

Agricultural Change and Population Growth: A Brief Survey on the Case of China in Historical Perspective*

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Abstract

The population of China was recorded as around 60 millions in A.D. 2 and slightly more than 1,000 millions in 1982. To feed these millions of people has always been the major task of Chinese agriculture. This paper is attempted to give a brief survey on the relation between agricultural change and population growth in China in a historical perspective.

This paper will try to discuss four aspects of agricultural change that are related to population growth. They are: (1) expansion of agricultural frontier, (2) changes in cultivation methods and land use, (3) improvements in agricultural technology, and (4) irrigation and water-control. These aspects are treated briefly with temporal and spatial perspectives as long as it is possible to do so with available evidences.

This paper concludes that the intensification of agriculture began rather early in China and a system of careful farming methods reaching the level of gardening was developed as early as around 200 B.C. With a review on the process of evolution in cultivation methods and the response to population pressure demonstrated in the more and more intensified agriculture in China, this paper has tried to test Boserup's thesis and found that it can be applied to explain the case of China to some extent although not perfectly at certain points.

Introduction

China has been the most populous country in the world ever since the beginning of Christian era. In A.D. 2 the Chinese population was officially recorded as 59,594,978 mouths (persons),¹ which accounted only slightly less than one fourth of

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¹ The original record of this figure was in *Han-shu*, chuan 28, *Ti-li-chih* (Treatise on Geography).

the world population in A.D. 14 estimated as 256 million.² Except for short-term fluctuations from time to time, Chinese population continued to grow rather slowly by the twentieth century and it was only in the recent past thirty years that the population grew rather rapidly and reached a huge number of slightly more than 1,000 million according to a census in 1982.³

Since the official population figures in the past dynasties were mostly registered for the purpose of taxation and most likely under-recorded, many historians have tried very hard to find out the reasons for under registration and to re-estimate plausible number of population in various periods.⁴ With all these efforts of many historians, the growth trend of Chinese population may now be conceived as being marked off by the following landmark peaks:

A.D.	2	60-70 millions,
	754	100 millions,
	1100	120 millions,
	1400	65-80 millions,
	1600	120-200 millions,
	1850	410 millions,
	1933	500 millions,
	1953	583 millions,
	1982	1,003 millions.

To feed these millions of people has been the major task of Chinese agriculture. This paper is attempted to give a brief survey on the relation between agricultural change and population growth in China in a historical perspective.

To begin with, it must be kept in mind that the rather smooth trend of population growth as can be conceived from the figures listed above does not imply that the process of agricultural development in China is a simple story although it must be told quite simply in this paper. Obviously, many aspects related to the topic have to be omitted. To mention a few of them, for example, the institution and problem of famine

² David Grigg, *Population Growth and Agrarian Change: An Historical Perspective* (1980), p. 1.

³ For historical records of Chinese population, see John Durand, "The Population Statistics of China, A.D. 2-1953," *Population Studies*, Vol. 13, Part 3 (March 1960), pp. 209-256; Liang Fang-chung, *Chung-kuo li-tai hu-k'ou t'ien-ti t'ien-fu t'ung-chi* (1980), some summarized bar diagrams appeared in pp. 513-521. For a study on recent situation see, Nathan Keyfitz, "The Population of China," *Scientific American*, Vol. 250, No. 2 (February 1984), pp. 38-47.

⁴ There are quite a number of studies on the population of individual dynasty, for a bibliography of published works during 1935-1984, see James Lee, "The Population History of China before 1911: The State of the Field," *California Institute of Technology, Humanities Working Paper*, 109 (December 1984), pp. 13-30. Two articles about the population of T'ang dynasty not included in Lee's list are: Yang Yuan, "T'ang-tai te jen-k'ou," *The Journal of the Institute of Chinese Studies of the Chinese University of Hong Kong*, Vol. 10, No. 2 (1979), pp. 389-423; Yen Keng-wang, "T'ang-tai hu-k'ou shih-chi shu-liang chih chien-t'ao," *Kuo-hsueh wen-hsien-kuan kuan-k'an*, No. 9 (January 1985), pp. 5-9 and continued on p. 1; this was a lecture that Prof. Yen gave on November 10, 1984 in Taipei.

relief, the capability of providing clothing in traditional agrarian economy, the specialization and commercialization in agriculture in response to population growth, and the fragmentation of land use and land tenure that may be a result of and a response to population pressure, these are important issues related to the topic in concerned and yet are not touched upon in this paper.

In below, this paper will try to discuss only four aspects of agricultural change that are related to population growth. They are: (1) expansion of agricultural frontier, (2) changes in cultivation methods and land use, (3) improvements in agricultural technology, and (4) irrigation and water-control. Each of these aspects will be treated briefly with temporal and spatial perspectives as long as it is possible to do so with available evidences.

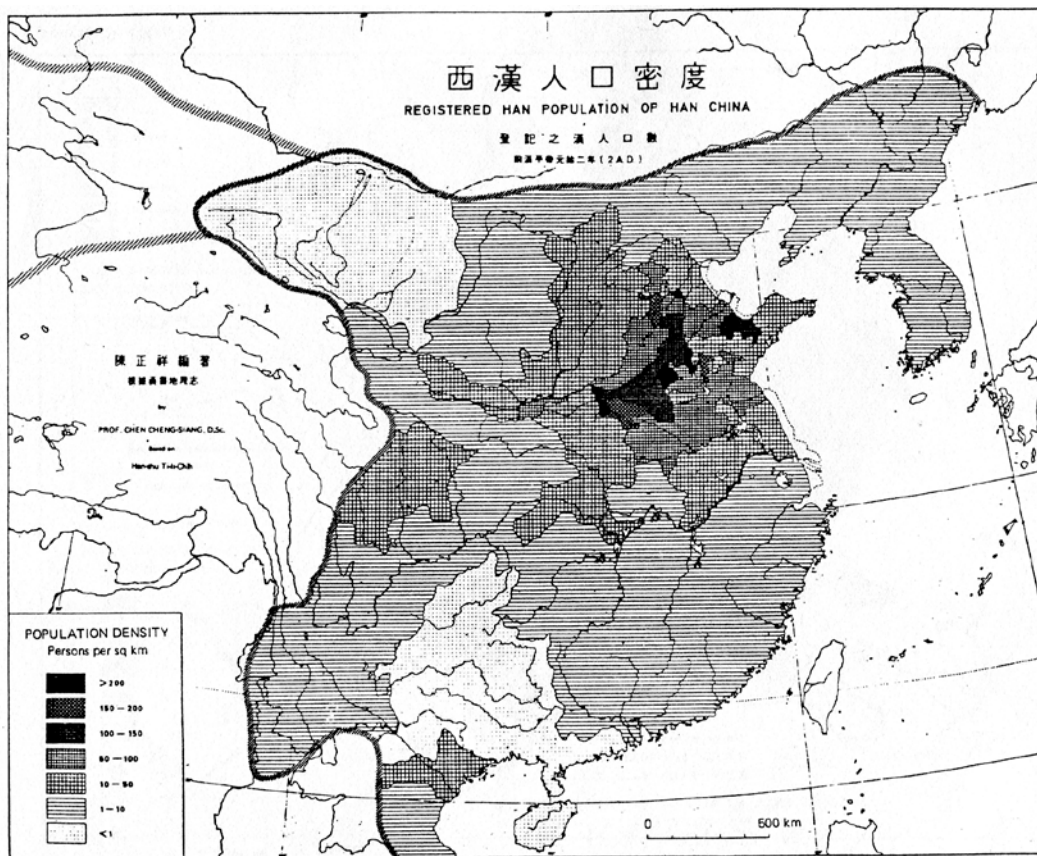
This paper concludes that the intensification of agriculture began rather early in China and a system of careful faring methods reaching the level of gardening was developed as early as around 200 B.C. This typical method of farming required hard toil became more and more complicated through time and was more and more widely adopted in many regions in China. As the agricultural technology improved slowly and even appeared to change very little after the thirteenth century, the increasing population pressure forced the farmer at certain highly density populated areas to give up usage of animal pulling plow and instead to rely on manpower to till the land. This was an indication of unavoidable diminishing returns to labor when population pressure reaching a critical point. With a review on the process of evolution in cultivation method and the response to population pressure demonstrated in the more and more intensified agriculture in China, this paper has tried to test Boserup's thesis and found that it can be applied to explain the case of China to some extent although not perfectly at certain points.

1. Expansion of Agricultural Frontier

China is a country of extensive territory and populous people, but this is a result of development through a long time. Ever since A.D. 1 China had the largest number of people among various regions in the world and her population density was comparatively high.⁵ Throughout her long history, both the territory and population of China changed. This can be seen clearly by comparing a few maps. At one glance, Chinese population was most densely distributed in the North China Plain along the lower Yellow River in A.D. 2 around the end of the Western Han dynasty (Map 1). In the mid-eighth century when the T'ang dynasty (618-907) reached its zenith, the

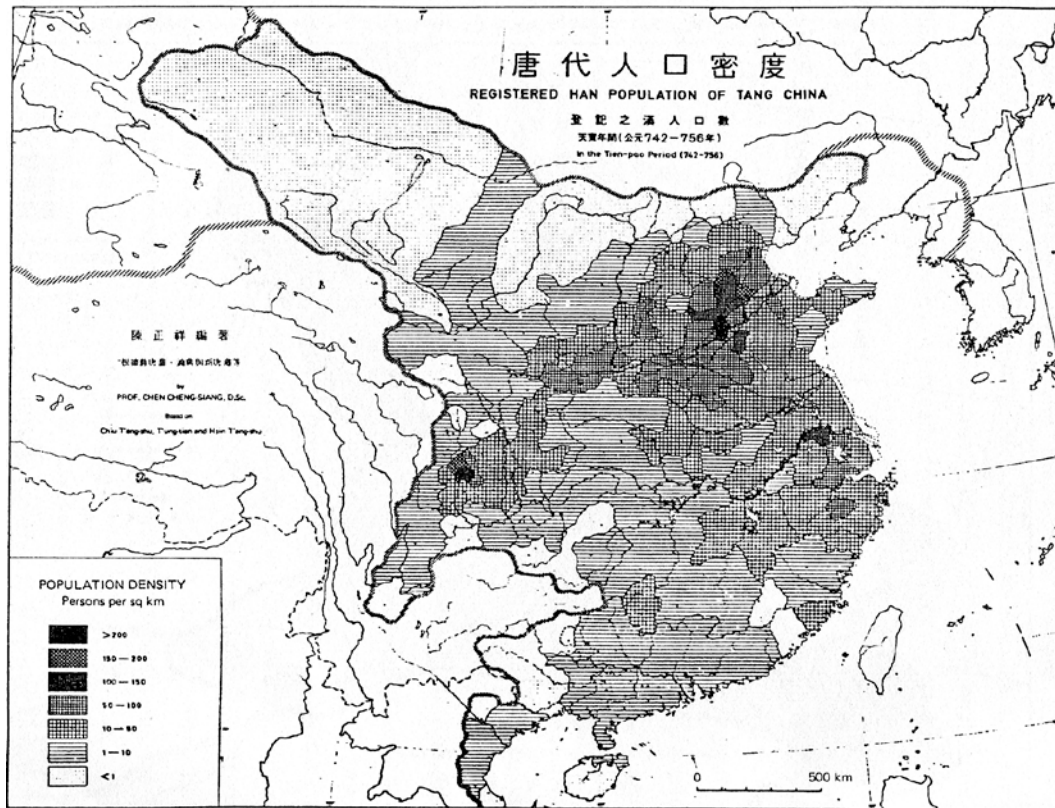
⁵ Ester Boserup, *Population and Technological Change: A Study of Long-term Trends* (1981), pp. 10-11, Tables 2.1 and 2.2.

population density center was still in the North while two relatively small spots of density in the upper and lower Yangtze River valley were also notable at that time (Map 2). In the beginning of the twelfth century when the Northern Sung dynasty (960-1126) was close to its end, the North was still quite densely populated, however, around the two small high density spots along the Yangtze River the population had become more extensively distributed; the fact that the population and economic gravity center shifted from the North to the South was by that time undeniable (Map 3). In the mid-sixteenth century when the Ming dynasty (1368-1643) was still at its prime time, the most densely populated area was apparently located at the Yangtze delta and the South certainly had a higher density than the North (Map 4).

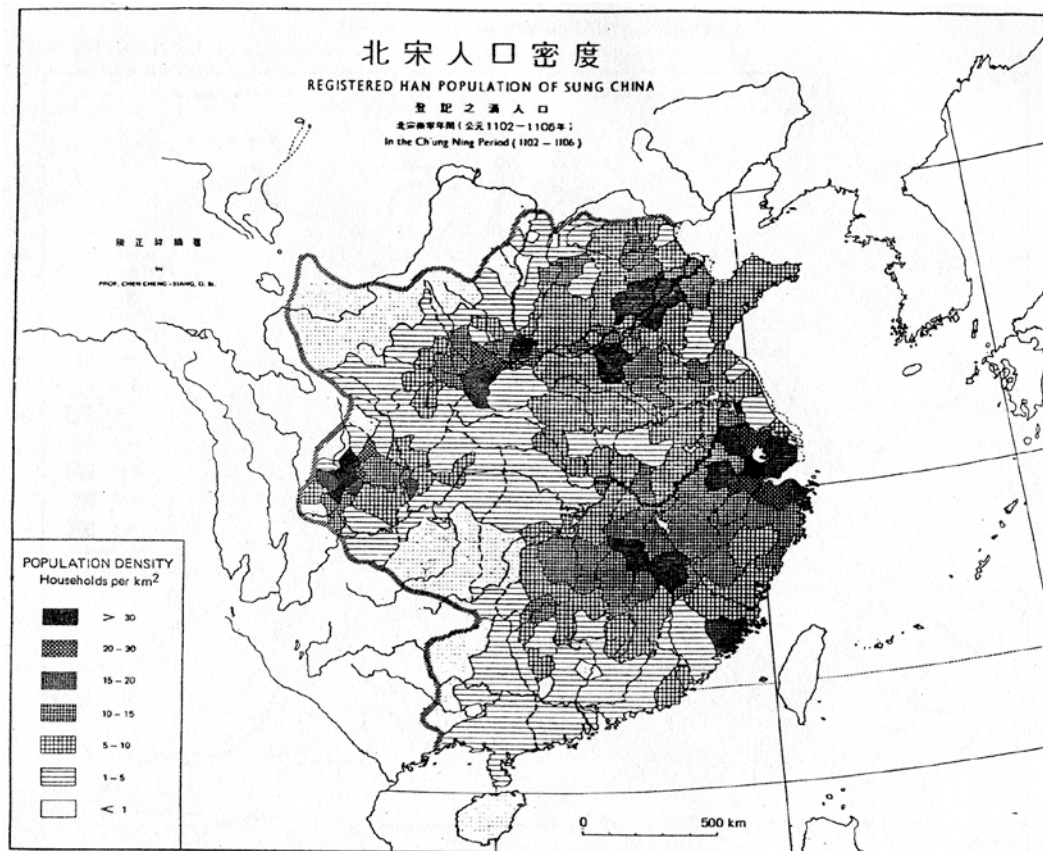


Map 1: Registered Han Population of Han China, A.D. 2

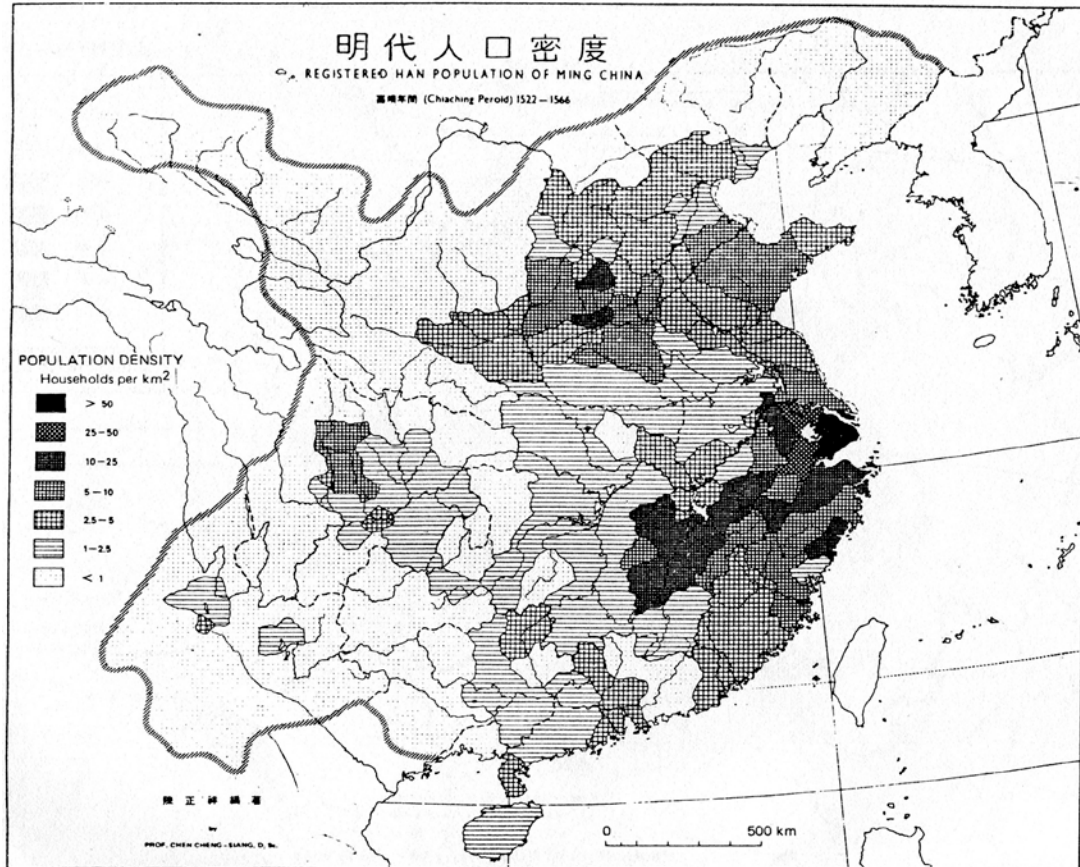
Source: For Maps 1-4, Chen Cheng-siang, *Chung-kuo wen-hua ti-li* (Taipei: Mu-to ch'u-pan-she, 1982), between pages 22 and 23.



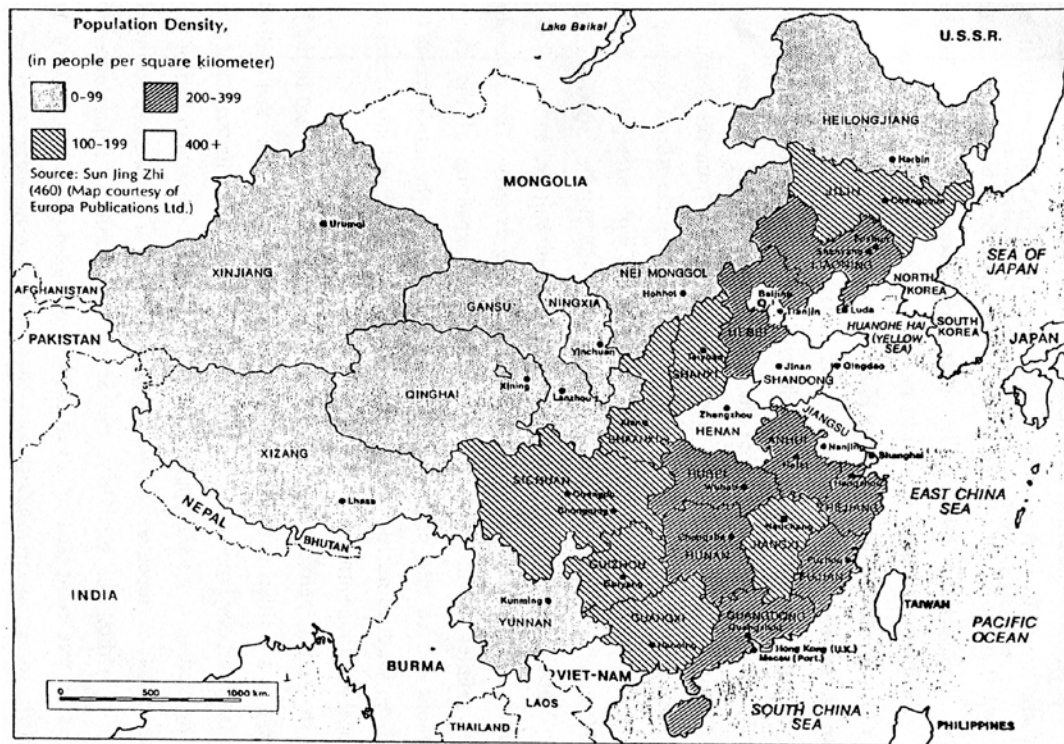
Map 2: Registered Han Population of T'ang China, 742-756



Map3: Registered Han Population of Northern Sung Chinam 1102-1106



Map 4: Registered Population of Ming China, 1522-1566

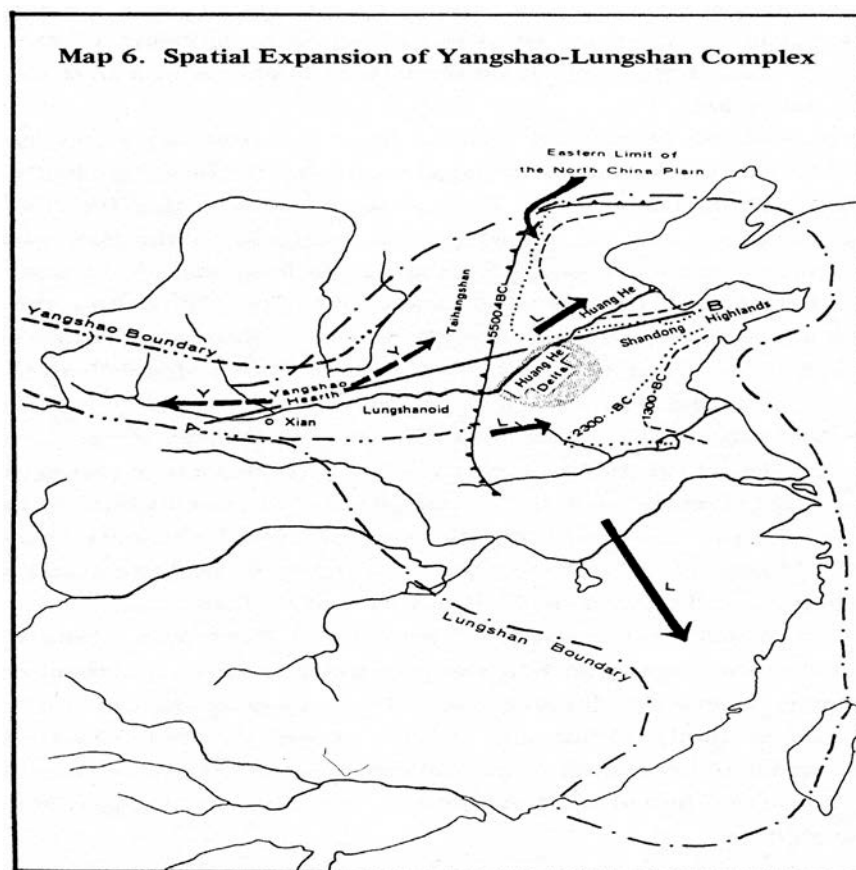


Map 5: Population Density in Mainland China, 1979

Source: Pi-chao Chen and Adrienne Kols, "Population and Birth Planning in the People's Republic of China," *Population Report*, series J, number 25 (Jan.-Feb. 1982), p. J-580.

The above four maps (Maps 1-4) of population density based on historical records which may not be all accurate in terms of population registration, however, they do reveal major shifts of Chinese population distribution spatially and temporally. When compared with Map 5 which depicted the situation in 1979, the shape of Chinese territory and population distribution was again very different from that of the historical past.

Parallel to the shifts of population distribution through time, Chinese agricultural frontier also expanded. According to recent archaeological discoveries, it is now well known that the origin of Chinese agriculture could be dated back to 6000 B.C. in the Neolithic period. Some earliest sites where relics of foxtail millet (*Setaria italica*) were discovered were located in modern Hopei, Shensi, and Honan; and the earliest rice relic was found at Ho-mu-tu 河姆渡 in modern Yu-yao 餘姚, Chekiang.⁶ With the discoveries of Neolithic sites of the Yangshao, Lungshanoid, and Lungshan phases, the expansion of Chinese Neolithic culture has been reconstructed as shown in Map 6.



Map 6: Spatial Expansion of Yangshao-Lungshan Complex

Source: Shin-yi Hsu, "The Ecology of Chinese Neolithic Cultural Expansion," in Clifton W. Pannell and Christopher L. Salter eds., *China Geographer, Number 11: Agriculture* (Boulder: Colorado: Westview Press, 1981), p. 21.

⁶ Chen Wen-hua and Chang Chung-k'uan eds., "Chung-kuo nung-yeh k'ao-ku tzu-liao so-yin," *Nung-shih yen-chiu*, No. 2 (1982), pp. 159-160.

Map 6 indicated that the spatial orientation of the three phases of Chinese Neolithic culture was from west to east, namely, from the Weishui 渭水 valley to the Shantung (Shandong) highlands represented by the line AB on the map. The time dimension of this expansion could be marked off in three stages: (1) the earlier Yangshao culture in 5000 B.C. at the Weishui valley; (2) the earlier Lungshanoid culture in 3000 B.C. at the Taihang 太行 foothills; and (3) the historical Shang dynasty in 1300 B.C. at the Shantung highlands. The archaeological evidences pointed to the fact that along with the expansion of the Yangshao-Lungshanoid culture into central and southern China and the introduction of rice culture from south to nuclear area, there was cultural interaction in existence among the regional Neolithic cultures.⁷

By the end of Neolithic age in China, the Shang dynasty (1766-1122 B.C.) emerged in the North China Plain as a political entity with rather complicated organization and civilization. The Shang state boundaries were shifting from time to time, but its territorial expanse defined by modern terms was approximately as follows: the northern half of Honan, the southern half of Hopei, western Shantung, northernmost Anhwei, and northwestern Kiangsu.⁸ Within this boundary, the Shang state with its capital area around An-yang 安陽 was composed of a vest network of walled towns (1,000 town names were known so far by archaeologists). These walled towns were under the direct control of the Shang King who was very much concerned about the harvests not only in his capital area but also in all these towns.⁹ Moreover, it was quite possible that there were still much empty lands not occupied by any lord of the township. Thus, within the Shang territory agricultural lands might be in a state of dispersion rather than closely connected.

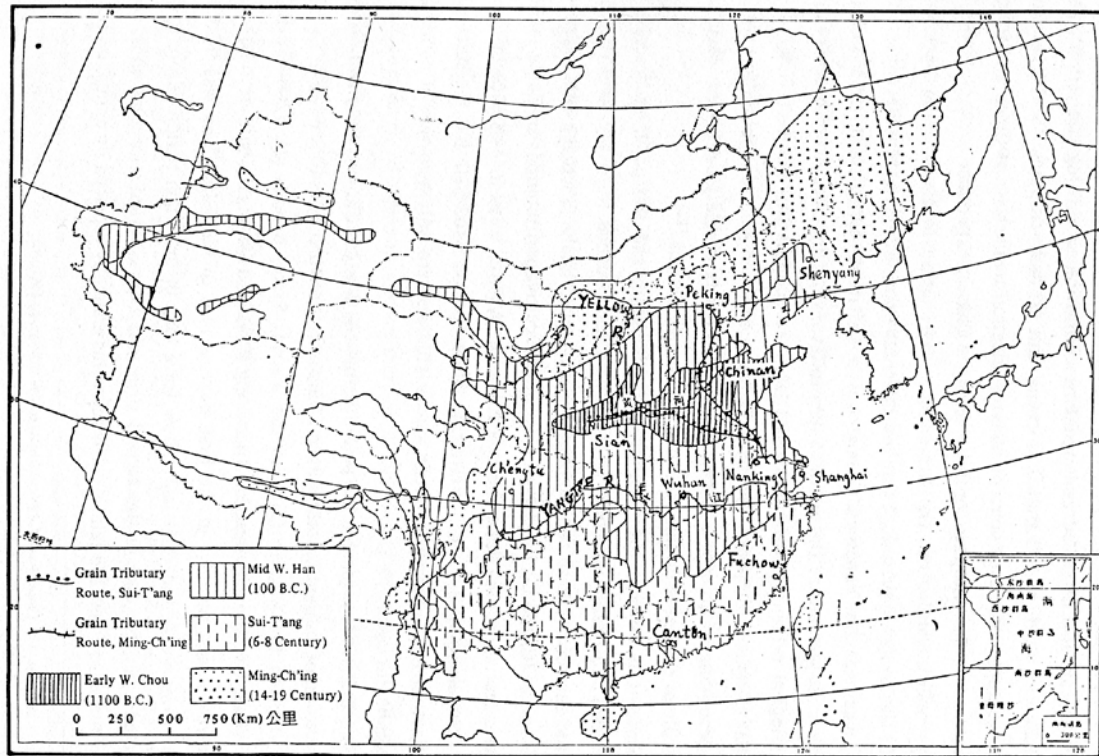
The expansion of agricultural frontier in China after the Chou dynasty (1121-249 B.C.) was depicted in Map 7. This map showed that the agricultural frontier gradually expanded from the North China Plain to the Yangtze River valley during the first thousand years before Christian Era, i.e., roughly from the Chou to the Han dynasties. It took about another thousand years for the agricultural frontier to extend to the southernmost boundary of China and by the end of the twelfth century, the cultivatable lands in China proper was perhaps mostly under cultivation. The expansion of agricultural frontier to marginal lands in southwest and Inner Mongolia and to relatively fertile lands in northeast was accomplished gradually from the fourteenth century on. As for the utilization of oases in northwest, even though it was dated back to the Western Han period (206B.C.-A.D.8), there was a long period of interruption after the T'ang dynasty when the Western Region was not included in the

⁷ Shin-yi Hsu, "The Ecology of Chinese Neolithic Cultural Expansion," in Clifton W. Pannell and Christopher L. Salter eds., *China Geographer, Number 11: Agriculture* (1981), pp. 17-23.

⁸ Kwang-chih Chang, *Shang Civilization* (1980), p. 252.

⁹ *Ibid.*, p. 216.

boundary of China. It was only in the Ch'ing dynasty (1644-1911) that new lands were opened to use in northwest. Comparatively, the agricultural bases in northwest and southwest were far less important than those in China proper and northeast.



Map 7: Expansion of Agricultural Frontier in China

Source: Chung-kuo K'o-hsüeh-yüan Ti-li yen-chiu-so ed., *Chung-kuo nung-yeh-ti-li tsung-lun* (Peking: K'o-hsüeh ch'u-pan-she, 1981), p. 55.

The above sketch of expansion of agricultural frontier in China confirms a historical fact that the interaction between population growth and agricultural change had gone through a slow and long process. Accompanying the extension into new frontier, the Chinese farmer ingeniously adopted new methods of cultivation through try and error under constrain of the natural environment. Thus, in the next section the discussion will be turned to development of cultivation methods and land use in China through time.

2. Changes in Cultivation Methods and Land Use

One important concept that Boserup has proposed for analysis of agricultural change and population growth is the intensification of land use in terms of frequency of cropping.¹⁰ Moreover, Boserup has chosen to group the methods of land use into

¹⁰ Ester Boserup, *The Condition of Agricultural Growth* (1965), p. 13.

five types: (i) forest-fallow cultivation, (ii) bush-fallow cultivation (the above two types can also be called as long-fallow cultivation or shifting cultivation), (iii) short-fallow cultivation, (iv) annual cropping, and (v) multi-cropping.¹¹ This section will try to apply Boserup's concept of intensification to the case of China and to see to what extent this concept is confirmed to the Chinese experience.

As mentioned before, the beginning of agriculture in China could be traced back to the Neolithic period. There are different opinions among scholars concerning about whether the Yangshao farmer was a sedentary agriculturist or a shifting cultivator. It seems that the opinions turn to favor "shifting cultivator" because more archaeological evidences were discovered lately to support this point of view. It is said that the Neolithic people lived in villages but shifted from one locale to another after occupying a site for a certain period. Some favorable locales were occupied repeatedly as evidences revealed multi-occupational remains.¹²

Since it is beyond the capacity of this author and this paper to describe in details the cultivation methods in Neolithic China, suffice it to say here that the Neolithic farmer, as a shifting cultivator, was most likely practicing some sorts of long-fallow cultivation. Recent studies on the cultivation methods in China tended to agree that long and short fallow cultivation systems were in existence in China from around 6000 B.C. to the Warring States period (403-220 B.C.). Since the periodization is somewhat different among studies, here only two sets of periodization will be discussed.

The first study neglected the period before the Western Chou dynasty and divided the evolution of cultivation methods in China into three phases as follows:¹³

(1) From the Western Chou to the Warring States periods (ca. 1200-200 B.C.) was a phase of fallow cultivation (*liao-huang* 撩荒). This phase could be subdivided into three stages, namely, in the first stage, a plot of cultivated land was used for two or three years and then laid fallow for a long or uncertain period before it was cultivated again for use; in the second stage, the fallow period was much shortened; and in the third stage, the fallow cultivation was gradually replaced by annual cropping at some localities. In short, during this long period of about one thousand years, the land use system in China was mainly long and short fallow cultivation through which the fertility of land could be recovered by natural vegetation.

(2) From the Ch'in to the T'ang dynasties (221 B.C.-A.D. 960) was a phase of annual cropping with rotation of crops. At certain locales there was already developed a system of three crops in two years during the Han dynasty (206 B.C.-A.D. 220).¹⁴

¹¹ *Ibid.*, pp. 15-16.

¹² Shin-yi Hsu, p. 12.

¹³ Kuo Wen-t'ao, *Chung-kuo ku-tai te nung-tso-chih ho keng-tso-fa* (1981), pp. 25-27.

¹⁴ Cho-yun Hsu, *Han Agriculture* (1980), p. 111.

Moreover, double cropping was developed in some places in the Sui-T'ang period (581-960). In general, this millennium witnessed a change of recovering land fertility relying entirely on natural forces to partly utilizing human creativity. During this period, Chinese farmers already knew how to rotate this planting of cereal crops with leguminous crops and to use green manure to maintain and improve the fertility of land. Moreover, the bases of typical Chinese way of intensive and careful farming (*ching-keng-hsi-tso* 精耕細作) were also laid and gradually evolved during this period.¹⁵

(3) From the Sung to the Ch'ing dynasties (960-1911) was a phase in which multi-cropping and the method of interlacing were further developed. During this period, double-cropping was prevalent in most part of the South and triple-cropping was also found in the southernmost areas. In the North, in addition to the prevalence of three crops in two years, there were also in some localities where double-cropping was adopted. Moreover, both in the South and the North, interlacing method of cultivation was adopted to a wide extent and thus the degree of land use was raised to a higher level. There was also an increase in the variety of organic fertilizer that was brought into use during this period. In short, the intensive farming methods perhaps developed to the highest limit under the traditional agricultural technology in this phase.

The second study traced the development of Chinese cultivation systems from the very beginning and divided the process of changes into five stages:¹⁶

(1) Before 6000 B.C., it was forest-fallow cultivation that was in existence when the agriculture was still very primitive. The primitive farmer used stone knife to cut down trees and burned them before a plot of land was ready for sowing; after using for a short time the land was abandoned and the farmer shifted to another place. Under this circumstance, there must be an abundance of forest and a sparsely distributed population. However, in the long-run the deforestation along the Yellow River valley could be traced back to this early age.

(2) From 6000 B.C. to the Western Chou dynasty (ca. 1200-720 B.C.) was a period in which short-fallow cultivation was gradually adopted and sedentary agriculture gradually developed. The most often cited ancient document for this type of short-fallow was the *Shih-ching* 詩經 (Book of Odes). The three terms: *tzu* 蓄,

¹⁵ The theoretical basis of the type of *ching-keng-hsi-tso* was first stated in the *Lü-shih ch'un-ch'iu* 呂氏春秋 compiled in the late Warring States period, for a discussion on this book and its contribution to Chinese agriculture, see Chung-kuo nung-yeh k'o-hsueh-yuan ed., *Chung-kuo nung-hsüeh-shih ch'u-kao* (1959), pp. 88-90; also see Hsu Cho-yun, "Liang-Chou nung-tso chi-shu," in *The Bulletin of the Institute of History and Philology, Academia Sinica*, Vol. 42, Part 4 (1971), pp. 817-818; for further development of this type of agriculture in Han time, see Cho-yun Hsu, *Han Agriculture*, pp. 109-128.

¹⁶ Sun Sheng-ju, "Shih-lun wo-kuo ku-tai keng-tso-chih-tu te hsing-ch'eng ho fa-chan," *Chung-kuo nung-shih*, 1984: 1, pp. 1-9.

hsin 新, and *yü* 畬 referring to lands that were under cultivation from one to three years — had been interpreted differently by many scholars.¹⁷ At any rate, it seems plausible to consider them as representing a type of short-fallow cultivation. Another type of short-fallow cultivation mentioned in the *Chou-li* 周禮 (Rituals of Chou) was known as *t'ien-lai-chih* 田萊制 referring that a plot of land was cultivated and laid fallow alternatively.¹⁸

(3) From the Eastern Chou to the Ch'in dynasties (722-207 B.C.) was a period in which annual cropping was adopted gradually. Moreover, the iron plow drawn by oxen was in use toward the end of this period. This will be discussed again in more detail later.

(4) From the Han to the Northern and Southern dynasties (206 B.C.-A.D. 580) was a period in which the method of crop rotation developed. The iron plow was more widely used and the knowledge of using organic fertilizer to maintain land fertility was also greatly improved.

(5) From the Sui-T'ang to the Ch'ing dynasty (580-1911) was a period in which double-cropping and multi-cropping developed. There were also developed various ways of interlacing and rotation. The agricultural gravity center shifted from the North to the South in this period.

The above two sets of periodization demonstrated that periodization was always a difficult art in historical study. This paper will not try to solve this one related to the evolution of cultivation methods in Chinese history. Rather it is simply aimed at showing that the five types of land use classified by Boserup were all adopted by the Chinese farmer at one time or the other during a very long process of evolution. It is particularly notable that both the two studies mentioned above agreed that the adoption of annual cropping in China could be dated as early as around 200 B.C. at least in the North China Plain. It should also be kept in mind that although the evolution of cultivation systems could be roughly periodized, the fact that the coexistence of different cultivation systems at certain time and place was undoubtedly possible.¹⁹ To take China as a whole into consideration, it is particularly important to recognize the fact that the development among different regions was rather imbalance through time.

¹⁷ Pint-ti Ho, *The Cradle of the East* (1975), pp. 49-50; also see *Chung-kuo nung-hsüeh-shih ch'u-kao*, pp. 39-40.

¹⁸ Ping-ti Ho, *The Cradle of the East*, p. 50; Ho Ping-ti, *Huang-t'u yü Chung-kuo nung-yeh te ch'i-yuan* (1969), p. 83.

¹⁹ For instance, although annual cropping was already prevailed in the North in Han time, yet the distinguished Han agriculturist, Fan Sheng-chih 氾勝之 still suggested: "If a field gave a poor crop in the second year, fallow it for one year." See Shih Sheng-Han, *A Preliminary Survey of the Book Ch'i-Min Yao Shu* (1962), p. 18.

3. Improvement in Agricultural Technology

Just as the evolution of cultivation systems had gone through a very long process, the adoption of new agricultural implements by human beings had also been very slow in China as in other civilizations in the world before the coming of modern technology. This section will focus discussion on the kinds of tool that were used along with the changing cultivation systems and the implication of adopting a new kind of tool in the long process of evolution.

The primitive farmer used sticks made of stone, wood, or bone to dig the land and knives made of stone or shell to harvest. These kinds of primitive tool were used by ancient Chinese farmer from the Neolithic age up to at least the Western Chou period when the prevalent cultivation system was long and short fallow. Although the Shang bronze was considered by modern scholars as object of fine arts which manifested masterful; bronze metallurgy and artistic technique, bronze was still seldom used for making agricultural implements in the Shang dynasty.²⁰ In the Western Chou period, wooden sticks and stone knives were still the most popular tools for agricultural production. However, some tools with bronze edge, such as *ch'ien* 錢, (a tilling tool), *po* 耨 (a hoe for weeding), and *chih* 鋌 (a harvesting tool), were also found to be in use probably mostly on the farm directly under the domain of the Chou King.²¹ As a matter of fact, a recent study pointed out that the bronze agricultural implements did exist and were especially commonly used in the lower Yangtze area during the Spring and Autumn period (722-403 B.C.) and they were not replaced completely by the iron agricultural implements until the middle of the Warring States period (403-221 B.C.).²²

A revolutionary step in the evolution of agricultural implements in China took place during the sixth century B.C. when the technique of making pig iron was first innovated and the iron tools began to be used in agriculture.²³ Recent archaeological discoveries in China found more than thousand pieces of iron tools (including agricultural implements, military arms and other daily utensils) which were belonging to the Spring and Autumn period and the Warring States period. These iron tools were discovered at more than one hundred sites in 22 provinces in China. Although a few pieces of tool were dated to the middle to late Spring and Autumn period, most of these iron tools were dated to the middle and late Warring States period (i.e., around

²⁰ Kwang-chih Chang, *Shang Civilization*, p. 223.

²¹ Yang K'uan, "Lun Hsi-Chou shih-tai te nung-yeh sheng-ch'an," in the author's *Ku-shih hsin-t'an* (1965), pp. 5-8.

²² Ch'en Liang-tso, "Wo-kuo ku-tai te ch'ing-t'ung nung-chü, (I) and (II)," *Han-hsüeh yen-chiu*, Vol. 2, No. 1 (June 1984), pp. 135-166, and Vol. 2, No. 2 (December 1984), pp. 363-402.

²³ For a discussion on the invention of making pig iron, see Yang K'uan, *Chung-kuo ku-tai yeh-t'ieh chi-shu fa-chan-shih* (1982), p. 14.

the third century B.C.). It is also notable that among the tools belonging to the Warring States period, the largest number was for agricultural production. The kinds of iron agricultural tool included plowshare, large and small spade, hoe, and sickle; each of these kinds again had various types. In other words, by 200 B.C. the iron tool used in China were basically suitable to carry out every important step in farming from tilling to weeding, and to harvesting.²⁴ The timing was very revealing that the adoption of iron tools just coincided with the appearance of annual cropping around the third century B.C.

The widespread use of iron agricultural tools occurred in the Han dynasty. The archaeological sites where the Han iron tools were found distributed widely from Inner Mongolia and Liaoning in the northeast to Yunnan and Kweichow in the southwest; from Kwangtung and Fukien in the Southeast to Kansu in the northwest. These kinds of tool included the spade, shovel, pick and plow, all used for tilling the land, the hoe for weeding, and the sickle for harvesting. Moreover, there were also found in Liao-yang 遼陽 (in Liaoning), Man-ch'eng 滿城 and Pao-ting 保定 (in Hopei), and Hsu-chou 徐州 (in Kiangsu) some two and three-toothed rakes used for loosening the soil.

As for the plowshare found in the Han sites, they were mostly entirely made of iron. Their sizes varied in order to be applied to different types of soil; some were small and light suitable for cultivated land and some were sharp and heavy needed for opening new and uncultivated land. At several locations in Liaoning, Hopei, and Shantung, giant plowshares were found and they were probably used in irrigation projects.

Another important improvement of plow during the Han dynasty was the addition of a moldboard attached on top of a plowshare, so that with the combination of the two parts the soil could be turned more deeply.²⁵ This improvement made it possible to till deeply and was a necessary condition for the development of multi-cropping and crop rotating that were started in the Han period.²⁶

Accompanying the use of plow was the use of draft animal. It is generally agreed among scholars that before the use of animals to draw a plow, the work was probably done by man.²⁷ As for the beginning of using draft animal, especially oxen, there

²⁴ For summaries of archaeological discoveries of iron implements in China, see two articles by Lei Ts'ung-yün, "San-shih-nien-lai Ch'un-ch'iu Chan-kuo t'ieh-ch'i fa-hsien shu-lüeh," *Chung-kuo li-shih po-wu-kuan kuan-k'an*, No. 2 (September 1980), pp. 92-102; "Chan-kuo t'ieh-ning-chü te k'ao-ku fa-hsien chi-ch'i i-i," *K'ao-ku*, 1983: 3 (May 1983), pp. 259-263. Also see Yang K'uan, *Chung-kuo ku-tai yeh-t'ieh chi-shu fa-chan-shih*, pp. 28-33.

²⁵ For details summarized in the above three paragraphs see, Wang Zhongshu, *Han Civilization*, trans. by Kwang-chih Chang and Collaborators (1982), pp. 53-54.

²⁶ Kuo Wen-t'ao, pp. 33-34.

²⁷ Kwang-chih Chang, *Shang Civilization*, p. 225; Hsu Cho-yun, "Liang-Chou nung-tso chi-shu," pp. 809-810.

were different opinions among scholars.²⁸ Recent studies tended to agree that it was only from the middle to late Western Han dynasty (i.e., in the first century B.C.) that the use of oxen to draw a plow became more widely adopted.²⁹

The structure of plow and the teamwork of man and ox to operate the plow also changed considerably during the period from the Han to the T'ang dynasties. Obviously, it was quite possible that changes in the structure of plow and the operating teamwork occurring side by side. Here, however, it seems better to discuss first the structural change of plow in order to make it easier to see the operational change. According to some drawing and carving remains of Han time (see Fig. 1 a-f), the structural changes of the Han plow seemed to have gone through the following steps:³⁰

(1) The primitive plow only had a V-shaped plowshare.

(2) When a moldboard was added on top of a plowshare, then, a plow could be used to turn the soil more deeply and make furrow.

(3) The wooden framework of a plow consisted of several parts, such as a shaft (*li-yüan* 犁轅), a handle (*li-ping* 犁柄), a bottom board (*li-ch'uang* 犁牀), a horizontal bar (*li-heng* 犁衡), and a controlling stem (*li-chien* 犁箭). However, it should be noted that the shaft of the Han plow was straight and long and the number was either one or two; it could not be operated lightly and easily as the curve shaft that was only first innovated probably in the sixth century. Moreover, the Han plow though already had a handle and a bottom board; the two parts were actually not separated perfectly.

The *Ch'i-min-yao-shu* 齊民要術 (an agricultural encyclopedia of the sixth century, compiled during 533-544) mentioned that a kind of *wei-li* 蔚犁 was in use in the area of Ch'i 齊 (in modern Shantung). From the structural point of view, the *wei-li* was much lighter than the Han plow and it had a shorter shaft (which was probable curve) than the long straight shaft of the Han plow. The author of the *Ch'i-min-yao-shu*, Chia Ssu-hsieh 賈思勰, described it as being "pliable and convenient."³¹

A further development in the structural change of plow was the appearance of *Ching-tung-li* 江東犁 (see Fig. 2a), a type of plow with a curve shaft and was in use along the lower Yangtze valley by the late T'ang period (in the ninth century).

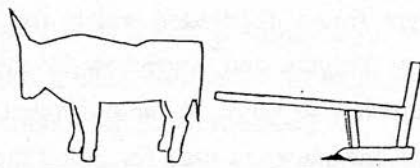
²⁸ Hsu Cho-yun, "Liang-Chou nung-tso chi-shu," p. 810.

²⁹ Huang Chan-yüeh, "Chin-nien ch'u-t'u te Chan-kuo Liang-Han t'ieh-ch'i," *K'ao-ku hsüeh-pao*, 1957: 3 (September 1957), p. 107; Chang Chen-hsin, "Han-tai te niu-keng," *Wen-wu*, 1977: 8 (August 1977), p. 57.

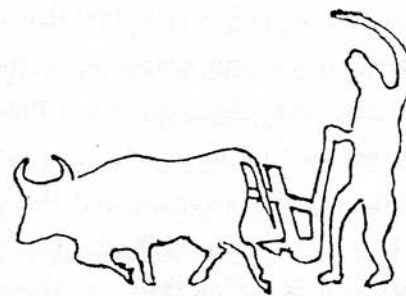
³⁰ For details see, Fang Chuang-yu, "Chan-kuo i-lai Chung-kuo pu-li fa-chan shih-t'an," *K'ao-ku*. 1964: 7 (July 1964), pp. 355-363; Chang Chen-hsin, pp. 57-62.

³¹ Shih Sheng-han annotated, *Ch'i-min-yao-shu* (1957), p. 13. For an analytical discussion on the type of plow see, Lu Ts'ai-ch'uan, "Han-T'ang chih-chien te niu-keng ho li pa mo lou," *Wu-han ta-hsüeh hsüeh-pao*, 1980: 6 (November 1960), p. 90.

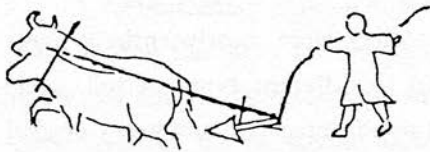
Figure 1: Some Pictures of Tilling



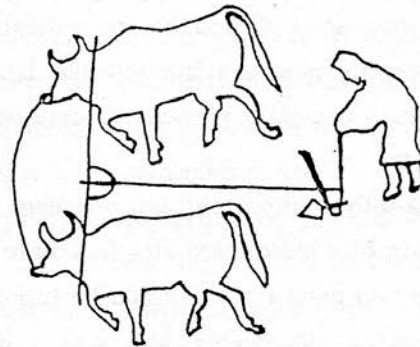
a) wooden plow model
Wu-wei, Kansu (武威, 甘肅)
Western Han (206 B.C.-A.D.8)



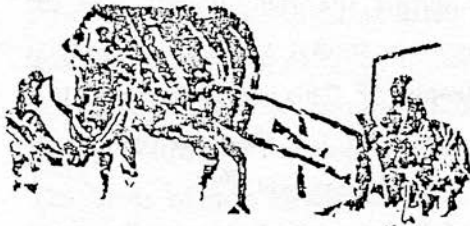
e) stone carving
Sui-te, Shensi (綏德, 陝西)
Eastern Han



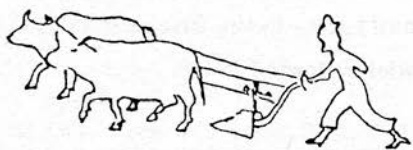
b) mural painting
P'ing-lu, Shansi (平陸, 山西)
A.D. 9-23



f) stone carving
Mi-chih, Shensi (米脂, 陝西)
Eastern Han



c) stone carving
T'eng-hsien, Shantung (滕縣, 山東)
Eastern Han (A.D. 25-220)



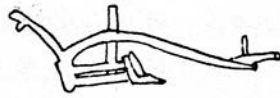
d) stone carving
Sui-ning, Kiangsu (睢寧, 江蘇)
Eastern Han



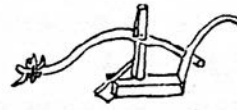
g) brick painting
Chia-yu-kuan, Kansu (嘉裕關, 甘肅)
Eastern Chin (A.D. 265-316)

Source: Chang Chen-hsin, "Han-tai te niu-keng," *Wen-wu*, 1977: 8, pp. 57-58; Lu Ts'ai-ch'üan, "Han-T'ang chih-chien te niu-keng ho li pa mo lou," *Wu-han ta-hsüeh hsüeh-pao*, 1980: 6 (November 1980), p. 96.

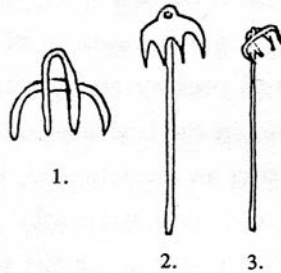
Figure 2: Some Iron Agricultural Implements in the T'ang, Sung, and Yuan Periods



a) a reconstructed model of the Chiang-tung-li by the Chinese Historical Museum



b) iron plow-knife in Wang-ch'en's *Nung-shu*



c) iron rakers during the Sung and Yuan periods

1. a Sung raker discovered in Yangchou, Kiangsu
2. a model in Wang Chen's *Nung-shu* in the *Ssu-k'u Ch'uan-shu* edition
3. a model in *Nung-shu* in a Ming edition



d) iron long-coulter in Wang Chen's *Nung-shu*

Source: Yang K'uan, *Chung-kuo ku-tai yeh-t'ieh chi-shu fan-chan-shih* (A history of the development of iron metallurgy in ancient China; Shanghai, 1982), pp. 276-278, 281.

This type of Chiang-tung plow consisted of eleven parts in its structure. Two parts made of metal (i.e., iron) were plowshare (*li-ch'an* 犁鏵) and a moldboard (*li-pi* 犁壁); nine parts made of wood included a bottom board (*li-ti* 犁底), a pressing board for the plowshare (*ya-ch'an* 壓鏵), a controlling bar for the moldboard (*ts'e-o* 策額), a controlling stem (*li-chien* 犁箭), a shaft (*li-yuan* 犁轅), a handle (*li-shao* 犁梢), a groove for controlling the moving of the stem (*li-p'ing* 犁評), a lock for controlling the shaft and the groove (*li-chien* 犁建), and a coil in front of the shaft (*li-p'an* 犁槃).³² Compared with the Han plow mentioned above, the Chian-tung plow was,

³² For the size and function of each component part of this plow see, Lu Kuei-meng, *Lei-ssu-ching* in *Ts'ung-shu-chi-ch'eng ts'u-pien* (1936), No. 1468, 2 pages. Lu Kuei-meng was a resident in Sung-chiang, Kiangsu, and had personal experience of farming. He died around 875 when his good friend, Li Wei, was promoted as Prime Minister; see *Hsin T'ang-shu* (I-wen reprint), 196: 17b-18b; 63: 15a.

indeed, more completely structured and more suitable for the rice paddies in the South. It is also notable that this plow of the ninth-century China was perhaps more advanced than a plow in the thirteenth-century Western Europe.³³

As for the operational changes of working team of man and ox, there were at least four basic patterns evolved during the period between the Han and T'ang. The first pattern was a team of two oxen and three men operating a plow. The plow was drawn by the two oxen which were fastened to a horizontal bar connected with the long straight shaft. As for the three men, one was in the front to guide the oxen, one was standing beside the shaft to control it, and one was at the rear to operate the plow. This pattern of operation was known as *ou-li* 耦犁 that was said to be an innovation of the famous Han agriculturist, Chao Kuo 趙過, who was appointed a chief official in the ministry of agriculture for promoting agricultural production in 87 B.C.³⁴ There were various interpretations on the structure and operation of *ou-li*, however, the most plausible one was that the plow was drawn by the two oxen as described above. Obviously, this pattern of operation required a large number of both human and animal labor forces and could not be brought into use to a wide extent.³⁵

The second pattern was a team of two oxen and one man operating a plow (see Fig. 1b). This pattern began to be used during the late Western Han and was the basic form during most of the Eastern Han period (see Fig. 1d, 1f). This improvement was made possible through a structural change in the plow so that the man who controlled the shaft was no longer necessary; also due to the improvement in the technique of operating, the man who guided the oxen was no longer needed, either. Thus, with a reduction of manpower from three to one for each plow, this pattern was no doubt a great improvement from the first one.

The third pattern was a team of one ox and three men. The ox was fastened to a plow with two long straight shafts. The three men were cooperating with the one guiding the ox, the other operating the plow, and the third holding a whip and shouting (see Fig. 1c). It seemed that this was still at the earliest stage of adopting a new apparatus of one ox pulling a plow with two straight shafts and thus one man was still needed to guide the ox. This Eastern Han stone carving was the first one known to the world so far and it undoubtedly indicated an improvement of plow operation towards the pattern of using only one man and one ox.

The fourth pattern was a team of one man and one ox. This was a pattern of operation developed perhaps during the period of division (ca. A.D. 220-580).

³³ Fang Chuang-yu, pp. 358-359.

³⁴ Nancy Lee Swann, *Food and Money in Ancient China* (1974), pp. 184-185; Cho-yun Hsu, *Han Agriculture*, p. 112.

³⁵ Sung Chao-lin, "Hsi-Han shih-ch'i nung-yeh chi-shu te fa-chan – erh-niu san-jen ou-li te t'uei-kuang ho kai-chin," *K'ao-ku*, 1976: 1 (January 1976), pp. 3-8; also see Lu Ts'ai-ch'üan, pp. 86-89.

During this period the evolution perhaps went through two phases: (1) the pattern of a team of two oxen and one man still prevailed during the third century and (2) the pattern of a team of one man and one ox was adopted at least in the beginning of the fourth century as demonstrated by pictures found at the sites in modern Kwangtung and Kansu (see Fig. 1g). The adoption of this pattern of operation manifested another step of improvement. It was widely adopted both in the North and the South since the fourth century. This pattern of operation was most suitable to the need of small farm agriculture that had become a typical form of agricultural organization as early as in the third century B.C. in China.

From the operational changes described above, it seems quite instructive to see that the evolution of plowing teamwork finally settled at the pattern of one man with one ox during a period when the Chinese population was known to be near the smallest number according to the historical records.³⁶ It seems reasonable that a labor-saving device was needed when there was a lack of enough labor forces. If this reasoning could be accepted, this at least demonstrated that the interaction between population and agricultural technological change was a rather complicated phenomenon. Population growth may not always be an independent variable determining technological change in agriculture as suggested by Boserup.³⁷ At least, it seems necessary to consider not only the possibility the population density may induce agricultural intensification but also the possibility that population scarcity may lead to the adoption of labor-saving technology in the historical past. One could, of course, argue that agricultural technological improvements would simply develop in the due course and not necessarily related to population scarcity.

In addition to the improvement of plow and its operational working team, there were also other agricultural implements related to the preparation of land, such as toothed and toothless harrows, improved during the period between the Han and the T'ang. In the historical writings, the use of harrows was first mentioned in the *Ch'i-min-yao-shu* which said: "After plowing, level down twice the clods with an iron toothed rake (*t'ieh-ch'ih-lou-tsou* 鐵齒[金扇]耨). Broadcast glutinous or ordinary panicle millets, harrow twice."³⁸ However, archaeological discoveries revealed that harrow was already in use in the Han dynasty. The harrows of Han time were found to be in two types: three-toothed and eight-toothed; both were operated by man. Following the spreading of technique to use oxen in pulling a plow, the same technique was also applied to pull a harrow at least no later than the period of three

³⁶ The official record of the population in A.D. 280, when the Western Chin unified China shortly, was 16,163,863 persons and this figure was almost the largest during the period of division, see Liang Fang-chung, pp. 38-39; also see John Durand, p. 222.

³⁷ Ester Boserup, *The Condition of Agricultural Growth*, p. 11.

³⁸ Shih Sheng-han, *A Preliminary Survey of the Book Ch'i-min-yao-shu*, pp. 37-38

Kingdoms (200-265). At first, a harrow was also drawn by two oxen. It was during the Eastern Chin period (266-316) that one ox pulling harrow was widely adopted both in dry land farming in the North and rice paddies in the South. Moreover, type and shape of harrow varied. There were found a six-toothed harrow in the Lien-ch'eng 連城, Kwangtung and an inversed V-shaped (lit. *jen-tzu hsing* 人字型) harrow in Chiu-ch'üan 酒泉, Kansu, belonging to the fourth and fifth centuries. The inversed V-shaped harrow was regarded to be a more advanced type than the straight one as there were more teeth on it.³⁹

Another type of harrow was toothless. Similarly, its evolution from being drawn by two oxen to one was also during the Eastern Chin period. This type of harrow was mainly used in the North as it was very important to keep the humidity of soil by making the surface of soil very fine and flat. As for the need to make the rice paddies flat, a special type of toothless harrow known as *liu-chou* 陸軸 was mentioned in the *Ch'i-min-yao-shu*.⁴⁰ These varieties of toothed harrow (*pa* 耙) and toothless harrow (*mo* 耨 or *lao* 勞) demonstrated that by the end of the sixth century, there was already developed different types of implements to satisfy the need under different geographical conditions.

Finally, during the Han-T'ang period, there were also evidences indicating improvements in seeders. During the first century B.C., a kind of seeder with three feet (*san-chiao-lou* 三腳耩) was invented by Chao Kuo and introduced over the country with great efforts. During the Northern dynasties (386-580), seeders with two feet and single foot were also created based on the Han predecessor. As for the operation of seeder, it was known that by the T'ang period, the work was already done by a team of one man and one ox.⁴¹

To sum up briefly the above discussions on the evolution of plow, harrow, and seeder during the period from the Han to the T'ang dynasties, three points should be noted here: (1) iron was the basic metal for these agricultural tools and this implied that the making of tools must have been specialized;⁴² (2) the evolution in the operation of these tools demonstrated a tendency towards labor-saving, namely, from a team of three men and two oxen to a team of one man and one ox; and (3) each kind of these tools had various types to accommodate the need of different natural conditions. Moreover, it should be emphasized that these improvements were taking place during a period when China was divided and the population was certainly

³⁹ Lu Ts'ai-ch'üan, p. 91; Wang Zhongshu, *Han Civilization*, p. 54.

⁴⁰ Lu Ts'ai-ch'üan, p. 92; Shih Sheng-han annotated, *Ch'i-min-yao-shu*, p. 111.

⁴¹ Lu Ts'ai-ch'üan, pp. 92-93.

⁴² As a matter of fact, iron industry was a state monopoly in most of the Han period; there were 50 localities where official were appointed to take charge of the iron industry, see Chen Chih, *Han Shu hsün-cheng* (1979), p. 144. Agricultural tools were mostly made by official forges in Han time and in later periods, private forges also took over some jobs of manufacturing small size tools, see Yang K'uan, *Chung-kuo ku-tai yeh-t'ieh chi-shu fa-chan-shih*, pp. 47-53.

growing very slowly in general, and at particular places even decreasing due to wars and disorders that occurred from time to time during this period of divisions. It was most likely that in the regions, such as the lower Yangtze area in the South, the Liao遼 River area in the Northeast, and Liang-chou 涼州 area in the Northwest, where the local conditions were comparatively peaceful the agricultural technology was still improving. Particularly, migrants from the North to the South during this period brought with them some comparatively advanced techniques which further enriched the native technology in the South.⁴³ In this sense, the interaction between migration and agricultural change stood out as a more relevant factor than the mere density itself during this period.

In the Sung dynasty (960-1279), the technology of iron metallurgy had a revolutionary improvement. The productivity of iron was raised due to improvements in furnace, bellows, and the use of coal as fuel. Moreover, a method of “mixing the steel” (*kuan-kang-yeh-lien-fa* 灌鋼冶煉法) which was first invented and adopted in the South during the sixth century was further spread all over the country during Sung time. Owing to this improvement in the method of iron metallurgy, large size agricultural implements could be made of wrought iron with steel blade.⁴⁴ As for the output of iron in China, one estimation showed that by 1078, annual output was from 75,000 to 150,000 tons which accounted for 2.5 to 5 times of the yield of England and Wales in 1640. The manufacturing of agricultural implements was one major way of consuming this large amount of iron.⁴⁵

A further improvement in the structure of plow during Sung time was the addition of a plow-knife (*li-tao* 犁刀). This was closely related to the improvement in iron metallurgy mentioned above. According to Wang Chen 王禎 (1271-1333), the author of *Nung-shu* 農書 (A Book on Agriculture), in the Yuan dynasty (1280-1368), the plow-knife was either fixed to a large plow or to a small plow (see Fig. 2b: this plow was most suitable to open new land because the knife with steel blade was sharp and durable.⁴⁶

Moreover, a kind of iron raker (*t'ieh-ta* 鐵搭, see Fig. 2c) which was also made of wrought iron with steel blade was found very popularly used in the lower Yangtze region since the Sung period. It is notable that this kind of raker was operated by strong farmers in the Lake T'ai (太湖) area during the Ming-Ch'ing period (1368-1911) because the soil around this area was heavy clay that could not be turned

⁴³ Lu Ts'ai-ch'uan, p. 93.

⁴⁴ Yang K'uan, *Chung-kuo ku-tai yeh-t'ieh chi-shu fa-chan-shih*, pp. 157, 172, 247-250; also see Sung Ying-hsing, *T'ien-kung k'ai-wu*, trans. E-tu Zen-sun and Shiou-chuan Sun (1966), p. 250 for a description of this method of “mixing the steel”.

⁴⁵ Robert Hartwell, “A Revolution in the Chinese Iron and Coal Industries during the Northern Sung, 960-1126 A.D.,” *Journal of Asian Studies*, Vol. 21, No. 2 (February 1962), pp. 152-162.

⁴⁶ Yang K'uan, *Chung-kuo ku-tai yeh-t'ieh chi-shu fa-chan-shih*, pp. 276-278.

easily by an usual plow drawn by an ox. Another iron tool known as long-coulter (*ch'ang-ch'an* 長鑿, see Fig. 2d) also was in use popularly since the Sung period. This tool was also called *t'a-li* 踏犁, a tread-plow, revealing that it was operated by a farmer using his foot to tread the plow and turn the soil. It was said that during the eleventh century, along the middle and lower Yangtze areas, this kind of tread-plow was widely used and the work accomplished by four or five men could be comparable with that by a plow drawn by an ox. In the Ch'ing period, this tool was still used by farmers to open new lands.⁴⁷

In the Ming-Ch'ing period, the population density in the lower Yangtze region was already reached a rather high level. The common usage of an iron raker or a long-coulter by man to till the land instead of using a plow drawn by an ox reflected perfectly the fact that the population density of this area reached a critical point just as Boserup suggested that people facing this critical point would accept any method of more steeply diminishing return to labor.⁴⁸ In other words, the adoption of these man-operated iron tools in the most densely populated region in China in the Ming-Ch'ing period provided a good example to illustrate the limit of traditional technology and the unavoidable hard toil under this technological level.

It has been mentioned above that during the period from the Sung to the Ch'ing dynasties, the cultivation system prevailed in China was multi-cropping and various types of rotation and interlacing. The degree of intensification was gradually reaching the highest level within the limit of traditional technology. Generally speaking, two major types of agriculture had gradually been developed into distinct forms with the dry land farming in the North and the rice paddies in the South. The kinds of tool applied in these two major types of farming were also gradually developed into integrated sets, such that the preparation of land was done by a set of tools including plow, toothed and toothless harrows which in the North was known as *keng-pa-mo* 耕耙耨, while in the South as *keng-pa-ch'ao* 耕耙耖.⁴⁹

Although the kinds of tool did not change very much since the Sung dynasty as demonstrated by modern scholars through careful comparison of the records in agricultural writings of the Sung, Yuan, Ming and Ch'ing dynasties, under the highly intensified usage of land (e.g., the degree of land use under triple-cropping is 300 per cent) and the extension into marginal lands, the agricultural output in China during the last six centuries from the Ming period on was still capable to keep pace with the population growth with little stimulation from technological improvements.⁵⁰

⁴⁷ Ibid., pp. 278-281. For the use of iron raker in the Kiangnan area, also see Chu Kuo-chen, *Yung-ch'uang hsiao-p'in*, 2: 14a, in *Pi-chi hsiao-sho ta-kuan*, Vol. 8 (1962).

⁴⁸ Ester Boserup, *The Conditions of Agricultural Growth*, pp. 42-42.

⁴⁹ Kuo Wen-t'ao, p. 34.

⁵⁰ Dwight H. Perkins, *Agricultural Development in China, 1368-1968* (1969), pp. 56-58.

Nevertheless, in addition to the mechanical aspect of technology such as the agricultural tools mentioned above, the technological improvement could also be perceived from the biological aspect, namely, the adoption of new seeds and new crops. Since it has become a common knowledge that the introduction of the early-ripening rice in the eleventh century and the American food crops, such as maize, potatoes and peanut, in the late sixteenth century were two influential events in the history of agriculture in China, this paper will not try to repeat these stories here.⁵¹ However, it should at least be emphasized that the adoption, development of new varieties, and spreading of these new seeds and crops certainly was not merely a historical accident during the period in which multi-cropping system was predominant in Chinese agriculture. During this long period of almost a thousand years, there must have been countless experiences of try and error through which the Chinese farmer was able to maintain enough food supply under the traditional technology which had reached a high level and finally had to find a breakthrough in modern technology to solve the problem of food supply in contemporary China.⁵²

With the above discussion on the improvements in agricultural tools and their occurrence at particular times, it seems appropriate here to try again to relate the agricultural technological change and population growth through time. One of the most important events during the past two millennia in the Chinese agricultural history was the adoption of iron implements. The iron plow drawn by oxen was first spread to a wider extent in the north during the Western Han period when Chinese population reached the first historical peak of 60-70 million at the beginning of Christian era. In the middle of the eighth century, Chinese population probably reached 100 million according to a recent re-estimation by an eminent historian of the T'ang history.⁵³ When this new figure of the T'ang population is accepted, it may help to explain the improvements in agricultural technology between the Han and the T'ang as discussed above. Regardless that there were short-term fluctuations of population during this period, in the long-run the population was growing in a slow and moderate upward trend. This perception of the population growth during the Han-T'ang period seems to be more plausible than a previous one that conceived the population as fluctuating along a stable level of around 60 millions.⁵⁴

⁵¹ For details, see Ping-ti Ho, "Early Ripening Rice in Chinese History," *Economic History Review*, Vol. 9 (1956-1957), pp. 200-218; Ping-ti Ho, "The Introduction of American Food Plants into China," *American Anthropologist*, Vol. 57, No. 2 (April 1955), pp. 191-201. Also see Ping-ti Ho, *Studies on the Population of China, 1368-1953* (1959), pp. 183-191.

⁵² For a theory of the high level equilibrium trap that was designed to explain the relationship between population growth and technological change in traditional China, see Mark Elvin, *The Pattern of the Chinese Past* (1973), p. 313.

⁵³ Yen Keng-wang, p. 1.

⁵⁴ John Durand, "The Population Statistics of China, A.D. 2-1953," Fig. 3 between pp. 246-247; John C. H. Fei and Ts'ui-jung Liu, "Population Dynamics of Agrarianism in Traditional China," in C. M.

In the next thousand years from around the tenth century on, the population continued to grow and reached a new peak of 120 millions by the end of the eleventh century, and again reached a higher peak of 400 millions around 1850 regardless of some interim short-term declines. This unmistakable upward trend of population growth was achieved during a period of very intensive land use in agriculture. As a result of population pressure, in the most densely populated lower Yangtze region the method of labor-using farming was even adopted to replace the animal pulling plow. Moreover, accompanying the widespread of the American food crops into marginal lands from the seventeenth century on, the Chinese farmer also faced the diminishing returns to land regardless the fact that the knowledge and variety of organic fertilizer had been increased. The Chinese agriculturists had been very much concerned about the application of organic fertilizer to improve land fertility as early as in the Warring States period, and from the Sung period on, a concept of “keeping the land fertility forever renewable” (*ti-li-ch'ang-hsin* 地力常新) became almost a cliché in most agricultural writings.⁵⁵ Behind this concept, there laid the fact that the good earth which had raised millions of Chinese people, indeed, required careful and tender treatment so that it could be as productive as before. This concept sounds to have a positive meaning in contrary to the classic theory of diminishing returns to the land. Thus, with this strong belief, even in the contemporary China, organic fertilizer still contributed 56.2 percent of the increased nutrients for agriculture on the China mainland during 1957-1971. During the same period, the human labor required to compost and process the manure amounted to more than one third of the rough total of 97.3 million workers added to China's agricultural labor force.⁵⁶ Intensification in agriculture has still been relied on as a major method to absorb increased population after 1950 in China.⁵⁷

At this point, one can not help to pause and wonder when the highly intensified Chinese agriculture will reach its ceiling if there were no modern inputs applied already to some extent.

4. Irrigation and Water-control

Another aspect of agricultural activities that related to the intensification of cultivation in China was irrigation. It was almost a certain conclusion that “irrigation

Hou and T.S. Yu eds., *Modern Chinese Economic History* (1979), pp. 59-60.

⁵⁵ For a discussion on the use of fertilizer in ancient China, see Ch'en Liang-tso, “Chung-kuo ku-tai nung-yeh shih-fei chih shang-ch'üeh,” *The Bulletin of the Institute of History and Philology, Academia Sinica*, Vol. 42, Part 4 (1971), pp. 829-842. For a discussion on the concept of *ti-li-ch'ang-hsin*, see Kuo Wen-t'ao, pp. 51-64, 102-133.

⁵⁶ Thomas G. Rawski, *Economic Growth and Employment in China* (1979), pp. 92-94.

⁵⁷ *Ibid.*, pp. 71-122, for details of intensification in agriculture in today's China.

arrived late in China”.⁵⁸ The Neolithic farmers in China chose to utilize first the lands on the “loess terraces or mounds along various tributaries of the Yellow River rather than the great river itself.”⁵⁹ Thus, primitive irrigation was not necessary in the Neolithic China.

Simple dikes for preventing the flood water and dams for conservancy were found in some poems in the *Book of Odes*. Moreover, there were also evidences in some poems indicating that the river water was utilized to irrigate fields, especially rice paddies south to the Wei 渭 River.⁶⁰ By the sixth century B.C., these were most likely primitive water conservancy devices or simple methods of utilizing natural waterways for irrigation.

It was in the middle of the six century B.C. that the first records about construction of ditches and dikes for irrigation were mentioned in the *Tso-chuan* 左傳 (Chronicles of Feudal States in the Spring and Autumn Period). In the north, there were two statesmen of Cheng 鄭 State, Tzu Ssu 子駟 and Tzu Ch’an 子產, who respectively tried to construct ditches among fields in 563 B.C. and in 543 B.C.; and in the south, there was a Minister of War in Ch’u 楚 State, Yuan Yen 蔣掩, who was in charge of building dikes in 548 B.C. Modern scholars tend to consider these events as representing the beginning of irrigation in China.⁶¹

Some famous large scale irrigation works were constructed during the Warring States period when the cultivation system was in the process of transforming from short-fallow to annual cropping in some localities. One of these works was Tu-chiang-yen 都江堰, a dam constructed during the reign of Ch’in Chao-wang 秦昭王 (306-251 B.C.) by Li Ping 李冰, the great hydraulic engineer and Prefect of Shu 蜀 (in modern Szechwan). This work not only irrigated five million *mou* 畝 (1 Ch’in *mou* = 0.47 acre) of land in the Ch’eng-tu 成都 plain but also reduced the harmful floods along the Min 岷 River. During the Ch’in-Han period, the Ch’eng-tu plain was one of the most developed and important agricultural areas in China. This was certainly a result benefited by the construction of Tu-chiang-yen.

Another famous work was Cheng-kuo-chü 鄭國渠, a canal of more than 300 *li* 里 (1 Ch’in *li* = 0.46 km) built along the Ching 涇 River around 246 B.C.. This canal was constructed originally under a plot intended to exhaust the manpower of Ch’in State to prevent her from engaging in military expansion. However, the canal

⁵⁸ Ping-ti Ho, *The Cradle of the East*, p. 46.

⁵⁹ Ibid., p. 45. For a brief survey on land use in the Neolithic China see, Chia Wen-lin, “Ts’ung wo-kuo hsin-shih-ch’i shih-tai i-chih te fen-pu k’an tang-shih nung-yung-ti k’ai-fa li-yung te ch’ü-shih,” *Nung-shih yen-chiu*, Vol.2 (1982), pp. 54-63.

⁶⁰ *Chung-kuo nung-hsüeh-shih Ch’u-kao*, pp. 48-49. The poems cited were *Ju-fen* 汝墳, *Tse-p’i* 澤陂, *Pai-hua* 白華, and *Chiung-cho* 洞酌 which were dated to the Western Chou and the early Spring and Autumn periods.

⁶¹ Ping-ti Ho, *The Cradle of the East*, p. 46; Huang Yao-neng, *Chung-kuo ku-tai nung-yeh shui-li-shih yen-chiu* (1978), pp. 30-31, 58-64.

turned out to be so beneficial to the agriculture of Ch'in and that Cheng Kuo, the engineer sent by the King of Han 韓 State to carry out this plot, was forgiven for his spying role and the canal was named after him. It was recorded by the Grand Historian, Ssu-ma Ch'ien 司馬遷 (139?-86 B.C.), that this canal irrigated more than four million *mou* of land around the Kuan-chung 關中 area, and each *mou* of land could produce one *chung* 鍾 (= 6.4 Ch'in *shih* 石 = 128 litres). Thus, the Kuan-chung plain became so fertile that Ch'in State was finally able to conquer other states and unified China with this wealthy agricultural base. Cheng-kuo-chü was renovated and maintained during the Han period and thus the Kuan-chung plain became the granary of China during the Ch'in-Han period.⁶²

The above two irrigation works undertaken by Ch'in State were so much praised by ancient historians certainly because their scales were large and their benefits great. Particularly, the Ch'in canal was remarkably long in comparison with an irrigation canal of 20 *li* constructed along the Chang 漳 River in Wei 魏 State (in modern Honan) during the time of Wei Hsiang-wang 魏襄王 (445-296 B.C.).⁶³ The ancient historians tended to emphasize the beneficiary effects of the Ch'in irrigation constructions which laid down the material base for the Ch'in to unify China, it seems more relevant here to speculate about whether these irrigation works had any relations to the transformation of cultivation system. Although there is a lack of direct record related to this aspect, indirect evidences seemed to support a positive relation. For instance, before the canal was built to lead the water of Chang river to irrigate lands around Yeh 鄴 (in modern Honan), a typical farmer there was still practicing a kind of short-fallow by occupying an amount of land in 200 *mou* which was a double of the standard amount prevailed in Wei State.⁶⁴ As it has been mentioned above, by the end of the Warring States period annual cropping gradually appeared in North China, the evidence showed here was, of course, very scanty but it was rather supportive to the positive effect of irrigation on transformation of cultivation system.

Once the irrigation became one of the crucial factors that affected agricultural production was well recognized, both the rulers and the people in later generations paid great attention to it. In addition to some famous large scale projects, there were countless small works which were even not recorded in any document. Since it is not the purpose of this paper to go into details of every major irrigation project and its effects on agriculture in China, suffice it to mention here some statistics that may provide an overall view of the development in irrigation and water-control spatially and temporally.

⁶² *Chung-kuo nung-hsieh-shih Ch'u-kao*, pp. 82-83; Cho-yun Hsu, *Han Agriculture*, p. 101; Wang Zhongshu, *Han Civilization*, pp. 55-56.

⁶³ *Chung-kuo nung-hsieh-shih Ch'u-kao*, p. 83.

⁶⁴ Yang K'uan, *Chan-kuo shih* (1980), pp. 59-60.

The first attempt to quantify the water-control activity in China was taken some fifty years ago.⁶⁵ Temporally, this statistics showed that there was an increasing trend in the development of water-control activities throughout the period from 722 B.C. to A.D. 1911, if some short dynastic records were neglected. In terms of total number, there were 56 projects in the Han, 254 projects in the T'ang, 1,116 projects in the Sung, 2,270 projects in the Ming, and 3,234 projects in the Ch'ing dynasties. Spatially, the total number of water-control projects in fifteen provinces throughout the whole span of time ranged from 50 (in Kansu) to 1,406 (in Chekiang); a general view was that except for in the Ch'ing dynasty, there were more projects in provinces in the South than in those in the North.

Although the periodization of Chinese economic history into five periods based on the concept of key economic area defined by Chi Ch'ao-ting 冀朝鼎 was still debatable, his efforts to demonstrate the shifting of key economic areas from the Yellow River to the Yangtze River valleys and secondary key area in Szechwan and the Pearl River valley was quite plausible as long as the water-control activities were related to agricultural development.⁶⁶

A more recent attempt to quantify water-control projects in China was undertaken by Perkins and his associates.⁶⁷ This statistics had been organized by century and by region, unlike the first one that was arranged by dynasty and by province. The regions included the Northwest (Shensi), the North (Hopei, Shantung, Shansi), the East (Anhui, Kiangsu, Chekiang), the Central (Kiangsi, Hupei, Hunan), the Southeast (Fukien, Kwangtung), and the Southwest (Yunnan, Szechwan). The time spanned from before the tenth century to the nineteenth century. Throughout this time span, the sixteenth century stood out as having the largest number of water-control projects (counted 1,074), and the next largest number fell in the eighteenth century (818 projects) followed by the tenth-twelfth centuries (792 projects). It seems that these three peaks of water-control development coincided roughly with some of the peaks in the trend of population growth.

In terms of regional distribution, in the tenth-twelfth centuries, most of the projects took place in the Southeast (353) and the East (315), the projects in these two regions accounted 84 percent of the total at that time. In the sixteenth century, the Central (361), the East (314), and the North (200) together occupied 81 percent of all projects in that period. In the eighteenth century, all projects were more or less evenly distributed among regions, such that the Southwest had 195 (23.8%), the North had 186 (22.7%), the East had 128 (15.6%), the Central had 116 (14.2%), the Southeast

⁶⁵ Ch'ao-ting Chi, *Key Economic Areas in Chinese History: As Revealed in the Development of Public Works for Water Control* (1936; 1963), p. 36 for the statistical table.

⁶⁶ *Ibid.*, pp. 9-11; also see the map next to the title page of the referred book.

⁶⁷ Dwight Perkins, *Agricultural Development in China*, pp. 60-70, especially see Table IV.1 on p. 61.

had 115 (14.1%), and the Northwest had 78 (9.5%). This phenomenon of more even distribution perhaps related to the fact that the eighteenth century was a period of rather rapid population growth and expansion of agricultural frontier into marginal lands through migration movements, especially those moved to the Southwest.

To sum up briefly, although the Chinese rulers recognized the importance of water-control activities as early as in the sixth century B.C., the soundness of the idea of “oriental despotism” proposed by Wittfogel has been rather doubtful for its applicability to the case of China.⁶⁸ The point must be emphasized here is rather the fact that there is a positive relation between the frequency of water-control projects and regional agricultural expansion and population growth through time as revealed by the two sets of statistics so far available.

Concluding Remarks

From the above discussions, this paper has tried to reiterate some salient features related to the agricultural change and population growth in China through time. The following points should at least be emphasized here:

(1) The agricultural frontier expanded through time and the gravity center of agriculture shifted from the North to the South. Simultaneously, the population distribution also changed temporally and spatially. The turning point was around the T'ang-Sung transition period (10-11th centuries) when the South assumed definitively the place as the economic center of China.

(2) In the evolution of cultivation systems, annual cropping appeared rather early in China. Of course, there was coexistence of various systems in any period and in any region, it was certain that as early as around 200 B.C., annual cropping appeared in some places in the North and multi-cropping probably was already adopted in the first century B.C. With this early development of systems of annual cropping and multi-cropping, the typical Chinese agricultural method was thus tended to be rather intensified and this was no doubt a response to the pressure of population growth.

(3) The process of improvements in agricultural technology was rather slow although seemed to be compatible with the pace of population growth to some extent before the tenth century. It was most remarkable that when population density of the lower Yangtze area had reached a considerable high level in the Ming-Ch'ing period, the use of animal-pulling plow was replaced by human-operating rakers and long-coulters. This reflected that the diminishing returns to labor was unavoidable even more efforts had put into to keep fertility of land with large amount of organic

⁶⁸ See Ping-ti Ho, *The Cradle of the East*, p. 48; Lien-sheng Yang, “Economic Aspects of Public Works in Imperial China, in the Author’s *Excursion in Sinology* (1969), p0. 12-17.

fertilizer.

(4) Irrigation arrived comparatively late in China. However, once its importance was well recognized, its development was tended to be parallel with that of agriculture. The shifting of key economic areas defined by frequency of water-control activities reflected quite well the shifting of agricultural and population gravity centers throughout Chinese history. In this sense, the frequency of water-control activities may serve as one of indicators to help explain the relation between agricultural change and population growth through time.

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摘要

中國人口在西元二年 (漢平帝元始二年) 的紀錄接近六千萬人，在一九八二年則已超過十億。養育這眾多的人口一直是中國農業最重要的任務。本文試由歷史觀點扼要的考察中國農業變遷與人口成長的關係。

本文由四方面來探討與人口成長有關的農業變遷。這四方面是：(一)農業開發地域之擴張，(二)耕作法與土地利用之改變，(三)農業技術之改良，以及(四)水利與灌溉。每一方面都盡量在資料許可的範圍內，從時間和空間兩角度來考察長期間之變化。

本文的結論是農業深耕化在中國發生得相當早，而且精耕細作的農作法早在西元前二百年左右就已採用。透過檢討耕作法之演進以及因應人口成長而形成的愈來愈深耕的農業，本文試以中國的歷史經驗來檢證包雪如 (Boserup) 的理論，發現她的理論在相當的程度內可以解釋中國的情況，但並不是每一點都可以完全解釋。