict in China, however, would be the stagnation or even decline of industrial and urban land. Foreign investment in China, which is a growth engine of the economic success, would immediately go down if the country looses its stability. The ambitious plans for infrastructure expansion, however, could not be carried out without foreign assistance.

In conclusion, if China would loose its current economic and political stability in a civil conflict, the country would remain more *rural*. Urban land use would grow much slower or even decline -- as recently arrived peasants would probably go back to their village. Agricultural land use would be more affected by agroclimatic conditions than by market demand. The intensity of cultivation would decline, as modern inputs, such as fertilizers, pesticide and seeds of high yielding varieties would become scarce during the economic crisis.

Scenario 3: Restoration of central authority and planning

If there is one thing every Chinese ruler is aware of then it is the threat to the country's unity. China is the most enduring human civilization, because whenever the country was in danger of being split up the center managed (sometimes after many decades) to re-centralize authority. And whatever went wrong with communism in China, one achievement is undisputed: it helped to reestablish and maintain the country's unity. China's leaders have not forgotten the decade of civil war in the 1920s, when China was in danger to fall apart as civil warlords fought for power after the Manchu empire collapsed.[36]

One obvious possible scenario for China, therefore, is that the leaders might put on the brakes and re-centralize the power structure. Most likely this would include a backslash to a centrally planned, Soviet-style command economy.[37] And one of the first decisions of a new "strong-man" or authoritarian power elite would be to seriously restrict mobility. The old guard of communists from the "Great March" always hated the urban society, because they (correctly) suspected it ideologically unreliable. The "Cultural Revolution" promoted by a radical fraction around Mao's wife, was not only a campaign against intellectuals, it was

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[36] Harland, B. (1993): For a Strong China. In: Foreign Affairs, No. 94, 48-52

[37] Hornik, R. (1995): Bursting China's Bubble. In: Foreign Affairs, Vol. 73, No. 3, 28-42

an attempt to weaken the urban areas. De-urbanization is one of the core ideas of radical communism -- from China to Cambodia and Russia to Cuba.

The land-use consequences of a return to central authority and communist economy would probably be a slow down of urbanization -- partly due to stricter control of mobility, partly due to a slow down of urban economic growth. With a re-establishment of central planning land cultivation would become more homogenous. In the current system of family farming the peasants have some incentives to increase productivity: they can use part of their production to generate private profits, either by selling it on urban markets or to state agencies. Hence, the farmers will try to optimize land cultivation so that it meets the specific biophysical, climatic and hydrological conditions. This is not necessary and possible with centralized planning, where land use is determined by a general economic scheme.

3. Discussion

Of all anthropogenic factors that might affect future land use change in China the increase of population is probably the most predictable. Not much can be done to *prevent* a significant population increase. Fertility is already down to a West European level and a massive increase of mortality is not in sight. On the contrary, it is quite likely that mortality will further decline with economic development. There is also a clear potential for an increase in fertility. China was so successful with its "one child policy", that the government might have to relax restrictions to cool down widespread frustration with the measure.[38] Of course, no one can predict fertility for the middle of the next century, but most demographers would be very surprised if the Total Fertility Rate were lower than 2 and much higher than 2.5 children.[39] Depending on mortality assumptions this would be equivalent to a population increase of at least 400 million. To curb this growth rather drastic (if not coercive) measures would be necessary in order to reduce average fertility to about 1.5 children per woman. But even then China's population would grow for the next two or three decades and only then begin to decline to its current size.

Urbanization seems to be a different story. There are various measures which can affect the speed and extent of an urbanization process. The mobility of a population can be controlled and restricted by both direct and indirect measures. One important factor is the relation of agricultural to non-agricultural income; but one can also impose legal restrictions, or reduce the availability of cheap transportation and urban housing. The location of industrial sites also affects the urbanization process. All these means of intervention, however, only work in the planned economy of an authoritarian state. Not much can be done to control or even prevent rural-urban migration and city growth in a liberal society and a market economy. As China moves into this direction the country will experience much

[38] Feeney, G. / Wang, F. (1993): Parity progression and birth intervals in China: The influence of policy in hastening fertility decline. In: Population and Development Review, Vol. 19, No. 1, 61-101

[39] Feeney, G. / Jingyuan Yu (1987): Period parity progression measures of fertility in China. In: Population Studies, Vol. 41, No. 1, 77-102

the same population re-distribution as is typical for all industrialized democracies.

But what about the economic trends? Can we just extrapolate China's present economic growth rates into the future? For all its impressive industrial growth in recent years, China is still a poor and underdeveloped country. Even if we believe the economic growth statistics cited above (which, of course we do only to a certain extent), there is reason to suspect that the boom will slow down. As Paul Krugman has outlined in his review of recent economic research on the Pacific Rim, the popular enthusiasm about Asia's economic miracle "deserves some cold water thrown on it".[40] There is evidence that economic growth in Asia is running primarily on massive increases of inputs like capital and labor, rather than by gains in efficiency.[41] Due to the steep fertility decline in past decades, China, at the moment, has a huge labor force of healthy well educated adults in their 30s, who have few children and few elderly to take care of. The proportion of population in active to non-active age is extremely favorable in China. The economic liberalization also brought much capital into the country and the privileged access to the American market boosted demand. China became one of the largest importers for the US. But all these are *one-time* advantages. In a few decades the large generation of Chinese "Baby Boomers" (from *before* the steep fertility decline) will be in their 60s and 70s and will have to be supported by their few children (of the "one child policy" generation) (see Figure 12).

Moreover, capital investment works best in the initial phase of economic growth: a construction brigade with shovels will gain a huge increase of output when given a bulldozer; however a more advanced construction company with 50 bulldozers will produce only slightly more when given one more machine. Most economic indicators that show very high economic growth for China start in 1978, when the country was economically broke and in the firm grip of a Stalinist command economy. Indices based on more recent years are less impressive. In other words, there is a clear level effect in China's spectacular economic growth rates. It will take a long time, before China's economy is driven by real advances in (labor and technological) efficiency -- that is increases of output *per unit of input*. China's spectacular economic growth will probably run into diminishing returns.

The linear economic growth scenario also does not take into account environmental restrictions and side effects. For instance unlike the USA, China -- in the long run -- cannot afford to base its economy exclusively on road transport and make the excessive use of private cars a major growth engine of its industry. Not to speak about CO_2 emissions, there is simply not enough space. People tend to forget that China is *extremely* densely populated. For instance, Henan, Shandong, and Jiangsu have a combined total population of 237 million, which is only a little less than the total population of the United States of America; their population density, however, ranges from 512 to 654 people per km^2 -- up to 24 times higher than the average US population density of 27. 14 of the 30 Chinese provinces have a (much) higher population density than Germany.

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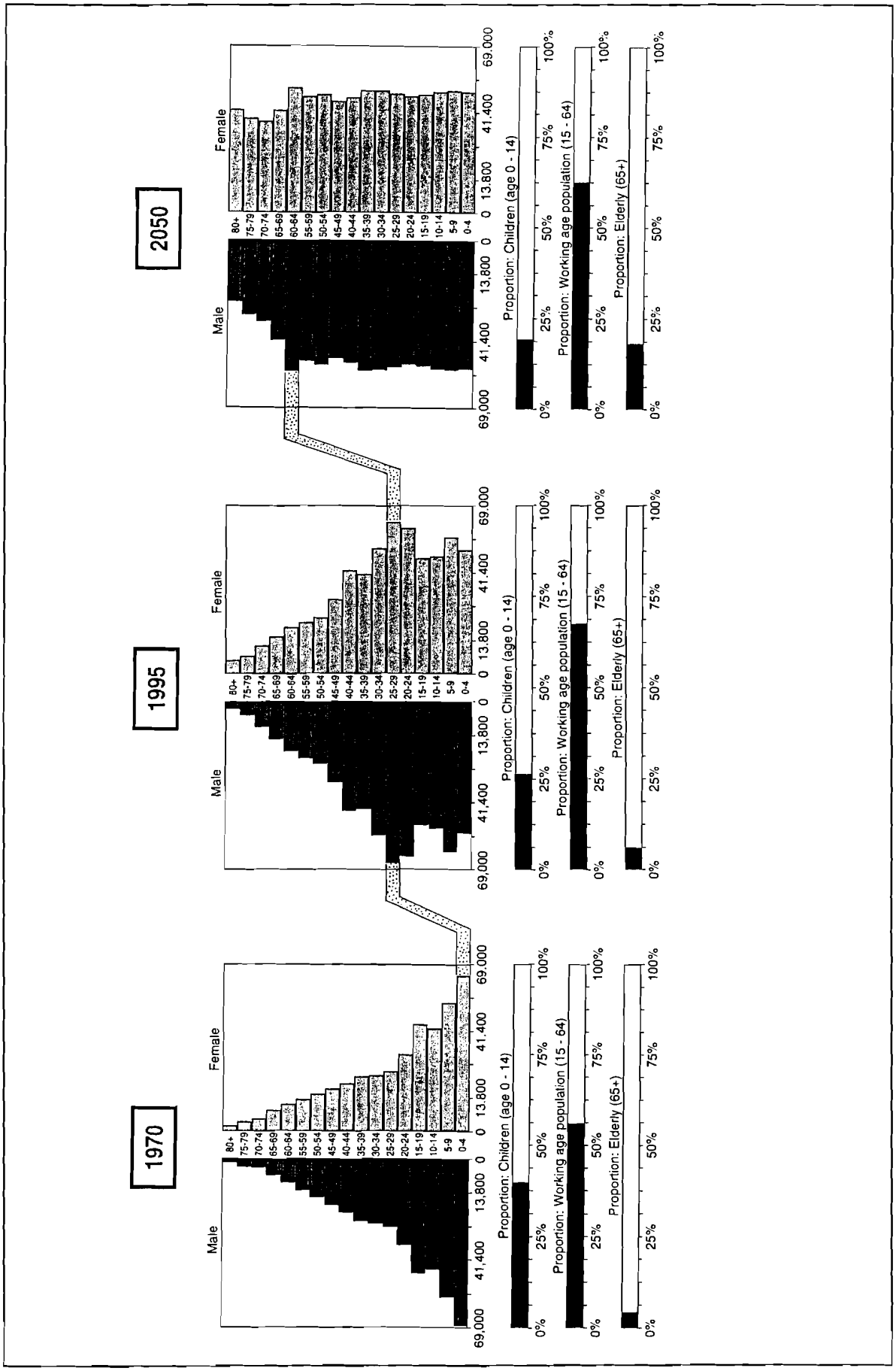
[40] Krugman, P. (1994): The Myth of Asia's Miracle. In: Foreign Affairs, Vol.73, No. 6, 62-78

[41] Lau, L. / Jong-Il Kim (1994): The Sources of Growth of the East Asian Newly Industrialized Countries. In: Journal of the Japanese and International Economies

Figure 12: China's Population by Age and Sex, 1970, 1995 and 2050



Source: UN Population Division (1995): Population Assessments and Projections, 1994 Edition (from DemoGraphics '94)

If China would have the same per capita car-related land consumption as the US or Europe, much of the valuable arable land would have to be converted to roads, highways, parking lots, and car production sites. In the long run, China's eastern provinces do not have the option of a car-based society such as the United States; they will need efficient mass transport to save valuable land. In the short run, however, cars and commercial road transport will significantly change land-use patterns in China.

How certain can we be, that land-use related lifestyles will change in China? Quite certain, if there is (at least a slight) growth in mass income! Despite cultural differences people all over the world seem to have an astounding array of shared consumption needs: from Indonesia to Germany and China to the United States people, for instance, immediately begin to change their diet when a broader range of food becomes available and when they can afford it. They begin to eat more meat and sugar, but also more vegetables, fruits and stimulants (coffee, tea, beer). Their diet becomes less monotonous. China has already switched from the rice and noodle diets of Mao's time to a more varied cuisine. Western style food is very popular among the growing urban middle class. If you want to see a really crowded MacDonald's the one behind Tianamen Square is a good choice.

In this context it might be interesting to know that the McDonald's restaurant on Moscow's Pushkin Square has served 80 *million* customers (!) since it was opened in 1990.[42] (It was impossible to get equivalent data for the MacDonald's restaurants in Beijing). Unfortunately, the impact of this astounding fact is easily misunderstood. People usually consider it just a triumph of "western capitalism". But the *socio-cultural* side of this success is *far more* important. It indicates a *globalization* of taste and lifestyles -- which is the basis of worldwide marketing of "hamburgers", "Coca Cola", rock-music CDs, videos, movies, or computer games. If we like it or not, what MacDonald's is doing in Beijing (or Moscow, Jakarta, New Delhi, or Paris) is not just selling squashy buns with minced meet, but *educating* (or brainwashing) the world about taste. Tastes, especially food preferences, which once were an element of ethnic identity, will gradually become the result of marketing techniques from multi-national corporations. This will also affect China, if the country remains open to the outside world.

Who ever has traveled the developing world knows that motorbikes and cars have a very high consumption priority not only in Los Angeles or Rome, but also among peasants emerging from poverty. The Honda revolution in Asia is a clear indication of this need. Millions of poor farmers in Indonesia, Thailand, Malaysia and the Philippines have saved all their money to get a motorbike for the eldest son. The automotive revolution will spread to all parts of the world as soon as economic conditions allow it -- no matter what green activists might grumble about. We better face what seems to be a *basic human need* and make sure that the most advanced technology is available to minimize energy consumption and pollution when Asia's multi-billion population will hit the road. In the long run, China will need mass transport to save its land from the concrete of roads (and the world from CO_2 emissions). But for the next one or two decades we will see an

[42] "Borscht and Blini to Go. From Russian Capitalists, an Answer to McDonald's". In: The New York Times, August 9, 1995, p. 1 (Vol. CXLIV, No. 50148).

explosion of motorbikes and cars -- especially in China, and much land will be used for roads and highways.

Finally, what are our chances to predict China's political system or at least to design useful scenarios? Very poor, I suspect! One could easily fill a whole book from cover to back with *false* predictions and absurdly *gross* misinterpretation on China (and, I am afraid, some arguments and data in this paper might be among them). The reason for poor predictions is an unusual lack of valid information.

Data Validity

When Lord Boyd-Orr, former head of the UN Food and Agricultural Organization visited China he was obviously pleased with what he saw and what the battalion of statistical number crunchers and analysts at his Rome headquarters had told him about the country. He announced that Chinas peasants had raised their crop yields to British levels and ended the traditional famine cycle. "Speaking in 1959, he concluded, 'China has one-quarter of the world's population but seems capable of feeding it well'. "[43] Not quite -- as we know today. While the UN director was lecturing his audience on China's agricultural success, some 23 million or more peasants were dying in the largest famine ever recorded.

Such colossal failure to see the truth, however, was not the privilege of a high rank official who was a bit detached from reality. Even hard-core China watchers, careful scientists and nosy journalists who pretended to know the country like their pocket, missed the tragedy of the Great Leap Forward. In fact, there is evidence that Mao himself didn't know what was going on. Why is it so difficult to understand China?

Not many countries have a more advanced system of *institutionalized* misinformation. The dynastic bureaucracy had always been a powerful buffer and selective filter between the real world and the court of the emperor. That didn't change much under the communist government. For the first few years after the founding of the People's Republic of China there was almost no *nationwide* collection of statistical data -- the only exception was the 1953 population census. When the State Statistical Bureau was established in late 1952 to monitor the First 5 Year-Plan period (from 1952 - 1957) the situation temporarily improved. By the end of 1957 a few economic and demographic data (from the census) were published and accessible to foreigners.[44] But then the statistical system began to disintegrate and fell under strict political control for more than two decades. Party cadres, instead of statisticians collected data and almost everything was restricted for foreigners. Economy statistics were used for allocation of resources, income, privileges and power. They were manipulated to "show success" and fulfillment of the plan. There was gross exaggeration of production statistics -- which contributed to the widespread (national and international) unawareness of disastrous consequences of the Great Leap Forward. A short period of recovery in the early 1960's was ended by the Cultural Revolution which began in 1966.

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[43] Cited from: Kristof, N.D. / Wudunn, S. (1994): China Wakes. The struggle for the soul of a rising power. New York (Vintage), p.453

[44] It was a small booklet on "Ten Great Years: Statistics of the Economic and Cultural Achievements of the People's Republic of China"

Statisticians became politically suspect, as the fanatical Red Guards roamed the streets and harassed, attacked, deported or killed thousands of intellectuals. After Mao's death and the imprisonment of the "gang of four" statistical work in China slowly recovered. But only since 1984, when a new statistical law took effect, the People's Republic of China has a central statistical system that operates according to western standards of objectivity. This we should keep in mind, whenever we analyze those spectacular time series of economic and social progress in China.

Even today there are statistical data on China which are questionable or not accessible to foreigners. A good example are land use / land cover data: If one would believe official re-forestation statistics from China one would expect a country covered by forest and woodland. Table 2, for instance, indicates that the largest kind of land use change in China between 1949 and 1990 was the *expansion* of forest -- a diagnosis not shared by those who have seen the country. It is also impossible for foreigners to get any county-level information other than simple population statistics. There is one statistical data set, however, which is usually considered of good quality and which is published and accessible in great detail: the 1990 population census of the People's Republic of China.

Conclusion

Five anthropogenic factors have been identified as major driving forces of land use change in China: (1) population growth, (2) urbanization, (3) industrialization, (4) changes in lifestyle and (food) consumption, (5) (future) political and economic arrangements and institutions. A first set of empirical data have been collected and analyzed to better understand the current trends of demographic and socio-economic changes in China that will affect future land-use. Further data collection and analysis is necessary. Based on the currently available data we have to assume that rural-urban migration and the growth of cities and (industrial) infra-structures will be the *dominant factor* of land use change in the Eastern provinces of China.

Appendix

Table A1: Total Sown Crop Areas by Province, 1993 (in 1000 ha)

	Total Sown Area (in 1000 Ha)	Rice (in %)	Wheat (in %)	Corn (in %)	Soybeans (in %)	Tubers (in %)	Oil Crops (in %)	Cotton (in %)	Hemp (in %)	Sugar (in %)	Tobacco (in %)	Vegetables (in %)	Tea (in %)	Orchards (in %)
Beijing	565.3	4.7	31.4	38.6	2.0	1.2	2.2	0.7	0.0	0.0	0.0	13.8	0.0	9.2
Tianjin	565.7	7.4	24.4	27.6	13.9	0.7	4.3	1.7	0.1	0.0	0.0	11.7	0.0	5.1
Hebei	8,676.7	1.5	29.1	24.5	9.5	4.9	6.4	6.0	0.1	0.1	0.1	4.0	0.0	8.4
Shanxi	3,999.0	0.2	25.6	16.3	12.1	7.3	8.5	2.3	0.0	0.7	0.3	3.3	0.0	6.1
Inner Mongolia	4,868.3	1.5	24.4	15.7	16.2	5.4	10.3	0.0	0.0	2.2	0.1	1.7	0.0	1.2
Liaoning	3,630.0	13.3	5.0	39.0	9.6	2.8	3.9	0.7	0.0	0.6	0.7	8.1	0.0	11.6
Jilin	4,050.7	10.6	2.8	50.3	15.0	2.2	3.8	0.0	0.1	1.1	1.0	4.6	0.0	1.8
Heilongjiang	8,647.2	8.5	15.5	20.5	35.5	2.7	1.8	0.0	0.8	3.3	1.0	3.0	0.0	0.4
Shanghai	558.1	38.7	13.6	1.5	2.1	0.0	13.2	1.7	0.0	0.2	0.0	13.9	0.0	2.3
Jiangsu	8,032.3	28.4	28.4	5.9	5.2	2.5	7.4	6.4	0.1	0.1	0.0	5.8	0.2	1.6
Zhejiang	3,926.2	54.4	6.3	1.0	3.3	3.7	6.0	1.6	0.4	0.4	0.0	7.2	3.7	5.6
Anhui	8,265.1	26.3	25.2	5.6	7.5	6.9	12.1	4.3	1.0	0.1	0.3	3.8	1.5	1.0
Fujian	2,733.3	50.6	3.1	1.0	4.2	11.8	4.2	0.0	0.0	1.5	3.5	12.1	4.8	16.8
Jiangxi	5,721.0	50.1	1.3	0.3	4.2	2.5	14.7	2.6	0.2	0.8	0.8	6.5	1.0	2.4
Shandong	10,743.5	1.0	38.7	22.7	5.8	6.1	7.3	7.1	0.1	0.0	0.7	5.9	0.0	7.3
Henan	12,068.0	3.7	40.1	16.2	6.3	6.0	8.9	8.1	0.6	0.0	1.9	4.0	0.2	2.3
Hubei	7,125.5	33.4	17.8	5.1	4.4	5.4	10.3	6.8	0.4	0.2	1.4	7.1	1.4	2.3
Hunan	7,653.9	52.6	2.3	1.7	3.5	4.7	9.1	2.2	0.2	0.4	1.8	5.6	1.9	3.3
Guangdong	5,145.6	51.1	0.8	1.0	2.4	8.8	6.8	0.0	0.1	4.9	1.0	13.7	0.8	13.3
Guangxi	5,385.2	44.9	0.3	9.8	5.3	5.0	4.4	0.1	0.3	7.4	1.0	7.4	0.5	5.2
Hainan	884.4	44.1	0.0	1.6	1.6	19.0	5.5	0.0	0.1	9.9	0.1	9.4	0.8	2.4
Sichuan	12,664.2	24.0	18.5	13.5	4.2	15.0	7.0	1.0	0.4	0.3	1.4	6.0	0.9	2.1
Guizhou	3,971.9	18.0	13.9	15.2	5.3	11.5	9.7	0.1	0.1	0.2	8.3	6.5	1.2	0.9
Yunnan	4,770.0	19.5	12.8	19.6	9.9	6.2	2.5	0.0	0.1	3.2	10.2	4.0	3.4	2.3
Tibet	215.0	0.5	20.3	1.3	8.6	0.6	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Shaanxi	4,790.2	3.4	34.3	20.9	8.7	7.5	6.3	1.9	0.1	0.1	1.6	3.2	0.6	10.0
Gansu	3,638.7	0.2	38.6	8.5	9.1	8.2	8.5	0.3	0.1	0.7	0.7	2.1	0.0	6.0
Qinghai	548.2	0.0	38.3	0.0	11.9	6.7	23.5	0.0	0.0	0.0	0.0	1.9	0.0	1.1
Ningxia	905.0	6.9	34.6	8.4	12.1	4.9	10.6	0.0	0.0	1.5	0.0	2.7	0.0	3.5
Xinjiang	2,992.7	2.3	36.3	13.3	2.4	0.3	7.8	20.3	0.1	2.0	0.0	2.2	0.0	4.5

Source: Statistical Yearbook, 1994. People's Republic of China

Table A2: China Total: Total Sown Crop Areas, 1978 - 1993 (in 1000 ha)

Year	Total Sown Area	Rice	Wheat	Corn	Soybeans	Tubers	Oil Crops	Cotton	Hemp	Sugar	Tobacco	Vegetables	Tea	Orchards
1978	150,104	34,421	29,183	19,961		11,796	6,222	4,867	751	879	784	3,331	1,048	1,657
1980	146,379	33,879	29,228	20,353		10,153	7,928	4,920	666	922	512	3,163	1,041	1,783
1983	143,993	33,137	29,050	18,824		9,402	8,390	6,077	389	1,198	768	4,102	1,105	2,015
1984	144,221	33,179	29,577	18,537		8,988	8,678	6,923	486	1,230	897	4,320	1,077	2,219
1985	143,626	32,070	29,218	17,694		8,572	11,800	5,141	1,231	1,525	1,313	4,753	1,045	2,736
1986	144,204	32,266	29,616	19,124		8,685	11,414	4,306	762	1,470	1,125	5,304	1,024	3,672
1987	144,957	32,193	28,798	20,212		8,867	11,180	4,844	967	1,357	1,128	5,572	1,044	4,508
1988	144,869	31,987	28,785	19,692		9,054	10,619	5,535	735	1,669	1,555	6,032	1,056	5,066
1989	146,554	32,700	29,841	20,353		9,097	10,504	5,203	563	1,529	1,798	6,290	1,065	5,372
1990	148,362	33,064	30,753	21,401		9,121	10,900	5,588	495	1,679	1,593	6,338	1,061	5,179
1991	149,586	32,590	30,948	21,574		9,078	11,530	6,538	453	1,947	1,804	6,546	1,060	5,318
1992	149,007	32,090	30,496	21,044	8,983	9,057	11,489	6,835	434	1,906	2,093	7,031	1,084	5,818
1993	147,741	30,355	30,235	20,694	12,377	9,220	11,142	4,985	420	1,687	2,089	8,084	1,171	6,432

Source: Statistical Yearbook, 1994. People's Republic of China