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AGRICULTURE AND DAIRY PRODUCTION SYSTEMS IN CHINA: AN OVERVIEW AND CASE STUDIES

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AGRICULTURE AND DAIRY PRODUCTION SYSTEMS IN CHINA: AN OVERVIEW AND CASE STUDIES

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Executive Summary

PART I: INTRODUCTION TO CHINA AND ITS AGRICULTURE: THE CONTEXT IN WHICH THE CHINESE DAIRY INDUSTRY IS DEVELOPING

Chapter 1: Overview of China: Another Land, Another People, Another Agricultural System

- China is a country that is about the size of the US (9.6 vs. 9.4 million km^2), but its agricultural production system feeds a population about five times that of the US (1.27 vs. 0.28 billion people). China's available arable land is 70 percent that of the US (1.2 vs. 1.8 million km^2). China's agriculture feeds 21 percent of the world with 9 percent of its arable land.
- China is made up of twenty-three provinces, five autonomous regions and four "large cities." China has a larger urban population than the US (430 vs. 213 million people), and a much larger rural population (843 vs. 64 million people). The degree of urbanization is about 66 percent in China compared to 77 percent in the US.
- Large differences in levels of agricultural technology and industrialization are reflected in the number of people whose livelihood depends directly on agriculture. The agricultural population is reported to be 855.2 million in China and 6.3 million in the US.
- Population statistics also reveal that a significant number of urban Chinese are directly involved in agricultural production, especially in the urban and peri-urban production of fruits and vegetables (see Part II).
- The "Han" are by far the largest ethnic group, but the Chinese central government has recognized more than 55 "minority" groups (8% of the total population). In contrast to most Han people, many minority groups have cultural traditions and experience in livestock husbandry.
- China's agricultural area can be divided in three main regions based on climate, elevation, and soil fertility, and thus suitability for agricultural production:
  1) Intensive agricultural (cropping) regions in the lowland plains;
  2) Hospitable pastoral regions of the uplands; and
  3) Harsh pastoral regions of the high continental plateaus.
- Since 1978, Chinese farmers have enjoyed a certain autonomy in decision-making regarding production of agricultural commodities on their farms. This and other fundamental changes in China's agricultural system were the result of the "household responsibility system" introduced by the economic reform launched in 1978 by former Chinese leader, Deng Xiaoping.
- Under the "household responsibility system," the village land was distributed equally among the residents. In 1997, the central government extended farmers' land contracts for 30 years. Under the current system, the land used by farmers is taxed by local units of government. The land can be rented to neighbors, but it cannot be sold.
- China's agricultural sector continues to face great challenges as conflicting government policies strive to:
  —Achieve food security for a huge population:
  —Transition from centrally planned agriculture toward a market economy; and
  —Reduce rural poverty by maintaining farm income.
- Agriculture in China is moving toward modernization, commercialization, and specialization to serve an increasingly affluent urban population.

Chapter 2: Crop Production, Livestock Production, and Dietary Habits in China and the US

- The statistics presented in this section indicate a definite shift toward more animal products in the Chinese diet and the increasing importance of animal production in China's agriculture.
- Rice and wheat remain the major crops in China, in contrast to corn and soybeans in the US. However, corn became the second highest yielding crop in China (after rice) beginning in mid-1995. Corn displaced wheat as animal husbandry increased and the demand for animal feed increased.
- The number of hectares of vegetable crops is 10.6 times higher in China than in the US, and vegetable production is 7.1 times higher. One can assume that a significant portion of vegetable and fruit production is taking place in urban and peri-urban areas because of the perishable nature of these products and the limited transportation infrastructure in China.
- Within the livestock sector, pork production has been, and remains, the primary component of China's livestock industry. China has about 438 million pigs, which is more than half the world swine population, and the country produces five times the US output of pork.
- Poultry and bovine meat production lag far behind pork production in China, but these sources of meat are contributing to an increasing proportion of the total meat supply. The rise in beef and poultry production became substantial by the late 1990s.
- With the exception of milk products, the availability of animal products to the Chinese diet is above world averages.
- In 2000, China's commercial milk production was still in its infancy. Milk availability was seven times lower in China (6.9 kilos per person) when compared to the world average (46.4 kilos per person), and 17 times lower than in the US (117.3 kilos per person).
- Vegetables and fruits remain the primary sources of calories and protein in the Chinese diet. However, in the last 25 years—especially in the last decade of the 20th century—the Chinese diet has included an increasing amount of animal products including seafood, eggs and meat, and to a lesser extent, milk.
- It is likely that the demand for animal products will continue to increase considerably because of the combined effects of:
  — Population growth;
  — Growth in income of an increasingly urban population; and
  — Current policies supportive of animal product consumption as a way to improve the nutritional status of the Chinese population, especially protein and calcium levels.

Chapter 3: The Dairy Industry in China

- China's milk output changed from not even being recorded 25 years ago to a level similar to Wisconsin's milk output (11 million metric tons), but substantially lower than US milk output (76 million metric tons). Government predictions place national milk output at 42.5 million metric tons by 2030.
- The dairy industry in China has a very short history, but it is growing very rapidly. Rate of growth in milk production and dairy cow inventory averaged 8 percent in 1999.
- Although dairy cows contribute an increasing proportion of China's national milk output, buffalo and sheep milk also contribute substantially.
- The number of dairy cows in the US fell annually between 1985 and 2000, averaging 123,600 per year. In contrast, the average annual increase in China's dairy cow numbers between 1980 and 2000 was 210,000 per year. Assuming that the same trend continues, by 2012 there will be as many cows in China as in the US—approximately 7.45 million cows.
- While US milk production per cow increased from approximately 4600 kilos to 8400 kilos in the last 25 years—an average increase of 163 kilos per year, milk production in China has essentially stagnated around 1,700 to 1,800 kilos per cow per year since the 1980s.
- From the last two points, one can infer that the increase in national milk output in China resulted primarily from the increase in cow inventory rather than cow productivity. In contrast, the

increase in national milk output in the US resulted from increased cow productivity at the expense of cow numbers.

- Historically, milk production in China was primarily located in and around urban centers. Collectively, the highly urbanized areas of the three "large cities" of Beijing, Tianjin and Shanghai comprise nine percent on national milk output.
- Among the pastoral provinces, Heilongjiang may be considered by far the "Chinese Dairyland" with 18 percent of national output in 1999. Hebei Province and the autonomous region of Inner Mongolia are the second and third largest milk producing areas in China.
- For a long time, the central government supported the popular view that milk should be reserved for babies, young children, the sick, and the old. Recently, however, the central government has recognized the human nutrition and health benefits that would accrue from increasing milk and dairy products in the diet of the Chinese people as a whole. Thus, the government is encouraging and supporting the development of the dairy industry.
- Milk consumption was less than two kilos per person per year in China in 1975, but increased to 6.9 kilos in 1999. Milk consumption shows strong differential patterns ranging from 0 to 24 kilos per person in urban areas and 0 to 14 kilos per person in the rural areas of China.
- More than half of China's raw milk output is used for processed dairy products. Ice cream and milk powder are the top two processed products—both in terms of volume of production and milk equivalents. In contrast, production of cheese and butter is almost negligible.
- Imported dairy products are more popular and the quality is more highly valued than domestic brands in China's niche urban markets (e.g., cheese and butter in hotels and restaurants, milk powder and whey products for infant formula, and ice cream in the fast-food industry).
- In 1998, China spent 84.6 million dollars to import 111,000 metric tons of dairy products. In 1999, the value of dairy products exported from the US to China was $17 million, but $60 million to China and Hong Kong combined.
- In 1998, the top three imported products and the top supplier along with their percent share of the imported market in China were:
  1) Fluid milk from Australia (72%);
  2) Powdered milk from New Zealand (50%); and
  3) Whey products from the United States (30%).
- Upon entry to the World Trade Organization (WTO), China will commit to dramatically reduced import barriers by lowering tariffs. They will also commit to using sound scientific measures for sanitary import regulations.

PART II: A STUDY OF THE DAIRY INDUSTRY AND DAIRY FARMS IN THE PROVINCE OF YUNNAN, THE CITY OF BEIJING, AND THE PROVINCE OF HEILONGJIANG

Chapter 4: Dairy Production Systems in Beijing, Yunnan Province, and Heilongjiang Province

- An increasing number of dairy cows are owned by private entrepreneurs. The transition in production systems from large state-owned farms to private farms that are primarily smaller creates challenges and uncertainties about the future of domestic production in China.
- Given China's strong emphasis on developing an infrastructure for the production and distribution of semen from tested North American bulls, feeding, management and disease control are more likely to limit cow productivity than the breeding value (genetic potential) of the cattle.
- In Yunnan and Heilongjiang, officials identified lack of access to financial resources and milk marketing strategies as the main factors limiting the expansion of milk production in their provinces. In contrast, in Beijing poor feed quality was considered the most limiting factor to the current production system.
- In Yunnan Province, there is an important constraint on land and forage available for milk production. However, producers in Yunnan Province use a wide variety of by-products to feed

their cows. They take full advantage of the cow's ability to utilize crop residue and other products unfit for human consumption.

- In Heilongjiang Province, land is abundant and forage production could be expanded considerably. Given the right set of economic circumstances, forage production could be doubled or tripled.

Chapter 5: Analysis of Chinese Dairy Farm Management Systems—A Series of Case Studies

- In a field study of Chinese dairy farms, four of the five farms studied were profitable. Although a large collectively-owned farm was losing money, return on assets on some of the well-managed Chinese dairy farms were higher than in Wisconsin.
- Small privately-owned farms were as profitable as much larger collective- or state-owned farms.
- Large, well-managed Chinese farms have net farm incomes approximately three times lower than Wisconsin farms of similar size. This difference may be due to a combination of lower milk prices and lower milk production per cow on China's farms as compared to Wisconsin farms.
- Estimates of the nitrogen recycled on crops ranged from 12 to 18 percent on Chinese farms, as compared to 21 percent on an average Wisconsin farm.
- Development of policies that value manure for its fertilizing value could contribute to dairy farm profitability and reduce the risk of environmental pollution both in China and in the US.

PART I: INTRODUCTION TO CHINA AND ITS AGRICULTURE: THE CONTEXT IN WHICH THE CHINESE DAIRY INDUSTRY IS DEVELOPING

Michel A. Wattiaux, Gary G. Frank, Yuyuan Guo*

Chapter 1: China—Another Land, Another People, Another Agricultural System

1.1 Introduction

The People's Republic of China (PRC) is the third largest nation on earth, after Russia and Canada. China's land area is slightly larger than that of the United States—9.6 and 9.4 million km,^{2} respectively. These two countries lie at about the same latitudes on opposite sides of the earth's surface (Figure 1.1). China is a nation with more than five thousand years of history, the oldest continuing civilization in history, yet its current political system and social structure were established just over 50 years ago (1949). By comparison, the US has an extremely short history—the Constitution defining its political system and social order was adopted approximately 225 years ago (1776).

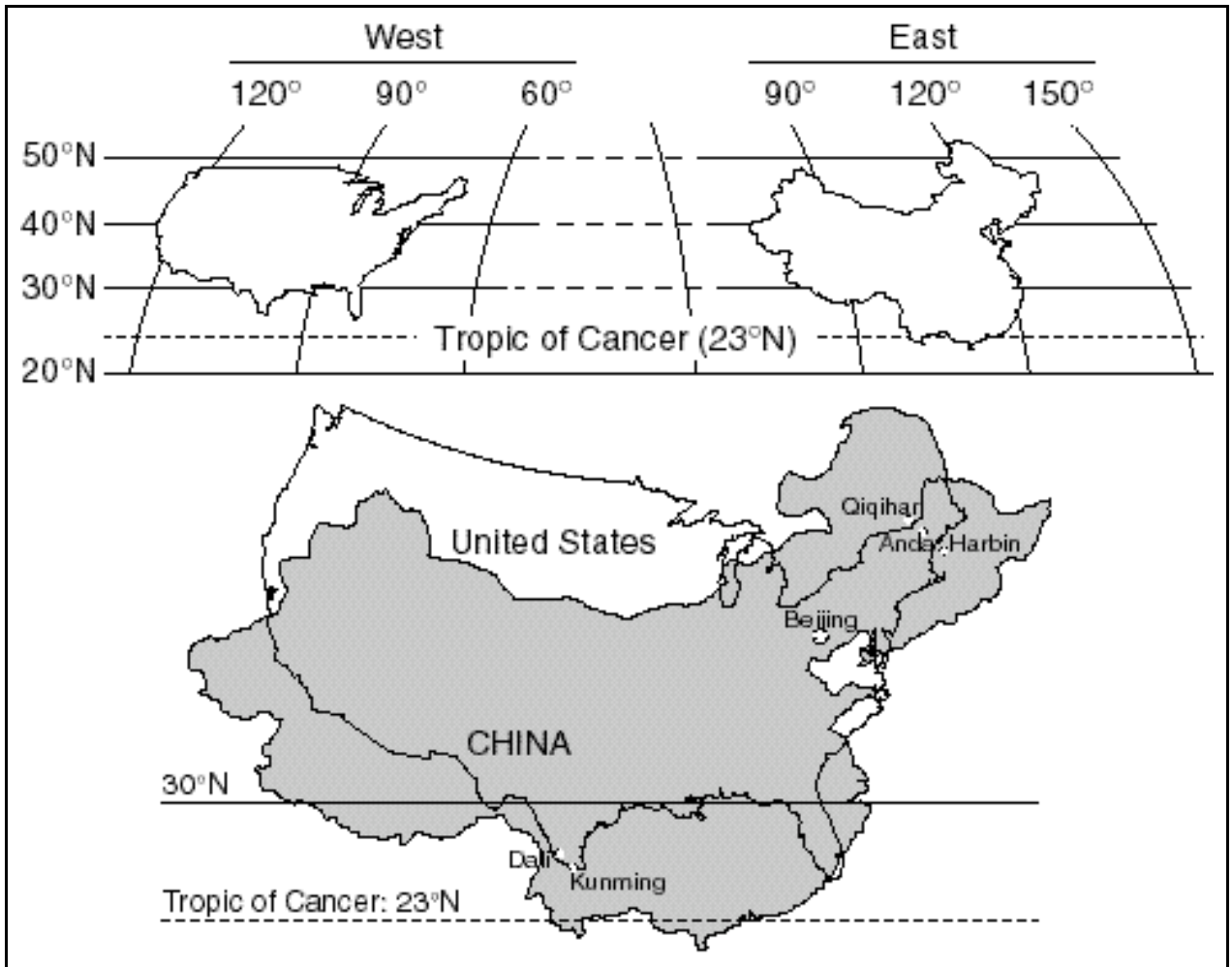

Figure 1.1: Location and relative size of China and the US. The Chinese cities listed on the map identify the sites visited and discussed in Part II of this paper.

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1.2 Social and Political Structure

Under the central government, China is administered through four large cities (Beijing, Tianjin, Chongqin, and Shanghai), twenty-three provinces, and five autonomous regions.[1] Provinces and autonomous regions are divided into prefectures and "big cities," which in turn are divided in urban and suburban districts and counties. Counties are divided generally into "county towns" and townships. Townships are made up of one or a series of villages. The final unit of decision-making is at the household level, which may consist of several generations of the same family.

This administrative and social structure has come about as a result of the economic reform launched in 1978 by former Chinese leader, Deng Xiaoping. The rural economy was to be transformed by shifting from a central planning system to a household decision-making system, referred to as the "Household Responsibility System." As a result, the "commune production teams" established in 1958, were officially abolished in 1978. The dismantlement process, however, was not completed until 1983. People in the countryside have elected their village leaders since the early 1990s. Despite these changes, all other positions in the administrative hierarchy, including city officials, are filled by individuals chosen by the communist party leadership.

1.3 Land

With the exception of the Southeast, China is a country of hills, plateaus, and mountains of marginal land. As indicated in Table 1.1, China has much more of its land classified as permanent pastures ("wild prairie" or "improved grazing land") than the US. Although the US has more arable land than China, the double and triple cropping possible in southeastern China allows farmers to effectively sow and harvest more acres than the arable land area. Estimates of China's sown area was 155 millions hectares in 1997 [37].

Table 1.1. Land use in China, the US, and the World*

Land cover, 1000 Hectares[1]	China	US	World
Permanent cropland: Land cultivated with crops that occupy the land over long periods and need not be replanted after each harvest—cocoa, coffee and rubber; land where flowering shrubs, fruit trees, nut trees and vines are grown, excludes land where trees are grown for wood or timber.	11,421	2,050	131,527
Permanent pastures: Land used for five years or more for herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).	400,001	239,250	3,426,531
Arable land:[2] Land where crops are grown temporarily (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land with market and kitchen gardens, and land temporarily fallow (fewer than five years).	124,144	176,950	1,380,239
Agricultural areas. Arable land, permanent cropland, and permanent pasture land.	535,566	418,250	4,938,296
Total Area (including areas under inland water bodies)	959,805	936,352	13,387,019

* Source: FAO, 2001.

[1] One hectare = 2.47 acres; one acre = 0.405 hectares.

[2] Data for "arable land" are not meant to indicate the amount of land that is potentially cultivable.

Topographically, China can be divided into three levels of elevation like "three gigantic steps" that start at sea level in the Southeast and rise in a northwestern and western direction to reach the Tibetan plateau and the Himalayan mountain range to the southwest (see gray areas in Figure 1.2). The first step includes the alluvial plains of the agricultural region along the east coast (0-500 meters above sea level) and the low hills of the Northeast (500-1000 m). The second step (1000-

[1] See the section 1.8 for more details.

2000 m) consists of hills, mountains, plateaus, and basins of the northern, northwestern and near southwestern provinces. This step is divided in its center by mountain ranges (Qinling Range), which effectively separate the dry, wheat growing lands of the north from the humid, rice growing lands of the south [19]. The third and highest step is the Qinghai-Tibetan plateau of the far Southwest with an average elevation of more than 4000 meters. Generally speaking, the three main agricultural regions of China overlay the "three gigantic steps." The location of these "overlapping regions" are presented in Figure 1.2 in which intensive agricultural areas of the lowlands are depicted in white (Step 1), the upland pastoral regions suited for ruminant livestock production are depicted in light gray (Step 2) and the rugged high plateaus of the southwest are depicted in darker gray (Step 3).

Figure 1.2: China's neighbors, provinces, major cities and regions. (Various elevations and agricultural regions of the country are shaded as follows: dark gray = Tibetan Plateau, light gray = mountains, plateaus and basins, white = lowlands. The gray areas include the 12 provinces officially recognized as China's pastoral regions while the white provinces are areas of intensive agricultural cropping practices [13].)

1.4 Climate

In winter, China's climate is under the influence of cold, dry continental air masses originating from Siberia. In summer, warm maritime air masses originate from the Pacific Ocean and bring rain-bearing monsoons, especially on the country's eastern plain. Annual precipitation decreases gradually from 2,000 mm along the southeastern coast (intensive agricultural region, Step 1), to 1,000-1,500 mm in central China, 500-700 mm in northern China, 400-600 mm in northeastern China (pastoral regions, Step 2), and less than 200 mm in most of the Northwest (inhospitable high plateaus, Step 3).

Although temperature generally increases rapidly from north to south, elevation is also an important determinant of temperatures throughout China. Figure 4.1 shows annual average temperatures and precipitation in Heilongjiang Province (northeast), Beijing (north central), and Yunnan Province (southwest). This figure also compares the climate in these three regions with that of Wisconsin.

1.5 Agricultural Regions

As described above, there are three main agricultural regions in China.

1) **Intensive agricultural (cropping) regions of the lowland plains (Step 1):** Intensive cropping systems on arable land are found along the entire eastern portion of China. Agricultural intensification increases from north to south because of improved weather conditions, increased irrigation, double cropping, and high return on fertilizer.
2) **Hospitable pastoral regions of the uplands (Step 2):** As the elevation increases to the west, soil fertility and productivity declines rapidly. The percentage of land area suitable for crops declines. Semi-arid and arid ranges, and permanent pasture become the predominant features of the landscape. China has one of the largest grassland and pastoral areas in the world. Three hundred thirteen million hectares of the 400 million hectares of grassland are being used [17]. Land may be classified as unusable because of its salinity, lack of water, overgrazing, or other reasons. Most of this region is officially recognized as China's "pastoral region" [11]. Pastoral pursuits and livestock raising (with variable degrees of intensification) are "a way of life" for many of the people in these regions of China—roughly a third of the country's land area.
3) **Harsh pastoral regions of the high continental plateaus (Step 3):** Finally, the inhospitable high desert plateaus of the far northwestern and the Qinghai-Tibetan regions are unsuitable for most crops and even forestry. Evolutionary adaptation to cope with conditions of extreme weather and scarce feed resources is found in the yak, the only large domesticated ruminants species able to survive and strive in high altitudes of Asia. The landscape above the snowline is mostly bare, precipitous rocky mountains.

1.6 Population

China is the most populated country on earth. In 1999, China was home to almost 1.3 billion people compared to 0.28 billion in the US. China contributed 21.3 percent to the world population, while the United States contributed only 4.6 percent.

If China's fertility rate for the average childbearing woman remains at its current value of 1.9, population dynamics predict that China's population will peak at 1.5 billion in 2030 before declining slowly thereafter. However, if for any reason fertility rate goes back above 2.0, China's population will not peak, but continue to grow and reach 1.6 billion in 2030 [16].

1.7 Urban, Rural, and Agricultural Populations in China and the US

Economic development studies have shown that the demand for livestock products increases with increases in household purchasing power. Thus, not only population but also household income must be accounted for when predicting the demand for livestock products in economically developing nations.

Tso [20] reports that the 1996 per capita income in urban area and rural areas averaged 4839 RMB and 1926 RMB, respectively.[2] True differences in purchasing power may be even greater than the 1 to 2.5 ratio in income because inflation for agricultural inputs was 8.4 percent, while the government purchase price for agricultural products only increased 4.2 percent.

As indicated in Figure 1.3, the Chinese rural population peaked in the early 1990s and began to decrease slightly in the late 1990s. In 1999, 843.1 million Chinese lived in the countryside. In contrast, total population continued to increase steadily throughout the 1980s and 1990s. China's urban population increased from 165 million to 430 million between 1975 and 1999. Despite a rapid rate of migration to the cities in the last 25 years, more than 66 percent of the population still lived in the countryside at the beginning of 2000. In contrast, only 23 percent of the US population was rural in 1999. The US has had a high degree of urbanization for a long time. In 1999, the urban population of the US (213 million) made up 77 percent of the total population, but it was only about half the size of the Chinese urban population.

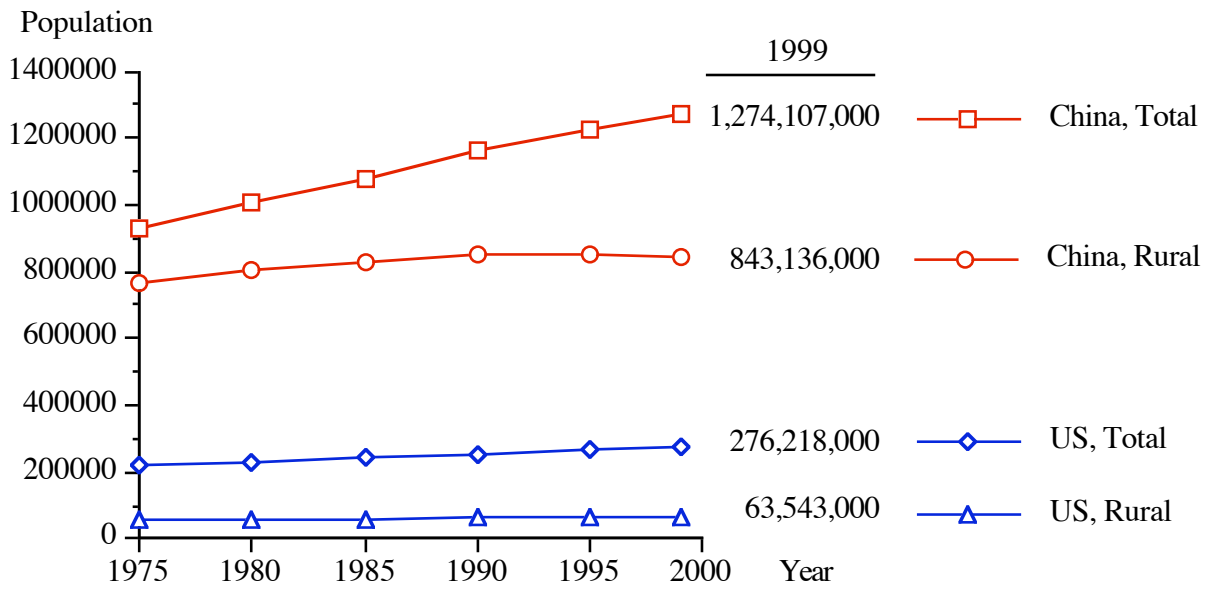

Figure 1.3: Change in total, urban and rural population in China and the US between 1975 and 1999

According to FAO, the agricultural population is reported to be 855.2 million in China and 6.3 million in the US [7]. Agricultural population is defined as all persons whose livelihood depends on agriculture, hunting, fishing, or forestry. This estimate includes all persons actively engaged in agriculture and their non-working dependants. A comparison of urban-rural and agricultural–non-agricultural populations indicates that:

- About 12.1 million Chinese (855.2 million total population minus 843.1 million living in the countryside) live in urban areas and depend on agriculture for their livelihood. This population may include those involved in private gardening activities and employees of "peri-urban" livestock farms. This estimate does not account for those who live in the countryside, but are not involved in agriculture [5].
- About 57.2 million people in the US (63.5 million minus 6.3 million) live in the countryside but do not depend on agriculture for their livelihood.

[2] RMB = Chinese currency is called Renminbi (meaning "people's money"); the RMB is formally referred to as the Yuan. At the time of the visit, the exchange rate was 8.2 Yuan = 1 US dollar.

1.8 Population Distribution and Ethnic Minority Distribution in China

Overall, population density averages 134 persons per km^2 in China and 30 persons per km^2 in the US. As in the US, China's population is very unevenly distributed throughout its land area. Fifty-seven percent of the land in China's western arid regions and high plateaus is sparsely populated and includes less than 10 percent of the country's population. Population density may be as low as one or two persons per square kilometer. In contrast, the 43 percent of land in the southern and eastern regions of the China is home to more than 90 percent of the nation's population. Population density peaks at more than 600 persons per km^2 in the Chengdu Plain [19].

The "Han" is the largest ethnic group in China, but there is also great ethnic diversity. Since the 1978 reform, China's central government has recognized more than 55 minority groups, which include 91.2 million people or 8 percent of the total population [13]. Typically, China's minority nationalities or groups are concentrated in autonomous regions located primarily along the borders of the north (Inner Mongolia), west, southwest (Tibet), and south. Compared to provinces, the autonomous regions have considerable freedom to legislate in relation to minority groups living in the region. As a result, they enjoy a certain degree of autonomy from the Han-dominated central government policies—for example, minorities are exempt from the one-child-per-family policy. Nevertheless, minorities do benefit from educational, social and economic programs from the central government.

1.9 Transition in Agricultural Entrepreneurship

Before 1978, there were no private farms in China. Peasants worked for the "commune brigade." Agricultural labor on state-owned or collective farms was akin to factory labor. However, since China has taken the path of a market economy, its agriculture has been in transition away from large state-owned agricultural enterprises. The progressive decentralization of the economy that began with the economic reform of 1978 has allowed producers to choose which crops to grow and what livestock to raise. Private ownership fostered entrepreneurship among the peasants. The purchase of cattle or buffalo to plow the household plot of land became an important investment for small "independent" producers. As a result of this transition, there are now multiple, competing forms of ownership and "units of production":[3]

- Household farms (small, privately operated);
- City-owned farms (often peri-urban) or state-owned farms (large and publicly operated);
- Collective farms (large, community operated); and
- Business enterprises (large, privately operated).

No formal mechanisms or guidelines were put in place for the reform of public institutions except that the tendency has been "to wean" them progressively from direct government funding [3]. Although state-owned or city-owned enterprises are on the decline and private entrepreneurs are on the rise, the transitional interaction between these "older" and "newer" modes of production is fascinating. In a way, both forms of agricultural production rely on the other to guarantee their futures. For example, for the economies of scale (or at least the potential for economies of scale), the state-owned farms currently possess the most experience or "know-how," and have benefited from years of investment and agricultural "extension" services. On the other hand, small private entrepreneurs benefit from current governmental policies and their labor force is more efficient. In the climate of current policies, some of the large publicly-controlled farming enterprises are taking up new roles: for example, they often serve as "demonstration farms" or provide "inputs and services" for the smaller private enterprises [29].

As China's agriculture continues its transition, there are at least two outstanding policy issues that have had—and will continue to have—critical impact on successful forms of agricultural entrepreneurship: price control and land tenure.

[3] This will be described in more detail in Chapter 3.

1.10 Land Tenure, Prices of Agricultural Products, and Private Investments

Reforming land tenure remains an important aspect of agricultural policy in China. Land reform and property rights may have an important impact on farmers' willingness to invest in the land and preserve its quality. Land tenure is made up of three parts:

1) Use rights;
2) Tenure security; and
3) Transfer rights (in case of death or change of residence).

Land tenure is a critical issue for the future of China's agriculture because it may play a critical role in the following:

- The amount of private investment in agriculture, and thus agricultural productivity;
- Which, in turn, influences food security; and
- The stewardship of the land, in a country where arable land is very limited.

Before the economic reform initiated in 1978, China's land was legally owned collectively by a production brigade that included at least one village. Under the "Household Responsibility System" (HRS), the village land was distributed equally among the residents (either on a person or labor basis). In addition, the 100 percent government procurement was replaced by a fixed quota of grain submission to the government (an explicit land tax) and a contracted grain procurement (an implicit land tax) [31]. In 1997, the government extended the farmers' land contracts for 30 years upon expiration of the previous 15-year land use rights [14]. The essence of the legislation was to provide farmers with a level of land tenure security. It was hoped that this would encourage long term investment and enhance the productivity of the land. Local authorities were mandated to secure the farmers' current land holdings. Yet under the current system, the land remains primarily communal, because it cannot be bought or sold. Land tenure remains uncertain for many farmers [14] and transfer rights are not fully guaranteed [31].

There are two schools of thought in the current debate of land tenure in China. The first argues that the tenant's lack of security is a major hindrance to the farmer's investment. Those who adhere to this view refer to research indicating that the major portion of farmers' household investment is going to tractors or draft animals (cattle or buffalo) rather than to land improvement. The second group argues that non-farming job opportunities (higher sources of income) and agricultural interventions (prices) are more influential in the producer's decision not to invest in the land.

These propositions may not be mutually exclusive, as many other factors influence the household decision-making process. In general, farmers do not make long-term investments in their land unless they feel confident they will be able to reap the benefits of those investments. International experience reviewed by Wei et al. indicated that when agriculture reaches a certain level of commercialization, there is a strong positive relationship between land tenure security and smallholder investment to acquire land, use it productively, and preserve its quality [31].[4]

While land tenure remains a hotly debated issue among policymakers, in the countryside, smallholders have their own way of coping with difficult situations. Now that it is possible for people to move about more freely, it is not uncommon to have the head of household leave the land and the family for weeks or months at a time to earn wages in the city. Women, children and elderly family members are becoming the de facto day-to-day managers of the land and the livestock.

In addition to land tenure, agricultural prices also influence producers to expand or abandon their operations. The 1990s price structure has not been conducive to private agricultural investment in China. Producers have suffered the hardship of controlled government prices for basic agricultural products, while prices for inputs such as fertilizers and concentrate feed have not

[4] Smallholder = Farming operations with one to five cows.

been regulated [29]. From 1995 to 1996, government purchase price of agricultural products increased by 4.2 percent, but the rate of inflation of agricultural inputs was 8.4 percent [20].

1.11 Private Versus Public Investment in Agriculture

Agriculture in China has always faced three major challenges:

1) To increase the food supply with a low per capita land endowment;
2) To create employment opportunities and raise farm incomes; and
3) To improve rural infrastructure for sustained development [2].

In the decades ahead, China must also meet the challenges arising from three fundamental changes in the economy:

1) The transformation from a largely agricultural economy to a modern industrial economy;
2) The transition from central planning to a market-oriented economic system; and
3) The internationalization of the Chinese economy.

In order to increase agricultural production and productivity, investments in research and development are necessary. Government investment in agriculture has declined in the 1990s compared to the 1980s, both in absolute and relative terms [34]. However, the decline in public funding has been offset by the considerable increase in investments by individual farmers for production purposes [3]. Fan has shown that public funding of agriculture should be re-evaluated and targeted specifically to improve technologies and infrastructure [4]. Although the current central government policy is to promote agricultural development through a science and technological revolution, Fan also suggests that the mechanisms to increase research capacity and set priorities are lacking [4]. Conflicting government priorities are apparent in policies that have distinct objectives, which are not necessary consistent. These include:

- Alleviation of (rural) poverty (by raising farm income and ensuring stable agricultural prices);
- Achievement of food security and self-sufficiency of the country as a whole, and in particular in urban areas; and
- Transition toward a market economy and become a participant in world trade [1].

On the other hand, the income of private citizens has been rising throughout China. Tso reported average per capita incomes of 4839 RMB in urban areas and 1926 RMB in rural areas in 1996 [20]. These incomes were 13 percent and 21 percent above 1995 incomes, respectively. In theory, both consumers and producers benefit from higher incomes. Consumers can be more demanding and spend more. And producers' new profits may be reinvested to strengthen their private operations. In reality, investment by private farmers intended to increase long-term production capacity has had various degrees of success in different parts of China. The income of more than 300 million people in China (mostly in the remote rural areas) is less than $1 a day. Additional reasons for slow, limited private investment in private agriculture have been discussed by Fan and Tso, and may be summarized as follows [4, 20]:

- Uncertainties about the future due to unstable government grain policies;
- Heavy tax burdens at the local level (New York Times, Sept. 17, 2000);
- Faltering rural education;
- Remaining quota restrictions and price controls (see above);
- Poor rural public services, which shift the use of new income toward more immediate priorities;
- Failure of related markets, such as credit and insurance;
- The long-held belief that investment in agriculture is a government responsibility and not that of the citizen; and
- Uncertainty over land use rights—in particular a lack of confidence in the permanence of current land (see above).

1.12 Case Studies: Land Tenure, Land Renting, and Taxation

Case Study 1: Observation Regarding Chinese Land Tenure (by Gary Frank)

The People's Republic of China (PRC) has distributed cropland to its farmers. This started in 1983 and was formalized in 1990. The basic formula for cropland distribution was "total cropland in a district or village" divided by "the population of that district or village." Therefore, in some areas of the country, each person received as little as 0.5 mu. A mu is one-fifteenth of a hectare or one-sixth of an acre. In another area of the country, each person could have received more than 15 mu.

The land is still owned by the state and cannot be sold. However, the current "rights" holder can rent it out to others and the local unit of government can tax it. The taxes vary from one governmental unit to another. The average tax rate appears to be about nine RMB per mu (or about $6.75 per acre).

The land tenure law states that this distribution of land will stay in effect for 30 years. In other words, no land rights can be transferred for the next 30 years. If the unfortunate should happen—death and no heirs—the local government will get the land back. After 30 years they will reevaluate the law. At that time, they may convey full ownership (with selling rights) or they may just redistribute the land again.

Case Study 2: Renting Pastureland in Heilongjiang (by Gary Frank)

All the hay and pastureland is still owned and run by the local units of government. It is rented to individuals for a period of years—usually five. When the lease runs out, the local unit of government holds an auction to see who will bid the most for use of the land over the next five years. They run ads in the newspapers telling people the day of the auction and the description of the land to be auctioned so prospective buyers can inspect the land prior to the auction. It was reported that large crowds show up for these auctions.

The local unit of government can also withhold some areas of land from re-rental for a year or more at the end of any lease period to "let it rest" if they feel that is necessary. They can also renovate the hay and pastureland.

Case Study 3: Observation Regarding Farmer Taxation (by Gary Frank)

It is always difficult to determine the exact method of tax collection used to run the government of a country. However, after discussions with many farmers, we concluded the following general idea of how the Chinese tax system works.

First, there is no taxation at the basic commodity level. So growers of wheat or rice (and dairy farmers) don't pay any taxes on their income. The largest part of China's tax money comes from their "value added tax," or VAT. For example, when a miller buys wheat and makes it into flour, the value added is taxed. The VAT rate in China is 13 percent.

Note: Mills making feed for cattle are exempt from the 13 percent VAT tax. It is a safe assumption that if there is one exception, there are more, but I wasn't told about any others.

The Chinese central government allows the local government units to tax the "exclusive use" rights to cropland. The amount of tax varies from one governmental unit to another. The average tax rate appears to be about nine RMB per mu (or about $6.75 per acre). Also, a new 10 RMB ($1.25) per dairy animal tax is on the horizon, because the government realizes that dairy farmers are making money and accumulating assets. (continued on next page)

In 1997, China instituted an income tax. The tax rate varies from three to five percent of income, depending on income level. The first 1,000 RMB per month ($125) is tax-free, so most Chinese do not pay any income tax.

Also, currently, interest earned on savings and money made by investing in stocks or other assets are tax-free (no capital gains tax). However, the Chinese government is debating the creation of a tax on the interest earned on savings accounts. That tax would only be on the interest earned on the money you save after the law has been implemented.

In other words, if you had $20,000 in savings before the law went into effect, all the interest you would ever earn on that would be tax-free. But interest earned on new savings would be taxed. They want to enact this law because Chinese government officials believe that the Chinese people are saving too much. They feel the people are not buying enough and causing the economy to slow down. Note: I talked to a couple of people about this and they said "We have all we need; we don't have room for anything more."

Chapter 2: Crop Production, Livestock Production, and Dietary Habits in China and the US

2.1 Introduction

China's agriculture has achieved remarkable results as it has moved the country from a state of chronic famine in the 1960's to a relatively secure food supply by the end of the last century. Nevertheless, given population growth predictions, food security remains a major issue in China's agricultural policy.

Production of cereals (rice and wheat) has driven the agricultural economy of China for a long time [6]. In the last 20 years, agricultural output has increased enormously in China. Given its population, it might not come as a surprise that China is by far the world's largest grain and vegetable producer. Notwithstanding these accomplishments, in terms of contribution to gross domestic product (GDP), China's agriculture has grown much slower than its industrial and service sectors [20].

Within the agricultural sector, the livestock sector is expanding rapidly. Between 1992 and 1996, the contribution of livestock products to the gross value of agricultural output increased substantially from 27.0 to 34.1 percent. The contribution of fisheries increased from 7.4 to 10.9 percent, but the contribution of crops remained around 54 percent [11].

A few highlights of China's agricultural production will be discussed in this section. We will use FAO data to help quantify changes in Chinese and US agricultural production and dietary habits at the national scale. Also, world and US averages are presented and discussed as reference points to better understand relative changes in each country.

Figure 2.1: Two examples of intensive cropping systems in China. (Upper photo) The use of plastic sheeting has allowed cultivation of rice and other crops in higher altitudes. (Lower photo) Small garden plots in and around cities are part of the fabric of a complex urban agricultural system. By-products from crops intended for human consumption are important resources for feeding cows, especially those in peri-urban farms (see Chapter 4).

2.2 Crop Production

Chinese statistics do not distinguish between grain for food or for animal feed. According to the traditional Chinese definition, grain crops consist of cereal crops (primarily rice, wheat, and corn), soybeans, and tubers (primarily potatoes). For statistical purposes, five kilos of tubers is equivalent to one kilo of dry grain [19]. Following this definition, grain crops increased from 113.2 to 442.7 million tons, an increase of 391 percent, which exceeded the population growth rate of 216 percent from 1949 to 1992 [19]. As a result, per capita grain production increased from 208 to 380 kilos, a net gain of 171 kilos per person.

The importance of grain production in the Chinese psyche and the economy of the country is illustrated by the relative stagnation of grain production in the early 1990s, while the economy shifted from central planning to the open forces of a market economy. As grain production declined, prices soared and contributed to high rates of inflation, which had an impact on the entire Chinese economy [12].

Table 2.1 presents a comparison of planted area, output, and yield of major crops in China and the US. Although China has exported grains intermittently, usually less than 5 percent of production is used for international trade [21]. Thus, the Chinese data in Table 2.1 provides a good indication of supply for domestic consumption. In 1999, rice and wheat together were produced to provide 263 kilos of cereal grain per person.

Rice and wheat remain the major crops in China, in contrast to corn and soybeans in the US. However, the rate of increase in total production was much faster for corn and soybeans (7-8% annually between 1992 and 1996) compared to rice and wheat (1-2%). Jianping summarized major changes in grain production in China during the 1990s as follows [11]:

- Corn became the second highest yielding crop in China (after rice) beginning in mid-1995. Corn displaced wheat as animal husbandry increased and demand for animal feed increased;
- Of the major grain crops, soybeans have enjoyed the fastest yield (tons/hectare) growth rate, which was more than 25 percent between 1992 and 1996.

Table 2.1 also highlights the importance of vegetables and fruits in Chinese agriculture. The number of hectares of vegetable crops was 10.6 times higher in China than in the US, and vegetable production was 7.1 times higher. As indicated in the population statistics described above, a significant portion of the urban population appears to be involved in agricultural production. One can assume that a significant portion of vegetable and fruit production is taking place in urban and peri-urban areas because of the perishable nature of these products and the limited transportation infrastructure in China.

Table 2.1. Major crops in China and the US, 1999*

Crop	Crop area (1000 Ha)		Production (1000 MT)		Calculated Crop Yield** (Tons/Ha)	
	China	US	China	US	China	US
Rice	31,720	1,442	200,499	9,546	6.3	6.6
Maize	25,869	28,546	126,244	239,719	4.9	8.4
Wheat	28,823	21,816	114,400	62,662	4.0	2.9
Soybean	8,201	29,330	13,701	71,928	1.7	2.5
Groundnuts	4,312	578	12,068	1,756	2.8	3.0
Fruit & Melon	9,983	1,300	59,530	28,400	6.0	21.8
Vegetables	14,779	1,363	250,341	35,150	16.9	25.8
Totals	123,687	84,374	776,783	449,161		

* Source: FAO, 2001. **Calculated as crop area divided by production from this table. MT=Metric tons.

Finally, one last point can be made from analyzing the data of Table 2.1. Given the land use described in Table 1.1, we calculated that growth of grains, vegetables and fruits takes up 100 percent of China's arable land, but only 48 percent of the arable land in the US is used for this purpose. Clearly, land constraints in China's agriculture are much greater than those in the US.

2.3 Livestock Production in China and US

Livestock population and roles in China

The short history of animal production in China essentially begins with the peasants' backyard pig-raising ventures at a time that most of the country's population was rural [8]. However, in the pastoral regions of the country, small ruminants, such as goats and sheep, have been found in large numbers for a long time [13]. Government officials realized that, compared to pigs, small ruminants do not compete with humans as much for grains. Appendix Tables A and B present the evolution of livestock populations in China from 1975 to 2000. Prior to the economic reform of 1978, China's livestock was made up of pigs (264 million), ducks (159 million), sheep (95 million), goats (66 million), cattle (57 million), and buffalo (18 million). Meat and (or) milk production were only one of the many purposes of livestock ownership in most of the rural parts of China, and this remains true today. For example, as indicated above, the history of raising pigs goes back to the early days of the People's Republic of China as a source of organic fertilizer (manure) for rice production. Similarly, sheep and goats have been the main sources of fiber (wool) and attempts to promote consumption of milk of these small ruminants were not always successful.[5] Likewise, large ruminants, such as cattle and buffalo, have been used to a great extent for draft, transportation, and other purposes—this also remains true today.

However, livestock agriculture has changed dramatically in response to:

1) Increased population;
2) Increased purchasing power of (urban) consumers; and
3) Improved infrastructure (transportation and refrigeration systems).

The numbers of pigs, ducks and ruminant animals are extremely high in China:

- In 2000, almost half of the world's pigs (438 million) and more than two thirds of the ducks (612 million) were found in China (Appendix Table B). In contrast, the US population of pigs and ducks were 59.4 and 6.6 million, respectively.
- In 2000, the number of goats (148 million) outnumbered the sheep (131 million), while the cattle and buffalo populations reached 105 million and 23 million, respectively. By way of comparison, goat, sheep, cattle, and buffalo populations in the US in 2000, were 1.4, 7.2, 98.0 million, and 3500, respectively.[6]

Given the large rural population in China, the traditional livestock practices have remained a vital component of the

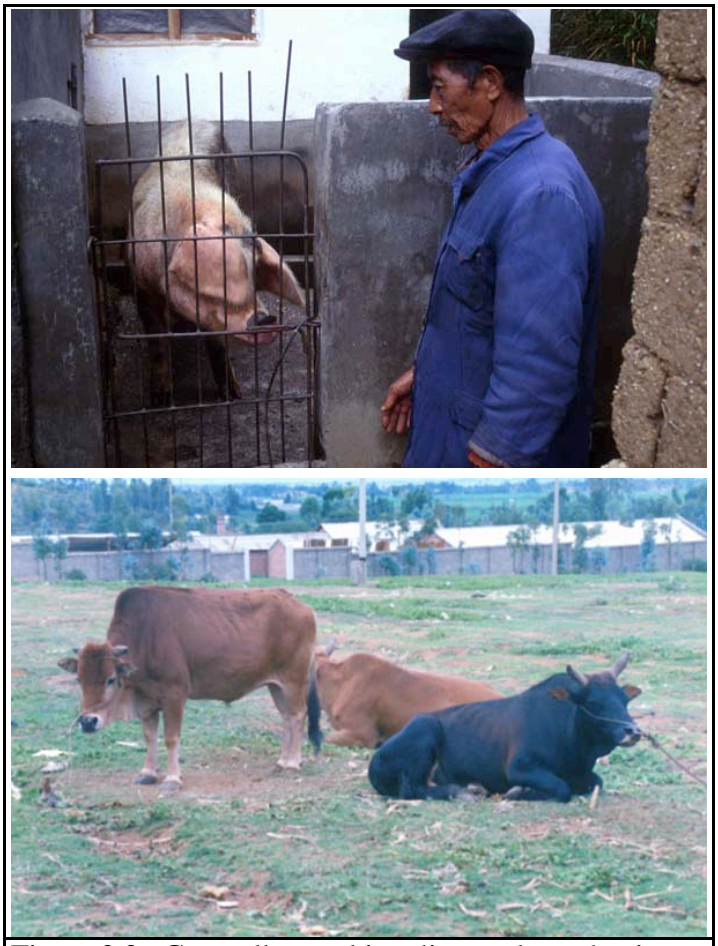

Figure 2.2: Generally speaking, livestock production systems are not as intensive as crop production systems in China. Yet, China has more pigs than any country in the world. (Upper photo) Traditional backyard pig production remains important, but Chinese pig production systems are rapidly industrializing. (Lower photo) Cattle raising for bovine meat has only taken a significant role since the 1980s. (See Figure 2.3 and text for more details.)

[5] Yuyuan Guo, personal communication.
[6] http://ww2.netnitco.net/users/djligda/wblinks2.htm#002.

rural economy. However, the increase in urban population over the last quarter of the 1900s (Figure 1.3) has called for industrialization of the livestock production sector. Pork was first to rise to the level of industrial production after the economic reform. China is now the largest producer of pork in the world, with five times the US pork production [13].[7] Poultry and bovine meat production lag far behind pork production in China, but they are contributing an increasing proportion of the total meat supply (Figure 2.3). China's commercial milk production is still in its infancy.

Output of animal products from China and the US

Except for specific ethnic minorities (e.g., Tibetan, Mongolian, Kahzack, and Bai people), livestock raising has not been a part of the cultural tradition of Chinese people. Throughout history, small animals such as chickens, ducks, and pigs provided eggs and meat for special occasions such as the Spring Festival (Chinese New Year). But these small animals were often used as a source of cash income for the purchase of salt, cloth, and other necessary household items.

Soon after the founding of the People's Republic of China in 1949, government policies promoted hog raising. The purpose of this effort was primarily for manure production to enhance cereal grain production, rather than for meat production. This policy was encapsulated in the words of Mao Zedong, the leader of the revolution: "One pig is a fertilizer mill." Hog inventory soared,

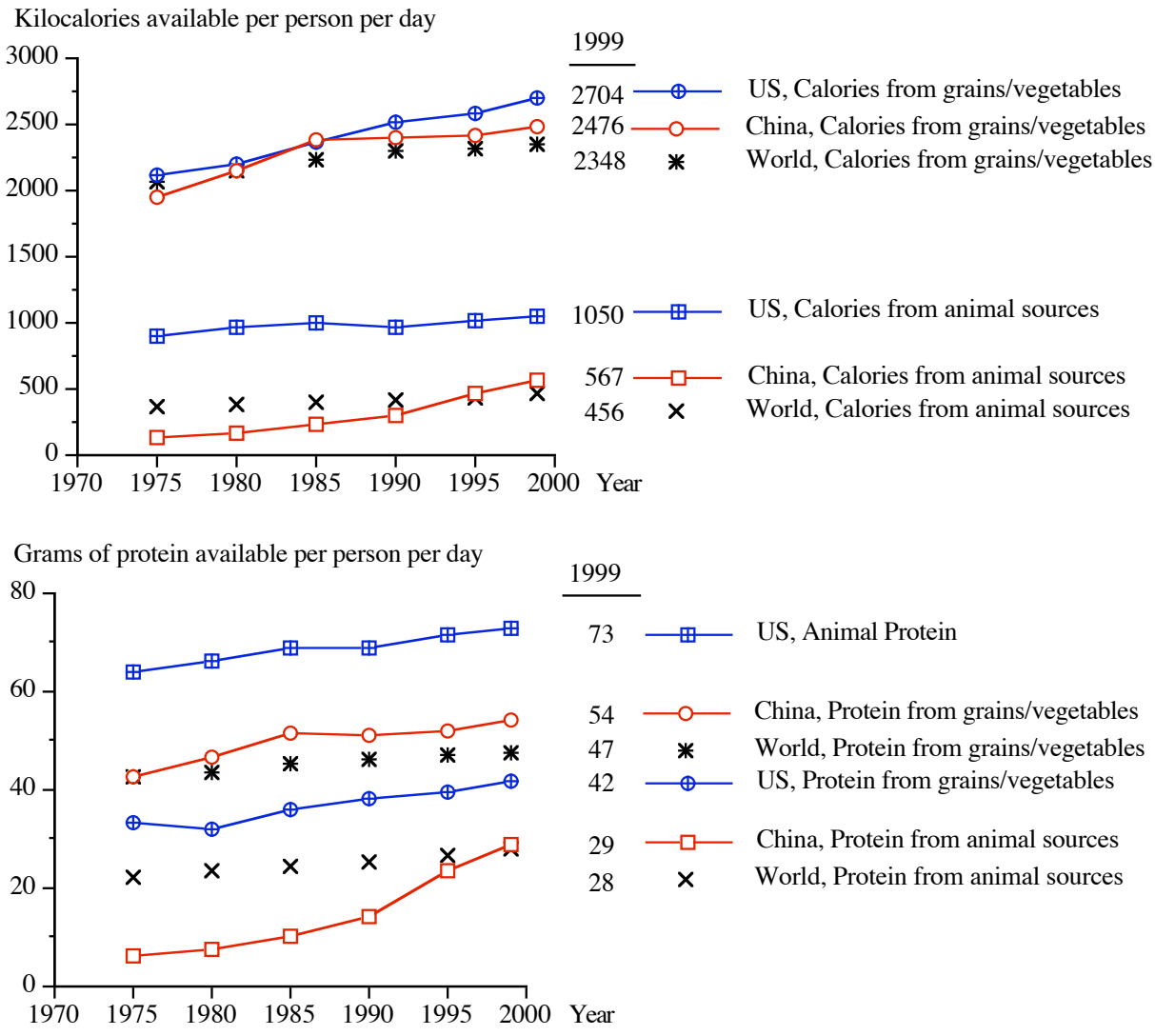

Figure 2.3: Energy (top) and protein (bottom) availability from animal and grain/vegetable sources per person in China, the US, and the World [7].

but not pork output [19]. At the time of the economic reform of the late 1970's, small amounts of meat were consumed, and pork was already the primary source of animal products in the Chinese diet (Figure 2.3). Table 2.2 compares the availability of animal products both in terms of total supply (production) and supply per person in China, the US, and the world in 1999.

Table 2.2. Supply of Animal Products in China, the US and the World in 1999

	Supply, kilos per person			Total Output, 1000 Metric Tons		
Supply	**China**	**US**	**World**	**China**	**US**	**World**
Meat, total*	48.7	124.0	37.9	64,444	37,636	233,218
Seafood	25.3	20.3	15.8	—	—	—
Eggs	15.6	14.5	8.0	22,593	5,011	54,728
Milk	6.9	117.3	46.4	11,459	76,294	568,487
Totals	96.5	276.1	108.1			

* See Figure 2.4 for details on different types of meat [7].

In 1999, the worldwide supply of meat averaged 38 kilos per person per year, but it was 49 kilos per person (128% of world average) in China and 124 kilos per person (326% of world average) in the US. Availability of seafood and eggs was relatively similar in both countries. In contrast, milk availability was 17 times lower in China (6.9 kilos per person) than in the US. With the exception of milk, the supply of animal products in the Chinese diet was above the world average. China's output of meat and eggs is much larger than in the US. In contrast, total milk output was seven times higher in the US than in China.

Animal, grain, and vegetable products in Chinese and US diets

The Chinese diet has consisted essentially of cereal grains, vegetables, and small amounts of meat, and has not changed much for thousands of years. In the south, the main cereal grain is rice, but in the north it is wheat and corn. Grains and vegetables have been at the core of the Chinese diet all along, but the economic reform of 1978 has resulted in important changes in the dietary habits of an increasingly affluent population. For example, in 1975 calories from grains and vegetables comprised 95 percent of the 2084 Kcal diet consumed by the average Chinese person. However, calories from grains and vegetables dropped to 81 percent of the 3043 Kcal diet in 1999 (Figure 2.3).

Thus, calories from animal products increased from about 5 to 19 percent of energy intake between 1975 and 1999. Figure 2.3 also shows that calories from grains and vegetables in the Chinese diet have been above the world average since 1985, and calories from animal products in the Chinese diet increased above the world average in 1999.

In 1999, animal protein availability was 73 grams per person per day in the US compared to 29 grams in China and 28 grams for the world average (Figure 2.3). The increase in animal protein supply in China has been remarkable over the last quarter of the twentieth century. The supply of animal protein in China is now above world average, yet in 1975 it averaged 6.4 grams compared to a world average of 22.4 grams. Finally, the data show that in the US diet, animal protein is 2.5 times above world average (73 grams vs. 28 grams) but protein from non-animal sources is less than the world average (42 grams vs. 47 grams).

Figure 2.4 was constructed to show in more detail the overwhelming changes that took place in the Chinese livestock sector over the last 25 years. Compared to a total supply of 49 kilos per person of a variety of meats in 1999 (Table 2.2), meat supply in 1975 was 10.1 kilos and composed almost exclusively of pork (Figure 2.4). The availability of pork continued to increase sharply throughout the 1980s and 1990s in China. In 1999, pork supplies in China and the US were about the same (32 versus 31 kilos per person per year).

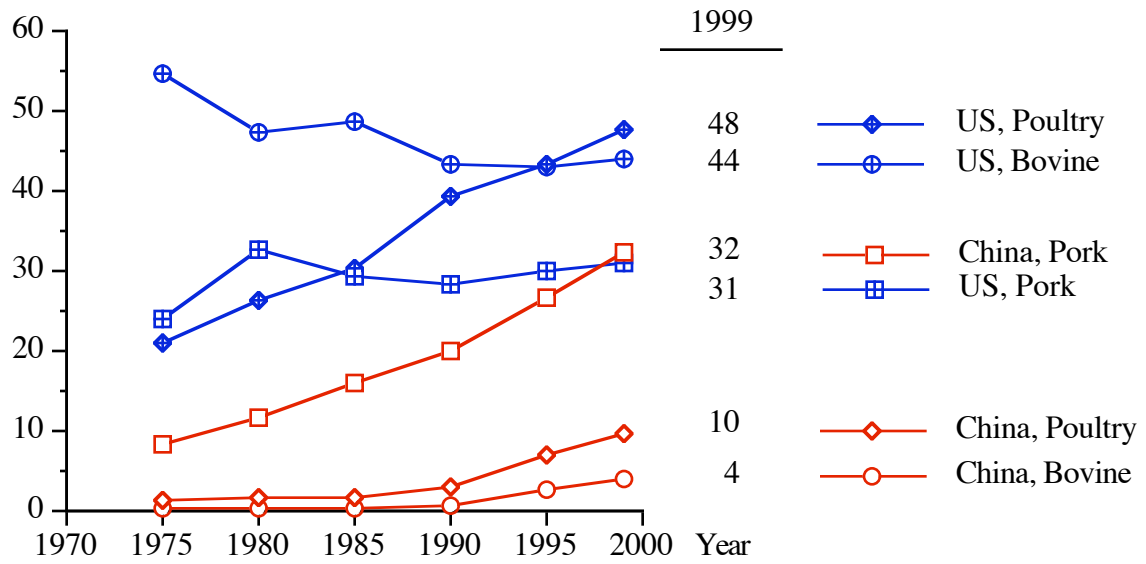

Figure 2.4: Meat availability in China, the US and the World [7].

In addition, the Chinese data in Figure 2.4 show:

1) Pork remains by far the primary source of animal products in the Chinese diet.
2) The availability of poultry and bovine meat remained marginal until the beginning of the 1990s.
3) The availability of all animal products rose during the last five years of the 1990s.

In contrast, trends in the US data throughout the 1980s and 1990s may be summarized as follows:

1) Poultry meat has surpassed bovine meat as the primary source of animal products in the US diet since the late 1990s;
2) Consumption of bovine meat decreased in the 1980s, but has remained relatively stable since;
3) Pork consumption has remained relatively constant since the early 1980s;
4) The supply of poultry meat more than doubled between 1975 and 1999.

Thus, Figure 2.4 demonstrates that the supply of pork per person is about the same in both countries, but bovine and poultry meat is largely responsible for the difference in meat availability between China and the US as found in Table 2.2.

2.4 Conclusions

There are major changes taking place in China's agriculture in response to changes in dietary habits of the Chinese population. In the last 25 years, but especially in the last decade of the twentieth century, the Chinese diet has included an increasing amount of animal products, including seafood, milk, eggs, and meat. Nevertheless, grains, vegetables and fruits remain the primary sources of calories and protein in the Chinese diet. Pork has been and remains the primary animal product in the Chinese diet, but consumption of beef and poultry meat began to increase by the late 1990s. Milk production and consumption will be discussed next.

Chapter 3: The Dairy Industry in China

3.1 Introduction

The objective of this chapter is to provide an overview of the Chinese dairy industry on a national scale and at the regional level. Comparisons with US and world figures are included only to help provide a context in which to interpret changes that have occurred over time. To achieve the objective of this chapter, we will begin with a short history and overview of the national structure and importance of the dairy sector. Next, an in-depth analysis of regional production and consumption of milk and dairy products in China will be provided. Finally, we will include a general description of the dairy processing sector and international trade.

Figure 3.1: Historically, dairy farms were built in and around cities. Here "peri-urban" cows are eating vegetable refuse from a local market. Notice the apartment building in the background.

3.2 Evolution of the Chinese and US Dairy Industries Over the Last 25 Years

When the People's Republic of China was founded, the total number of dairy purebred and crossbred animals was less than 140,000, most of which were located on state farms found in the suburbs of large cities, such as Beijing and Shanghai. Until 1978, water buffalo and sheep were the primary dairy animals in China. The country counted 3.0 million dairy buffalo (for a total of 18.1 million buffalo) and 15 million dairy sheep (for a total of 94.7 million sheep – Appendix Table A). Less than one percent of the cattle and goat population was classified as dairy.

The population of dairy animals in China has increased rapidly over the last 25 years. Dairy buffalo, goats, sheep, and cattle increased by 60, 100, 152, and 586 percent, respectively (Appendix Table A). The number of dairy cows was 0.7 million in 1975, but it had increased to 4.8 million by 2000. Thus, the development of today's dairy industry in China began after the economic reform of 1978. The history of modern dairy production system in China lies with farms that were built in and around cities to serve the urban population (Figure 3.1).

National milk output, cow inventory, and milk production per cow in China and in the US over the last 25 years are presented in Figure 3.2. National output in China was negligible in the late 1970s, but increased at a rate of about 0.384 million tons per year over the last 25 years. In comparison, since 1975, national milk output increased at a rate of 0.905 million metric tons per year in the US. Milk output in China by the end of 1999 was equivalent to the amount of milk produced by the State of Wisconsin—slightly above 10 million metric tons.

In order to develop a planned breeding program, the Ministry of Agriculture established breed organizations, including a Chinese Dairy Cattle Association (CDCA) [10]. Most Chinese dairy cattle, which are Chinese black and white, are derived from cross-breeding through artificial

insemination between the local "Yellow cattle" and the Holstein breed. Nevertheless, reports indicate that cattle owners, especially in traditional parts of China, prefer cattle that are reddish-brown in color. Because of this, dual-purpose crosses with Simmental or Brown Swiss remain fairly common [10].

The number of dairy cows began to increase in China in the early 1980s, but began to decrease in the US in the mid-1980s (Figure 3.2b). The average annual loss of dairy cows in the US between 1985 and 2000 was 123,600 per year (r^2= 0.95). In contrast, the average annual gain of dairy cows in China between 1980 and 2000 was 210,000 per year (r^2= 0.99). Assuming that the same trends continue, by the year 2012, there will be as many cows in China as in the US—approximately 7.45 million cows.

Cow productivity increased linearly in the US at a rate of about 163 kilos per cow per year (Figure 3.2c). This remarkable annual increase in milk yield per cow is due to improvements in feeding, management, and an intensive selection program that has bred only the most productive animals for the following generations.

Overall, milk production per cow in China has essentially stagnated around 1,700-1,800 kilos per cow per year since the 1980s. However, in the top herds in the country (*e.g.*, the Beijing Dairy Cattle Center) there are numerous cows producing well above 10,000 kilos of milk per lactation. The use of artificial insemination using the semen of selected bulls throughout most of the country indicates that Chinese dairy cattle have a high genetic potential for milk production [30]. Multiple reports have indicated that feeding and health management are, by far, the most limiting factors in cow milk production in China [24, 30].

Figure 3.2 illustrates the following trends over the last 25 years:

- China's milk output changed from a number so low it was not even recorded 25 years ago, to a level similar to milk output in Wisconsin.
- The increase in national milk output in China resulted primarily from an increase in cow inventory rather than cow productivity. In contrast, the increase in national milk output in the US resulted from increased cow productivity at the expense of cow number.

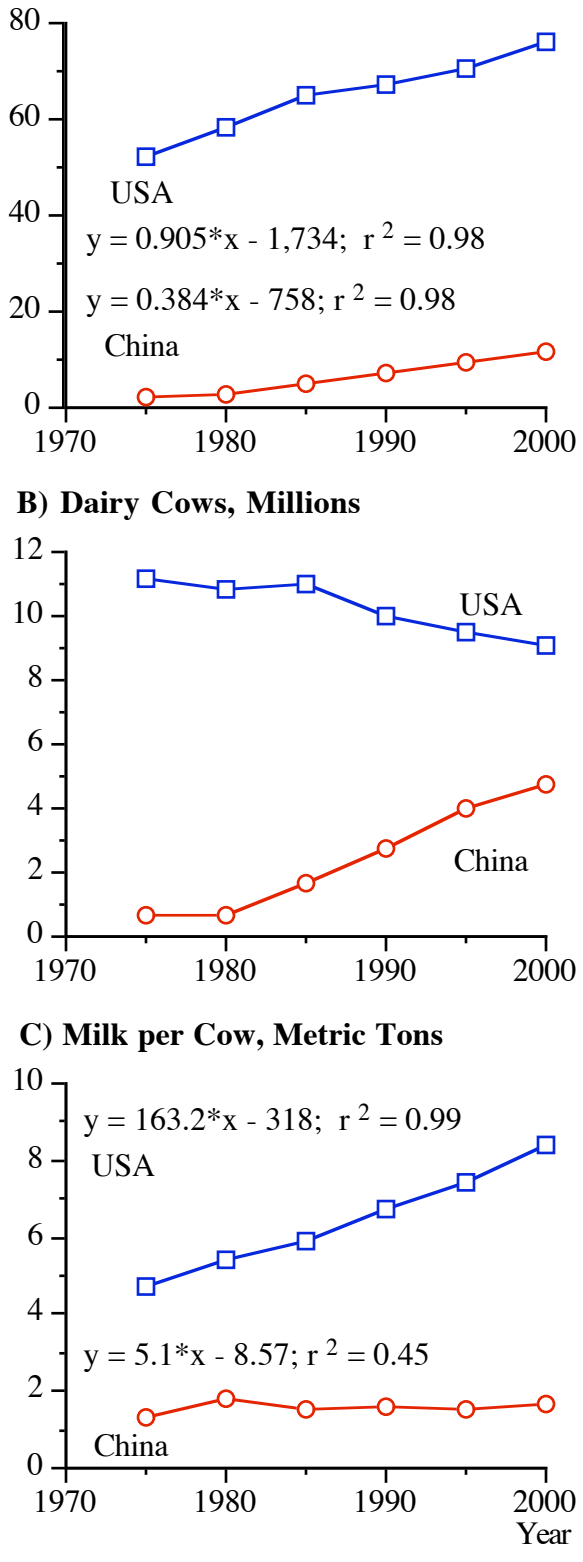

Figure 3.2: Evolution of the dairy industry in China and the US [7].

- One million specialized dairy cows are added to the Chinese dairy industry every five years. In contrast, one million specialized dairy cows are removed from the US dairy industry every eight years.

3.3 Current Structure and Review of China's Dairy Industry

Having compared a few parameters of the Chinese and US dairy sectors at the national level, the following sections present the current structure and an in-depth analysis of the structure of the Chinese dairy sector. The attention will focus on production, consumer demand, and international trade.

Although milk production in the US is the domain of dairy cows alone, milk production in China comes from a variety of ruminant species. Table 3.1 illustrates that:

- There are as many dairy buffalo as dairy cows. Despite lower productivity, buffalo milk comprises 21 percent of China's total milk output.
- There are considerable numbers of dairy sheep in China. Together with goats, these small ruminants contribute about 10 percent of national milk output (but this number is probably under-reported).
- Milk production from cows comprises about two-thirds of China's total milk output (7.8 million metric tons compared to a total of 11.5 million metric tons).
- In 2000, there were about twice as many dairy cows in the US as there were in China.
- In 2000, total milk output was approximately 10 times greater in the US than it was in China.

Table 3.1. Structure of the dairy sector in China and the US in 2000*

	Number (Millions)		Yield (Kg/Animal/Year)		Total Milk Output (Millions of Metric Tons)	
Dairy Animal	**China**	**US**	**China**	**US**	**China**	**US**
Buffalo	4.800	—	510	—	2.450	—
Cattle**	4.782	9.096	1,640	8,390	7.838	76.294
Sheep	38.000	—	243	—	0.925	—
Goats	1.220	—	190	—	0.232	—
Camels	0.072	—	200	—	0.014	—
Total					**11.459**	**76.294**

* Source: FAO, 2001. **Specialized dairy breeds only.

3.4 Production of Milk and Dairy Products

Milk production is highly regionalized in China; most takes place in the pastoral regions of the country and the highly urbanized areas. Figure 3.3 illustrates the distribution of milk production by Administrative Cities (Beijing, Tianjin, and Shanghai) and Provinces in 1999.[8] Collectively, the highly urbanized areas of the three Administrative Cities of Beijing, Tianjin, and Shanghai comprise 9 percent of the national milk output. Among the provinces, Heilongjiang is called "China's Dairyland," with 18 percent of national output in 1999. This province contributed 25 percent of national milk output in 1997, but severe flooding in 1988 reduced the dairy cow population from 850,000 to 680,000 in the province. Hebei Province and the autonomous region of Inner Mongolia are the second and third largest milk producing areas of China, respectively; both are also located in China's pastoral northeastern region.

Milk output is also fairly substantial in the highly populated provinces of Shaanxi and Sichuan, and in the pastoral provinces of the West—especially in Xinjiang Province. In contrast, milk production is almost negligible in the intensive agricultural cropping regions of the lowland plains

[8] For actual milk output (millions of metric tons) for 1997 and 1999, see Appendix Table D.

Figure 3.3: Regional distribution of milk production in China in 1999. The number next to each location is the percentage of milk contributed to national production (8.069 million metric tons). The gray shading is proportional to each province's contribution to national output—the darker the gray, the greater the contribution.

in China's East and Southeast. In these regions, provincial contribution to national milk output is generally one percent or lower (Figure 3.3).[9]

Milk from cows and other ruminants

Data shows that the provincial contribution of ruminants other than cattle (buffalo, sheep, and goats) to total milk output parallels the contribution of dairy cows—the contribution of buffalo, sheep, and goats to milk output is negligible in the agricultural regions of the Southeast, but is considerably higher in the pastoral regions of the country (Figure 3.4).[10] In the province of Shandong, for example, 42 percent of milk output (257 million metric tons) is not from cows. It would appear that goat milk is a major component of the non-cow dairy industry in Shandong, because goat inventory in China is highly concentrated in this particular province [17]. Other provinces with high levels of milk production from species other than dairy cows include Hebei and Shaanxi. In the high plateaus of Qinghai and Xizang (Tibet), the Yak contributes substantially to milk supply among the rural population, where milk consumption is much above China's average (Appendix Table D.).

[9] Provinces that contribute less than one percent include Guangxi, Guangdong, Fujian, Jiangxi, Hunan, Guizhou, Hubei, and Anhui.

[10] See Appendix Table D.

Milk processing in China

Traditionally, milk processing in China's northern provinces has been strong. Heilongjiang has 80 milk processing plants in operation, most of them producing milk powder for distant markets. However, in the last few years, some plants have specialized in fluid milk and ice cream production. With increased market sophistication, remote provinces such as Heilongjiang and Inner Mongolia are losing competitive advantage over provinces such as Hebei, which are building newer processing plants and are located closer to large urban markets. Over the last few years, the dairy industry has grown significantly in and around large urban centers such as Beijing, Shanghai, and Tianjin. In these areas, large corporations such as SanYuan Dairy or Kraft, in Beijing, are becoming major players in supplying a diversified range of dairy products [36].

It is estimated that processed dairy products utilize more than half of China's raw milk output. Yogurt is an important product in local markets. Official statistics indicate that ice cream and milk powder are the top two processed products, both in terms of volume of production and milk equivalent (Table 3.2). In contrast, production of cheese and butter is almost negligible. US Department of Agriculture (USDA) reports indicate that milk powder production has continued to increase and reached 480,000 metric tons in 1999. Also in 1999, processed fluid milk production reached 950,000 metric tons in the form of pasteurized milk (60%), ultra high temperature (UHT) milk (21%), and yogurt (19%).

Figure 3.4: The dairy cow is not the primary source of milk supply everywhere in China. Goats (top) contribute substantially to milk production in Shandong, and Hebei, while the Yak's adaptation to high altitude (bottom) makes it a prime milk supplier in Xinjiang and Tibet. (See Appendix Table A for more information.)

3.5 Consumption of Milk and Dairy Products

For many reasons, consumption of milk and dairy products in China has been—and remains—among the lowest in the world (Figure 3.5). However, the pattern of milk and dairy product consumption has changed dramatically over the last 25 years. Milk available for consumption per person was less than two kilos per person per year in 1975, but increased to 6.9 kilos in 1999. At the same time, milk availability per person remained almost constant in the world (45-46 kilos per person per year) and it decreased in the US (143 to 117 kilos per person per year).

Regional differences

Milk consumption shows strong differential patterns ranging from 0 to 24 kilos per person per year in China's urban areas and 0 to 14 kilos per person in rural areas (Appendix Table D). Among the urban areas, Beijing and Shanghai stand out as major centers of dairy product consumption. Consumption of milk is also much above average in the harsh pastoral regions of the far west (Xinjiang, Qinghai and Tibet), which are regions inhabited in large proportion by minorities (see above). In most other rural areas, milk consumption is marginal.

Table 3.2. Production of processed milk by dairy plants in China in 1997*

Dairy Product	Volume (Metric Tons)	Share (%)	Conversion Ratio**	Milk Equivalent (Metric Tons)	Share (%)
Ice cream	1,180,000	59.8	0.30:1	354,000	7.7
Powdered milk	390,000	20.0	8.85:1	3,451,500	74.9
Lactate drink	228,000	11.6	0.20:1	45,600	1.0
Condensed milk	153,120	7.7	1.20:1	182,744	4.0
Casein	10,440	0.5	30.00:1	313,200	6.7
Butter	8,700	0.4	28.00:1	243,600	5.3
Cheese	1,740	0.0	10.00:1	17,400	0.4
Total	1,972,000	100.0		4,608,044	100.0

* Source: USDA/FAS, 1999.

** Estimate of the number of units of raw milk needed to produce one unit of processed dairy product.

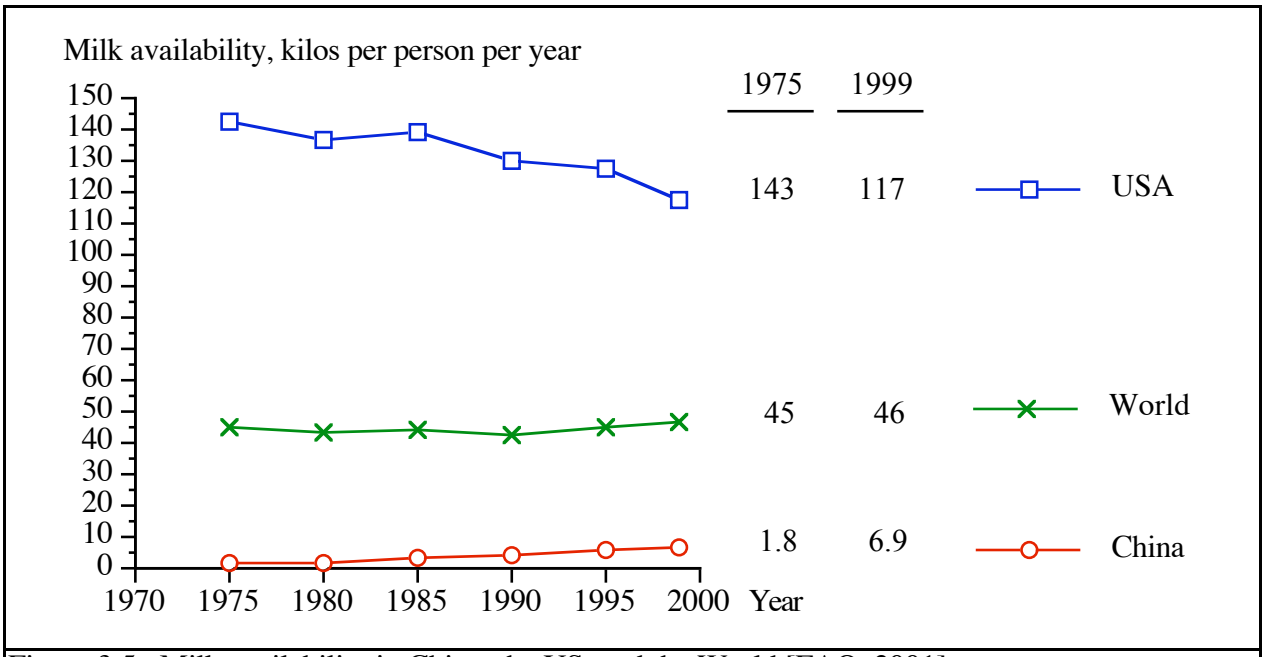

Figure 3.5: Milk availability in China, the US, and the World [FAO, 2001].

The concept of milk as a "warming food"

Although an increasing number of the Chinese people understand the nutritional value and health benefits of milk, many still have strongly-held beliefs about milk, especially in certain parts of rural China. Milk is often thought of as a "warming" food that should be consumed in moderate amounts (other "warming" foods include fried chicken and lychee fruit). According to Chinese tradition, excess consumption of warming food may result in sore throats and oral blisters. In contrast, excess consumption of "cooling" foods, such as watermelon and pears, may result in frequent urination, sweating and diarrhea [35]. A mix of cultural, educational, and economic constraints often limit milk consumption in China. Even in the urban populations, which tend to have more exposure to Western ideas, have higher educational levels, and enjoy a greater standard of living, only 20 percent are regular dairy product consumers. Thirty to forty percent of urban Chinese do not consume dairy products at all [25]. Thus, cultural tradition and dietary habits do not change rapidly, even when economic constraints are removed.

Governmental policies

In June 2000, the Chinese Ministry of Agriculture published an ambitious long-term plan for milk production. The Chinese government has set the goal of increasing cow milk output to 10

million metric tons by 2005. By that time, if the challenge is met, the Chinese dairy cow industry will be about the same size as the Wisconsin dairy industry. Further prediction shows national milk output at 42.5 million metric tons by 2030 [12]. Depending on assumptions about the strength of the future Chinese economy, China's milk output is projected to be between 20 and 39 million metric tons in 2030 [17].

These objectives contrast with past government policies. For a long time, government supported the popular view that milk should be reserved for those needing medical attention (babies, young children, the sick, and the elderly). However, in recent years, government has favored milk production and consumption by the population at large as a way to improve public health. Government support was reinforced in recent years by visits from highly ranked officials to several dairy companies [25].

Extensive advertisement campaigns have also been launched in the media to educate people about the importance of milk and dairy products in the diet. In particular, the media highlighted the widespread calcium deficiency in China and health problems related to this deficiency.

Although public funds to support the growth of the dairy industry are limited, the Ministry of Agriculture has initiated a "State School Milk Program" as part of its efforts to increase milk consumption. The cities of Beijing, Shanghai, Tianjin, and Shenyang were selected for a pilot project [12]. If this program proves to be sustained and successful, it may contribute significantly to the demand for milk and dairy products both in the short term and the long term. As indicated by Griffin in an international survey of international school milk programs, children who drink milk and consume dairy product regularly tend to continue to do so as adults because dietary habits established in childhood persist into adult life [9].

Preferred dairy products

Approximately 35 percent of the raw milk produced in China is consumed as fluid milk, with the remainder processed into various dairy products—primarily powdered milk [25]. Chinese consumers enjoy fresh dairy products, but have little taste for butter and cheese. The demand for ice cream and yogurt is increasing rapidly in urban areas, but remain "luxury items" for many. Domestic fluid milk is generally pasteurized or UHT (ultra heat temperature) processed and is generally well accepted by consumers. However, consumers do not have confidence in the quality of processed products. Annual random sampling of powdered milk has shown that 70-80 percent of domestic powdered milk met quality standard for human consumption. The remaining samples had problems with pathogens or contamination [12]. In urban areas, imported dairy products enjoy a better image than domestic brands. Example of competitive imported products include:

- The cheese and butter found in hotels and restaurants;
- Milk powder and whey products used for infant formula and other human consumables; and
- Ice cream and derivatives may be found at tourist destinations and American fast food restaurants—such as McDonald and KFC—in commercial centers.

3.6 International Dairy Trade

Figures related to Chinese imports and exports of dairy products are somewhat difficult to track because of the recent change in the status of Hong Kong, the border trade with neighboring nations (Vietnam, Thailand, North Korea) and regions under Chinese influence (Macau). Nevertheless, it is clear that China's dairy imports are much greater than its dairy exports, both in terms of volume and product value (Table 3.3). In 1998, China spent 84.6 million dollars for the importation of 111,000 metric tons of dairy products, while exporting approximately 37,000 metric tons of dairy products valued at 39.5 million dollars. In recent years, the United States has supplied approximately one-fifth of China's dairy imports [22].

In 1999, the value of dairy products exported from the US to China was $17 million, but was $60 million to China and Hong Kong combined [23]. In 1998, the top three imported products and the top three suppliers, along with their percent share of the imported market (numbers in parentheses) were as follows:

- Powdered milk from New Zealand (50%), The Netherlands (11%), and the US (10%);
- Whey from the United States (30%), France (20%), and Australia (11%);
- Fluid milk from Australia (72%), New Zealand (18%), and the United States (8%).

China imports very limited amounts of cheese and butter (almost exclusively from New Zealand). The large increase in imports of "other products," as listed in Table 3.3, between 1998 and 1999 reflects the increased importation of yogurt products.

On the exporting side, China's partners for dairy products include Hong Kong (for most of the exported fluid milk) and Myanmar (Burma), Hong Kong, The Philippines, and South Africa (for most of the exported powdered milk).

Table 3.3. China's international trade of dairy products*

	1998				1999			
	Volume[1]	**%**	**Value**[1]	**%**	**Volume**[1]	**%**	**Value**[1]	**%**
Imports								
- Fluid milk	8,884	8	3.3	4	14,839	9	8.4	5
- Powdered milk & cream	31,285	28	14.5	46	58,154	35	81.7	50
- Whey & related products	69,318	62	20.3	47	83,227	50	58.1	36
- Other products[2]	1,545	2	14.5	3	8,728	6	15.2	9
Total imports	111,031	100	84.6	100	164,948	100	163.4	100
Exports								
- Fluid milk	24,496	65	18.2	8.0	25,195	62	18.2	41
- Powdered milk & cream	10,952	29	17.3	15.8	14,160	35	23.9	54
- Whey & related products	796	2	1.3	8.0	393	1	0.4	1
- Other products	1,245	4	2.7	15.8	589	2	1.6	4
Total exports	37,489	100	39.5	8.0	40,437	100	44.0	100
Imports - Exports (totals)	73,542	—	45.1	—	124,511	—	119.4	—

* Data from Jianping and Senger, 2000 and USDA/FAS, 1999.

[1] Volumes are expressed in metric tons and values in millions of US$.

[2] Other products include fermented and acidified milk (yogurt products), butter, cheese and related products.

Tariffs and the impact of permanent trade relations with China

Under entry in the World Trade Organization (WTO), China will commit to a dramatic reduction in import barriers by means of lowered tariffs, and will be required to use sound scientific measures for sanitary import regulations. These agreements should allow for the expansion of China's import market for dairy products. A recent USDA report summarizes the opportunities as follows [23]:

- Already competitive whey products from the US may benefit from a rapidly growing food processing industry in China.
- The sharp drop in tariffs on cheese imports from 50 to 12 percent (by 2004) and the rapid growth in fast-food and pizza restaurants in China will offer opportunities for US cheese exporters.
- The tariff for ice cream will drop from 45 to 19 percent (by 2004) and the tariff for yogurt will drop from 45 to 10 percent (also by 2004).
- China will allow more direct marketing, distribution (wholesaling, retailing and franchising), and sales services by foreign companies.

These opportunities may well be realized because US dairy products have a much better image among Chinese consumers than do European products or China's own products [38]. However, central government policies will likely focus on domestic growth of the dairy industry rather than continued reliance on imports. Under its ambitious modernization plan, China will likely prioritize its imports to key industries such as energy, electronics, transportation, and communication.

PART II: A STUDY OF THE DAIRY INDUSTRY AND DAIRY FARMS IN THE PROVINCE OF YUNNAN, THE CITY OF BEIJING AND THE PROVINCE OF HEILONGJIANG

Michel A. Wattiaux, J. Mark Powell, Gary G. Frank, Zhiguo Wu*

Chapter 4: Dairy Production Systems in Beijing, Yunnan Province, and Heilongjiang Province

4.1 Introduction

As indicated in Part I, the size, productivity, and structure of the dairy industry in China and the US are extremely different from each other. In spite of these huge differences, producers, scientists, and policymakers in both countries are confronted with the challenge of developing low-cost dairy production systems that are environmentally sustainable.

During the last two weeks of August and the first week of September of 1999, a multi-disciplinary team of four US scientists traveled to China to visit with researchers, provincial government officials, Ministry of Agriculture representatives, and dairy producers throughout the country. The team included two dairy scientists, an agro-ecologist, and an economist. The overarching objectives of the visits were to:

- Gain an understanding of current trends in the Chinese dairy industry;
- Compare whole farm nutrient and economic parameters of Chinese dairy farms located in various agroclimatic zones and characterized by contrasting size, ownership and management styles; and
- Compare Chinese and Wisconsin dairy farms of similar characteristics (when meaningful).

This chapter reports on the results of the interviews conducted with officials in the selected sites. The next chapter will report on the farm visits.

4.2 Materials and Methods

Site selection and description

To achieve the objectives of this study, we selected three distinct sites: The province of Yunnan, the city of Beijing, and the province of Heilongjiang.[11] General bio-physical characteristics of each site and major reasons for including them in this study are described in the next sections.

Yunnan Province

Yunnan is China's southernmost province. It lies at the same latitude as the state of Texas and has a population of 41 million people—this is 8.5 times the population of Wisconsin on only 2.6 times its land area.[12] Elevation varies from sea level (76 meters above sea level) to a mountain peak of 6,740 meters above sea level; hills and mountains cover 94 percent of the province. Most of the province's population and economic activity are found in the hills with elevations of 1300 to 2500 meters above sea level—here the climate is mild throughout the year, despite the proximity to the Tropic of Cancer (Figure 4.1). Kunming (25°N, 102°E), the capital of Yunnan, has an average annual temperature of 15.6°C, no freezing days, and 1021 mm of precipitation.

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[11] Some of the planned visits in Beijing were cancelled because of team member illness. Therefore, limited data will be presented on the Beijing dairy sector.

[12] See Figure 1.1 for a map of latitude comparisons.

The dairy industry in Yunnan is in its infancy, but is strongly supported by provincial authorities. In addition, the rapid growth of the tourism industry in the region may offer unique possibilities for expansion of the dairy industry [28].

The City of Beijing

Beijing, population 13 million, is located in northeastern China in relatively close proximity to the Yellow Sea. Beijing's elevation is only 30-50 meters above sea level and the summer months are characterized by high temperatures and heavy precipitation (Figure 4.1). July and August make up the "rainy season" in Beijing. With a land area of 16,800 km,^{2} Beijing is one-tenth the size of Wisconsin, but its population of 12.6 million is 2.6 times Wisconsin's population.

In addition to its large and readily accessible market, Beijing was selected because its dairy industry is among the most competitive and it has set the trends in peri-urban production systems for the rest of China.

Heilongjiang Province

Heilongjiang is China's northernmost province, and lies at the same latitudes as the state of Maine (Figure 1.1). The population is 37.0 million, which is almost eight times Wisconsin's population with only 3.2 times its land area. The province was selected because it has the highest level of milk production in China (see Chapter 3). Harbin (45°N, 126°E), the capital of Heilongjiang, has a continental climate with an average annual temperature of 2.4°C, more than 160 freezing days, and 502 mm of precipitation. Thus the winter climate of Heilongjiang is quite cold. For comparison purposes, the state of Wisconsin's capital of Madison (43°N, 89°W) has an average annual temperature of 6.4°C, more than 120 freezing days and 810 mm of precipitation.

Questionnaires for visits with officials

Prior to departure for China, the team prepared a series of questionnaires to use specifically during interviews with local and provincial officials. The questionnaire was designed to collect data

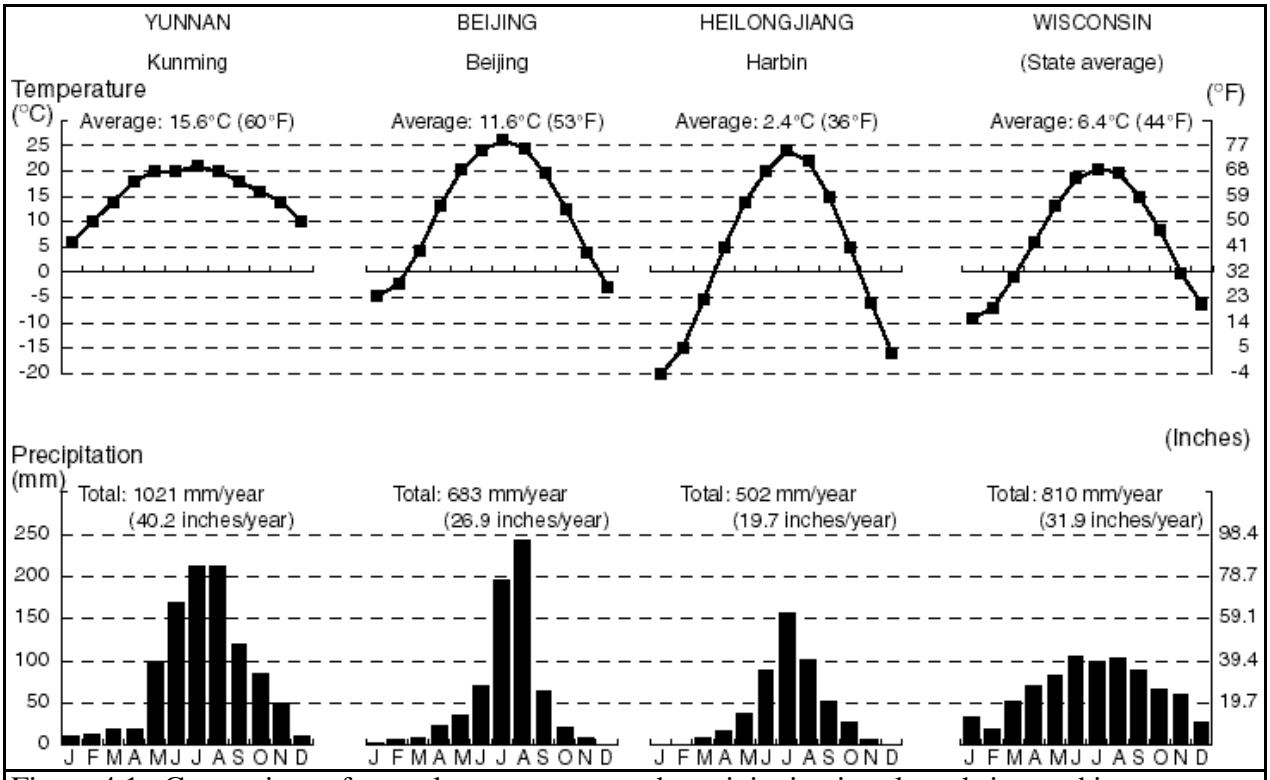

Figure 4.1: Comparison of annual temperatures and precipitation in selected sites and in Wisconsin.

and information about the size of the dairy industry, dairy farm structure and productivity, and the constraints and current trends of the local dairy industries. In addition, questions about the future direction of the dairy industry were included. The questionnaire was translated from English to Chinese prior to the visits. Our strategy was to leave a copy of the questionnaire with the officials at the time of our first official meeting with a request that they help us find answers to the questions. This strategy proved effective as all officials we met took great care in providing the requested information before the team left the province or city.

The information collected through these questionnaires and interviews has been summarized and discussed in relation to various aspects of China's dairy industry in Part I of this paper.

4.3 Results and Discussion

The information presented in Table 4.1 was reported during interviews with officials. Yunnan has a small dairy industry—cow population, production per cow, and milk price were the lowest of the three sites visited. Nevertheless, Yunnan's location makes it possible for its processing plants to export whole milk powder to Thailand and other Southeast Asian countries.

On the other hand, Beijing's dairy industry has the highest level of production per cow, highest milk price, and the most diversified processing plants in China. Milk production per cow in Beijing is comparable to the average milk production per cow in Wisconsin [33].

Table 4.1. Description of the dairy industry in Yunnan, Beijing, Heilongjiang

Items	Yunnan	Beijing	Heilongjiang
Land and people:			
- Km^2	383,000	16,800	469,000
- Relative to Wisconsin[1]	2.6	0.1	3.2
Population in millions	40.9	12.6	37.0
- Relative to Wisconsin[1]	8.5	2.6	7.7
Dairy Industry:[2]			
- Dairy cow population	85,400	61,000	680,000[3]
- Milk yield (kg/cow/year)	3,500-4,500	6,800-7,100	4,200-5,500
- Milk price (RMB/kg)[4]	1.10-1.25	2.0	1.10-1.80
- # of processing plants	> 6	> 6	> 80
- Dairy products[5]	Whole milk powder Ice cream	Fresh milk UHT milk[6] Yogurt Ice cream	Whole milk powder Fluid milk
- Major markets	Kunming Southeast Asia	Beijing	Harbin Other cities & provinces

[1] Wisconsin's land area = 56,154 square miles (145,439 square kilometers), population = 4.8 million.

[2] Source: Local provincial or city officials.

[3] The dairy cattle population in Heilongjiang was 850,000 before the devastating floods of 1998.

[4] RMB = Renminbi is the Chinese currency (meaning "people's money"); formally the basic unit of RMB is the Yuan. At the time of the visit, 8.2 Yuan = US$1.

[5] Dairy products are listed in decreasing order of importance.

[6] UHT = Processed at Ultra High Temperature.

The transition from public to private ownership of dairy farms

As indicated earlier, historically dairy production units in China have their roots in and around large cities rather than in China's rural areas [32]. After 1978, the government policy greatly promoted the dairy industry, and production was no longer confined to state farms in and around large cities. Collectives and individuals were also encouraged to take part in the development of the

dairy sector. As a result of the transition toward a market economy, there are now multiple, competing forms of ownership and units of production in China:

- Household farms, which are small and privately operated;
- Farms owned and operated under various management styles by units of government (city or provincial). These farms tend to be large and located in and around large cities; and
- Collective farms, which also tend to be large, but are managed by the community. These farms are located primarily in rural areas.

The resulting changes in the structure of dairy farms can be illustrated using Beijing as an example (Table 4.2). The number of dairy farms increased dramatically between 1978 and 1991. Small private dairy enterprises did not exist in 1978, but increased to about 3,000 by 1991. At that time, these small operations held only a small percentage of the total number of cows in Beijing.

Table 4.2. Farms, cow number, and herd size in Beijing in 1978 and 1991

	Number of Farms		Number of		% of Cows
	1978	1991	Cows 1991	Cows/farm 1991	1991
State farms	Not available	61	34,760	570	52%
Collective farms	8	214	25,268	118	37
Private farms	0	2,945	6,884	2.3	11

In this study, Beijing officials stated that all farms with fewer than 30 cows were privately owned (Table 4.3). As farm size increased to the range of 30 to 200 cows per farm, individual ownership declined and was replaced by collective ownership. Collective farms were being replaced by provincial ownership for the very large farms (more than 200 cows per farm).

Table 4.3. Farm ownership structure in Beijing, 1999*

		Ownership (% of farms)		
Herd Size	Farm (#)	Family	Collective	State
< 30	NA	100	0	0
30-50	NA	60	40	0
50-100	NA	50	50	0
100-200	> 50	40	50	10
200-500	30	10	30	60
> 500	30	0	10	90

* Estimates provided by local officials. NA = Not available.

Officials in Heilongjiang described farm ownership distribution in the province as follows: Family-owned 85 percent, collectively-owned 10 percent, and provincially-owned farms five percent. These percentages agree with current USDA estimates of dairy cows owned by small holders in the range of 60 to 85 percent [25]. A 1997 survey indicated that more than 328,000 smallholder farms produced 72 percent of China's cow milk. Each farm had an average of seven dairy cattle and four adult cows [25].

Unfortunately, small-scale milk production has received little logistical and educational support, and in general cows are not as well managed as those on larger, state-owned operations. Thus, the privatization of the dairy sector is hampered by poor cow nutrition, health, and milk quality. Despite their competitive disadvantage, current government policies favor the development of the dairy sector in rural areas and medium-sized cities through private sector initiatives. These policies go against the current competitive advantage of the large farms because of their better management, or "know-how," and economies of scale. Despite these differences, some managers of large state-owned farms interviewed in this study described their role in relationship to the small private producer as that of a supplier of goods and services. This "working relationship" should improve cow productivity and milk quality on smallholder operations, and may also facilitate the establishment of a network of milk collection centers [28].

Constraints limiting dairy industry growth, as described by local officials

The data in Table 4.4 was collected from provincial officials, who were asked to rank the listed factors in order of importance for their impact on limiting dairy industry growth in their province or city. The question was: "Please fill in the blank using a number between 1 and 5, where 1 means "not important" and 5 means "very important."

Table 4.4. Constraints on the dairy farms of Yunnan, Beijing, and Heilongjiang*

Factors	Yunnan	Beijing	Heilongjiang
Feed quantity	1	4	2
Feed quality	3	**5**	3
Animal genetics	4	3	4
Financial credit to producers	**5**	-	**5**
Inadequate price policies	**5**	4	3
Land (forage production)	2	3	3
Milk marketing	**5**	4	**5**
Others:			
- Feed cost	**5**	-	-
- Range of dairy products	-	-	**5**

* 1=not important; 5=very important. See text for more details.

Although officials in Yunnan and Heilongjiang shared some of the same priority concerns, officials in Beijing had a different sense of main factors limiting the dairy sector. Access to financial resources for investment on the farm and marketing of dairy products were ranked as "very important" both in Yunnan and Heilongjiang. In addition, feed costs and range of dairy products were additional constraints identified by officials in Yunnan and Heilongjiang, respectively. In contrast, feed quality was ranked as the most limiting factor to the current production system in Beijing.

Discussion of dairy genetics and artificial insemination

Animal genetics ranked high for all three locations, but was not the top concern in any of the sites. Similarly, land availability and forage production were not perceived as important impediments to the growth of the dairy industry.

In agreement with these results, we believe that the genetic potential of dairy cows was not a limiting factor in any of the dairy herds visited in this study (Figure 4.2). All the dairy cows were the "Chinese Black and White," which is the result of seven to eight generations of crosses between local yellow cattle and Holstein sires. Enormous resources in China have been invested to improve dairy cattle genetics, including:

- Importation of live animals (cows and bulls) or embryos;
- Development of a nationwide infrastructure to produce and disseminate improved genetics through artificial insemination; and
- Development of strong science and technology centers focusing on reproductive technology (embryo transfer, sexing, splitting, etc.).

Also, through international collaborations, selected locations (including Shanghai, Hangzhou, Xi'an, and Beijing) have begun a Dairy Herd Improvement (DHI) program for genetic and management improvement of dairy herds [27]. The US was a main supplier of genetics, both semen and embryos, to artificial insemination centers in Beijing and Heilongjiang. However, in the 1990s Canada replaced the US as the top supplier of superior genetics to China.

Discussion on the challenge of dairy cow feeding

Compared to the US, ration composition for dairy cows is more variable in China. In general, Chinese cows appear to be fed rations high in fiber and low in nitrogen because of the heavy government-directed reliance on crop residues such as wheat or rice straw (with or without ammonia treatment), sweet potato vines, etc. Many producers also have access to a wide variety of agro-industrial by-products of variable nutritive values; these include wheat bran, soy cake, distillers' grain, brewer's grain, cottonseed meal, etc. Simpson, et al. reported that the provincial and township

farms produce the bulk of their own feeds, such as green chopped rye, barley, and maize, and to a lesser extent alfalfa and clover [16].

During the growing season in Heilongjiang and throughout the year in Yunnan, producers also include fresh green fodder in the diet of their cows. Although fresh forages are presumably of good quality, their actual nutritional value was unknown to local producers (and to the nutritionists on the team). Predictably, these would be high in digestible fiber and protein. Examples of such feeds include:

- Fresh grass (grazed from a pasture or cut and carried from along terraces, fields, roads and swamps, Yunnan);
- Surplus vegetables not sold on the local market (Kunming, Yunnan);
- Young pasture grass (Heilongjiang).

Heilongjiang farmers have a low-cost, pasture-based production system. They harvest hay and corn silage to use as winter feed.

Dairy cows in Beijing must be fed a fair amount of concentrates to reach the level of production indicated in Table 4.1. In contrast, cows in Heilongjiang and Yunnan were fed very limited amounts of concentrates. Generally speaking, the feed industry in China serves the need of swine and poultry producers, and few dairy producers supplement their cows' diets with purchased concentrates or vitamins.

Figure 4.2: Dairy cattle genetic is no longer a limiting factor in China. The country has a sophisticated network of production and distribution of semen for artificial insemination. A leader in this industry is the Beijing Dairy Cattle Center, whose bullpens are shown in the top picture. At the center is a picture a smallholder in Yunnan bringing a cow in heat to the local AI center where a trained technician will inseminate the cow (bottom picture).

A serious problem is the widespread practice of simply feeding what is available without consideration of nutritional values or nutrient balance of the ration [16]. Indeed, feeding dairy cows presents a particular challenge in the context of Chinese agriculture. Land area is limited, yet dairy cows require diets with large amounts of forages rich in digestible fiber; thus, large land areas are needed to redistribute manure nutrients. The use of high levels of poorly digestible fiber may limit dry matter intake and milk production in dairy cows. However, whether it is out of necessity or because of conscious decision, the current feeding practices of the Chinese dairy cow makes full use of residual by-products that would otherwise go to waste and full use of marginal land that would otherwise remain unexploited—such as land of low fertility on which forages can grow but not row crops. In short, China's current feeding practices do not allow cows to produce to their full

genetic potential. On the positive side, however, Chinese dairy producers are able to take advantage of the dairy cow's excellent ability to utilize low-cost feeds, such as:

- Agro-industrial by-products from the food processing industry; and
- Grass and forage crops cultivated on marginal land that is inadequate to support row crops for human consumption (rice, corn, soybeans, etc.).

Discussion on dairy production systems

As in many countries, dairy production in China is extremely heterogeneous as it varies from very diversified small, privately-owned subsistence farms to large-scale, specialized operations owned by a public entity. Below is a general description of the dairy production system in China, most of which will be discussed in more detail in Chapter 5:[13]

1) **Subsistence farming found primarily in China's pastoral regions.** Milk is produced for family use by small ruminants or non-specialized dairy breeds that have multiple roles on the farm;
2) **Subsistence farming found primarily in China's agricultural regions.** Small private producers usually have one to four cows in lactation. Animals are herded alongside roads or in communal grazing areas when forage is available. These producers also cut and carry forages when available, and feed stored forages during the winter. (Example: Farm A, Chapter 5).
3) **Small to medium producers operating a five- to 25-cow herd in which the animals are maintained almost exclusively in barns and exercise yards**. This semi-intensive type of enterprise is usually integrated with an agricultural operation where the producer grows animal feed and may purchase limited amounts of commercially available concentrate feeds (Example: Farm E, Chapter 5).
4) **Former state or collective (communal) farms in rural China**. These production units are the heritage of centralized control of agricultural production. They typically involve a great number of labor units and are centered around substantial brick buildings, but usually have little modern equipment. Dairy cows may be specialized and maintained under general guidelines for feeding and reproduction (Examples: Farms C and D, Chapter 5).
5) **Peri-urban farms.** These intensive units of production may be owned privately, by a township, or by a commune. These units may also be the heritage of a centralized economy, but they seem to move much faster than their rural counterparts in adapting to a new structure. Another major feature of these units compared those above is the fact that they operate in complete isolation from a land base. All feed and bedding must be imported and all products (including manure) must be exported from the farms (Example: Farm B, Chapter 5).

[13] This description is modified from Simpson, et al. [16].

Chapter 5: Analysis of Chinese Dairy Farms Management Systems—A Series of Case Studies[14]

5.1 Introduction

Dairy producers and policymakers in both China and the United States are confronted with the challenge of developing dairy production systems that are economically and environmentally sound. During the late summer of 1999, a multi-disciplinary team of U.S. scientists, including two dairy scientists, an agro-ecologist, and an economist, traveled to China to study dairy farming in contrasting dairy production systems. The main objectives of this study were to compare:

1) Whole farm nutrient and economic parameters of Chinese dairy farms located in different agroclimatic zones and characterized by contrasting size, ownership and management styles;
2) Chinese and Wisconsin dairy farms of similar characteristics (when meaningful).

5.2 Material and Methods

To achieve the objectives of this study, we selected three distinct sites (see Chapter 4). The team interviewed farm managers and visited farm facilities in Yunnan and Heilongjiang (Figure 5.1). Scheduled farm visits in the city of Beijing had to be canceled, however, because of team member illness. Thus comparisons reported here will not include farms from the Beijing area.

Questionnaires for producers

Prior to the visit, the team of scientists prepared a series of questionnaires to be used on farms to evaluate production and business management, current dairy production practices and financial status (balance sheet, profitability, and cash flow analysis). Questionnaires included some redundancy as a means to verify the collected information.

During all visits, a local official and at least two translators accompanied the team of scientists. Farm managers were interviewed on the premises of their farms with each team scientist taking turns asking questions related to their discipline. Information was collected in approximately two to two-and-a-half hours on the following aspects:

- Household (family or business structure, distribution of labor, management);
- Livestock husbandry (with an emphasis on dairy cattle feeding, reproduction, milking practices);
- Crop and grassland management (cropping patterns, fertilization practices, yields);
- Crop-livestock interactions (manure storage, handling, application);
- Farm nutrient balance (production, import and export of crops, by-product feeds, animal products);
- Business, marketing, and financial management of the farm (assets, liabilities, income, expenses).

5.3 Results: Farm Descriptions

As planned by our protocol, the farms we studied were so different from one another that no attempt will be made to average them. Instead, they will be reported as case studies and compared to Wisconsin farms when meaningful. Five farms with distinct features were selected for the in-depth analysis reported here. Farms A and B were in Yunnan and Farms C, D, and E were in Heilongjiang. The general location of the farms visited can be found in Figures 1.1 and 1.2, and a detailed description of each farm is presented in Appendix Table E.[15]

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[14] A shorter version of this paper was presented at the 2000 Beijing International Conference and Exhibition on Dairy, Beijing, China, June 28-30, 2000.

[15] A supplementary CD-ROM contains additional photographs of Farms A, B, C, D and E, as well as a PDF version of this paper, two related PowerPoint presentations on China's dairy industry, and video clips of various farming practices in China. To obtain this CD, please contact the Babcock Institute (babcock@cals.wisc.edu).

The role of various ethnic groups in the Chinese dairy industry has been highlighted earlier, but it is interesting to note that Farms A and E were small operations owned by families from ethnic minority groups. In contrast, the large operations owned and operated by city or township governments were managed by the majority Han people (Farms B, C, and D).

Farm A (Smallholder, Eruyan, Yunnan)

Farm A was located in the prefecture of Eruyan, the village of Shanbi, in the region of "Dali." The interviewee was the farm owner, a member of the "Bai people," an officially-recognized minority group. The interview took place at the farmstead. The household is made of an extended family of eight individuals: five young adults providing the main labor for the operation and two older adults providing valuable additional labor and care for a young child.


Figure 5.1: The team interviewing Farm A manager.

Farm A was representative of a small-holder mixed farming (livestock-crop) system and included three cows, three heifers, 20 growing (feeder) pigs, 20 chickens, a fish pond, rice and garlic crops, and a silk bean starch extraction business. For the starch extraction business, the farmer purchased broad beans, ground and fermented them to extract the starch, which he sold to a candy maker in their village. The whey and the remaining solids from the broad beans were fed to the livestock. On this farm, the dairy enterprise can be considered a landless system because the majority (>90%) of the feed (dry matter) for the dairy animals came from purchased feed. Cows were milked by hand and milk was transported to the local processing plant once a day.

Farm B (Peri-urban farm, Kunming, Yunnan)

The interviewees for Farm B were the farm manager and his associate. Farm B is representative of a peri-urban large-scale specialized dairy farm with 320 cows, 130 heifers, but no land—except for the four hectares of land in a populated suburb of Kunming where the facilities are located (Figure 5.2). The farm is owned by the city government and has 68 paid employees (labor and management included). The buildings are along a busy street and separated from a busy road only by a tall brick wall. Facilities include tie stall barns, exercise lots, trench silos, a double-10 herringbone milking parlor, and a large milk tank. The current housing and exercise area were made of concrete and many cows on Farm B had foot and leg problems.


Figure 5.2: Manager of Kunming peri-urban farm in front of the farm office building (Farm B).

Like Farm A, Farm B may be characterized as a landless system, because all feed had to be purchased. The forage consisted of corn silage, rice straw, and vegetable-production by-products. There are a large number of vegetable growers in and around Kunming who supply the farm with vegetable refuse from the market.

Farm C (Cooperative farm, Anda, Heilongjiang)

Farm C was located in rural Heilongjiang, in Anda County in the prefecture of Suihua. The interviewee of Farm C was the farm manager. Farm C was an old collective dairy farm that remained under the control of the local government. It

was not run by the local government but was rented to a hired individual entrepreneur who hoped to make a profit.

Figure 5.3: Barn and cow exercise area as found on large farms in Heilongjiang (Farms C and D).

This farm was characterized as a mixed livestock-crop system with limited capital investment. The farm was a specialized dairy operation with 180 cows and 80 heifers. The crops on this cooperative only included 10 hectares of corn silage, but it operated 400 hectares of grassland for summer pasture, and rented 667 hectares of communal grassland for hay production. The individual entrepreneur managed the farm and its 33 hired workers. Facilities were extremely limited on this farm and included only old thick-walled dairy barns, adjacent exercise lots between barns, and essentially no engine-powered equipment (Figure 5.3). On this farm, cow feeding, milking, and manure handling was performed manually. There was no tractor, no vacuum pump, and no bulk tank—just milk cans cooled in a water tank inside the barn.

Farm D (State-owned farm, Daqing, Heilongjiang)

Farm D was located in rural Heilongjiang in the prefecture of Daqing. The interviewee of Farm D was the farm manager. Farm D was an old State dairy farm run under a new management style. It was now a profit-oriented, large-scale operation under a state-controlled corporation. The farm had its own vice-president of production, who was accountable to the State enterprise's CEO. The farm had 46 hired employees (labor and management included).

Farm D was classified as a mixed livestock-crop system with 226 cows, 230 heifers, 200 hectares of corn silage, 1,000 hectares of hay, and 800 hectares of pasture (which had flooded and currently could not be used). Among the Chinese farms reported in this paper, average milk production was the highest on Farm D—6,000 kilos per cow per year (Table 5.1).

A comparison of Farm C and Farm D exemplified the changes in management as a result of economic reform. Ultimately, both farms remained under State control, but each farm was managed quite differently. While Farm D was managed for profit as a corporation, the profit or loss of Farm C appeared to be concentrated more on the individual manager.

Farm E (Small private farm, Qiqihar, Heilongjiang)

Farm E was located in rural Heilongjiang, in the prefecture of Qiqihar. The interviewee of Farm E was the farm owner who belonged to an officially recognized minority group. Farm E was representative of a small-scale, privately-owned enterprise with four household members (parents and two children – Figure 5.4). The farm included 24 cows, 16 heifers, 13 hectares of corn silage, and two hectares of rice. In addition, 120 hectares of communal grassland were available for hay production.

Figure 5.4: Family of a small family farm in Heilongjiang Province (Farm E).

The farm had a 40-cow tie-stall barn and a self-contained milking machine, but no bulk tank. Under one of the local government programs, Farm E had received 5,000 RMB ($625) that year to help

construct a silo for corn silage storage. Like Farms C and D, Farm E was classified as a mixed livestock-crop system.

5.4 Results: Economic Analysis

Net farm income, land value, and total economic costs

In order to calculate Net Farm Income, an estimate of unpaid labor and management was made by multiplying the number of adult household members by 400 RMB per month ($US 46.5 per month).[16] This estimate was based on the following:

1) Salaries for handlers of milking cows on city or state farms averaged 400 RMB per month;
2) Salaries for heifer and dry cow workers averaged 300 RMB per month;
3) The stipend received from the government by the unemployed was 260 RMB per month.

Several attempts were made to obtain an estimate of the value of a hectare of cropland in China. No one would even offer an estimate because "it is illegal to sell land in China." Therefore, based on one land rent value (400 RMB/hectare) the value of cropland was set at 10,000 RMB/hectare ($500/acre), and the value of hay and pasture land at 2,000 RMB/hectare. Finally, in order to calculate total economic cost, an opportunity interest rate had to be assigned for the return to equity capital. It was set at five percent.

Milk prices

At the time of this study, milk price in China was lower than in Wisconsin (Table 5.1). Milk price was also extremely variable in China—ranging from 1.1 RMB/kilo ($6.08/100 pounds) to 2.25 RMB/kilo ($12.45/100 pounds).

The range in milk price was more extreme in Yunnan (a small, southern, provincial producer) than in Heilongjiang (the "powerhouse" of milk production in the north). Milk price was influenced more by farm size and distance from urban centers than by "province." Milk price was lower for Farms A and E, both of which were farther removed from urban centers than Farms B and D. Distance from urban centers alone does not explain differential prices of milk in Heilongjiang, however—both Farm C and Farm E were far from any major economic centers, yet Farm C received 0.3 RMB more per kilo of milk than did Farm E. In both Yunnan and Heilongjiang, a local plant committee set milk price. Unfortunately, no further details were available on how milk price was determined by the committees.

Cost of production

Total cost of milk production in Wisconsin (2.7 RMB/kilo or $15.10/100 pounds) was much higher than in China at the time of the study. Also, the cost of milk production in China varied from 0.85 to 2.07 RMB/kilo ($4.70 to $11.45/100 pounds), 2.5 time difference between the lowest and highest values. Cost of production was lower on the small farms (Farms A and E) than on the large farms (Farms B, C, and D). Although total cost of production was relatively similar on the small farms, Farms A and E (1.04 and 0.85 RMB/kilo, respectively), the cost structure was quite different on these farms. The major cost items were the unpaid labor and management on Farm A, but feeding costs were highest on Farm E. Labor cost (data not shown) was more important on the large farms where they all had a high number of employees per cow on the operation. The highest cost of production was for Farm B (2.07 RMB/kilo or $11.45/100 pounds) because of high costs associated with the purchase of all the feed required on this peri-urban farm.

During the interview, each manager was asked for an estimate of the total cost to produce one kilo of milk on their farm. One out of the five managers did not know (Farm E), one had quite a different estimate (Farm C), but the other three managers (Farms A, B and D) had estimates similar to those calculated in Table 5.1.

[16] RMB = Chinese currency is called Renminbi (meaning "people's money"); the RMB is formally referred to as the Yuan. At the time of the visit, the exchange rate was 8.2 Yuan = 1 US dollar.

Table 5.1. Economic Analysis of Chinese and Wisconsin Farms

Item	Location						
	Eruyan Farm A	Kunming Farm B	Anda Farm C	Daqing Farm D	Qiqihar Farm E	Wisonsin (Small)*	Wisconsin (Large)*
Cow number	3	320	180	226	24	38	251
Milk price (RMB, kg)	1.10	2.25	1.50	1.50	1.20	2.66	2.76
Cost (RMB, TFI/MP)[1]							
- Purchased feed	0.05	1.45	0.68	0.71	0.43	0.39	0.61
- Total cash (feed included)	0.27	1.98	1.59	1.27	0.59	1.83	2.03
- Depreciation costs	0.01	0.04	—	0.04	0.02	0.35	0.29
- Unpaid labor & mgmt.	0.72	—	0.02	—	0.11	0.39	0.19
- Equity	0.04	0.05	0.02	0.17	0.12	0.28	0.11
Total	1.04	2.07	1.62	1.48	0.85	2.84	2.62
Interviewee estimate[2]	*0.90*	*< 2.00*	*1.00*	*1.3-1.8*	—	—	—
Income (1000 RMB)							
- Net farm income	38.7	430.5	-65.1	343.1	77.7	204.2	1,283.0
- Net cash income	14.2	510.5	-65.1	413.0	63.2	418.4	1,675.0
Assets (1000 RMB)							
- Farm net worth	39.3	1,900.0	240.0	6,215.9	327.6	1,943.0	6,204.0
- Total net worth	119.3	1,900.0	240.0	6,215.9	387.6	2,343.0	6,700.0
Ratios (%)							
- Cash exp./Cash inc.	46%	88%	106%	85%	56%	55%	78%
- Cash inc. from dairy	46	98	100	100	83	89	90
- Return on assets	12	18	-32	6	18	4	12
- Return on equity	13	23	-32	6	19	3	15
- Net profit margin	10	10	-7	13	40	13	19
- Asset turnover ratio	125	174	460	43	46	31	63
- Equity to asset ratio	95	79	100	100	94	72	50

* Frank, Gary, and Jenny Vanderlin, "Milk Production Costs in 1998 on Selected Wisconsin Dairy Farms," Center For Dairy Profitability, University of Wisconsin, Madison 53706, July 1999. Small Wisconsin farm (average of 38 cows in 1998); large Wisconsin farm (average of 251 cows in 1998).

[1] TFI/MP = Total farm income divided by milk price.

[2] Interviewee's response to the following question: "What is your estimate of total cost to produce 1 kilo of milk?"

Farm A (Smallholder in Eruyan, Yunnan)

The dairy enterprise on this farm was an integral part, but only a part, of the farming operation. The total income, both cash and non-cash, was estimated at 51,500 RMB ($6,438) per year. Cash income was 52 percent of total income with 46 percent of the cash income coming from the dairy enterprise.

The net cash income on this farm was 14,180 RMB ($1,773). The farm's net worth was 39,267 RMB ($4,908), and the total net worth, including the house, was 119,267 ($14,908, Table 5.1). Although it would be difficult to compare this farm to any group of dairy farms currently operating in Wisconsin, this farm may have some economic attributes of Wisconsin farm in the early part of the 20th century: the diversified operation provides income and a slowly increasing net worth for its extended family.

Farm A was fairly removed from major urban centers. Milk produced on this farm, and on many like it in the region, was sold to a local milk processing plant (built with the help of the Dutch in the 1970s), which produced milk powder for export to Thailand. In addition to this "formal channel" of distribution, milk was also marketed in the form of specialized dairy products at local markets. This was possible because production and consumption of milk is a cultural tradition of the Bai people.

The owner of Farm A was not planning to expand his dairy operation, even though he thought dairying was a good source of cash income. However, he had just purchased a springing cow for 3,500 RMB ($438) to replace one he had sold for beef earlier.

A neighbor of Farm A, who operated a similar farm and was present during the interview, indicated that he was planning to expand his dairy herd. He had this opinion even though the milk price was lower than in previous years—1.1 RMB per kilo ($6.25 per 100 pounds) in 1998 vs. 1.3 RMB per kilo ($7.39 per 100 pounds) earlier. He said that the price was lower because of the slump in the Asian economies, but that this would not last forever.

Farm B (Large, city-owned farm in Kunming, Yunnan)

Farm B was a specialized peri-urban dairy farm with the highest cost of production and the highest milk price of all the farms in this study. The total income, all cash, of Farm B was 4,184,000 RMB ($523,000) per year. Ninety-eight percent of this income came from the sale of milk, cull cows, or calves. Two percent of the income came from the sale of manure.

The net cash income on this farm was 510,500 RMB ($63,813). The farm's net worth was estimated at 1,900,000 RNB ($237,500) (Table 5.1); however, that seemed low considering its location.

Farm B could be compared to the 1998 information on large Wisconsin dairy farms (average 251-cow). The similarity between "Total Cash Costs" of 1.98 RMB/kilo for Farm B and 2.03 RMB/kilo for large Wisconsin farms in Table 4.1 is extraordinary considering the price structures of the two countries. In addition, the percentage ratios (cash income from dairy, return on assets, and net profit margins) were fairly similar. However, the Net Farm and Net Cash Incomes on Wisconsin farms were approximately three times higher than those from Farm B. This is mainly due to large differences in production per cow.

The manager of Farm B wanted to expand and thought dairying was a good source of cash income; however, the space was limited.

Farm C (Large collective farm in Anda, Heilongjiang)

The manager of Farm C had secured the right to operate this 130-cow dairy farm with a bid of 2,020 RMB per cow per year (see Case Study box #4). The rent included 10 hectares of cropland and 400 hectares of pasture. The cost structure on this farm is not like any Wisconsin dairy farm because there is no non-current asset ownership.

The total income of Farm C was 1,104,500 RMB ($138,063) per year. This is all cash income and comes completely from the dairy. The Net Cash Income and Net Farm Income on this farm was -65,100 RMB (-$8,138). The farm's net worth was 240,000 RMB ($30,000)—essentially the value of the feed inventories. Despite its size, this farm was plagued with low milk production (4,500-5,000 kilos per cow per year or 9,900-11,000 pounds per cow per year). Cow yield were among the lowest reported in this study (Appendix Table E). Surprisingly, the manager of Farm C was planning on expanding even through the farm was losing money at its current size.

Case Study 4: Observation on becoming a dairy farm manager of a former collective (by Gary Frank)

Farm C is not run by the local government but rented to an individual entrepreneur who hopes to make a profit. An auction, of sorts, was held to determine who would manage this farm. However, more than the bid price was considered.

In addition to the bid price, the local unit of government looked at the individual's ability (education) and the amount of collateral the bidder could bring to the farm. The winning bidder had to have collateral to pay for custom planting and harvesting of the crops. The winning bidder then signed a contract that "was full of clauses." The contract length was five to 10 years. The farm was inspected monthly by two technicians and one or more members of the local government to see if the winning bidder is complying with the clauses in the contract.

The winning bids have been about 2,000 RMB ($250) per cow per year to rent the cows, the facilities, and land. This is not as inexpensive as it sounds, because there were so few pieces of equipment on this dairy farm (see text for more details).

Farm D (Large farm, corporation-owned in Daqing, Heilongjiang)

Farm D was managed with a clear for-profit objective. The total income, all cash, was 2,679,100 RMB ($334,888) per year. One hundred percent of this income came from the sale of milk, cull cows, or calves. This farm was able to generate 2.5 times the income of Farm C with only 1.25 times more cows.

The Net Cash Income on this farm was 413,100 RMB ($51,638) (Table 5.1). The rate of return on assets was six percent. This return increases to 15 percent when the land has zero value—because the land cannot be sold, an argument can be made for giving the land a value of zero. The farm's net worth was estimated at 6,215,900 RMB ($776,988) with land valued at 10,000 RMB for cropland, 2,000 RMB for hay land, and zero for unusable land.

Farm D can be compared to the 1998 information on large (average 251-cow) Wisconsin dairy farms. The Net Farm and Net Cash Incomes on Wisconsin farms were approximately four times those of Farm D. This is mainly due to more production per cow. In addition, the ratio of capital to labor and the economic ratios were also quite different. The Farm Net Worth was similar (6,200,000 RMB); however, on the average, the large Wisconsin dairy farms have twice the total assets of Farm D because large Wisconsin farms have 50 percent equity versus 100 percent equity found on Farm D

The vice president (farm manager) of Farm D wanted to expand. This farm was located several kilometers outside of Daqing and had the land base required for expansion. The only "obstacle" to getting the funds for expansion was the CEO and the board of directors of the state enterprise. They had to approve a plan that was in direct competition with the plans of other profit centers.

Farm E (Small farm, privately-owned in Qiqihar, Heilongjiang)

Dairying is this farm's major business. On Farm E, three adults provided the daily labor for the operation. However, during harvest and at other times of increased labor needs, crews consisting of themselves and neighboring farmers moved from farm to farm.

The total income, both cash and non-cash, was estimated at 159,900 RMB ($19,988) per year. Cash income was 88 percent of total income, with 82 percent of the cash income coming from the dairy enterprise. The net cash income on this farm was 77,670 RMB ($9,709) (Table 5.1).

The farm's net worth was 327,600 RMB ($40,950) and the total net worth, including the house, was 387,600 ($48,450). This farm had the largest debt of the private farms visited—20,000 RMB ($2,500).

Farm E can be compared to the 1998 information on smaller (average 38-cow) Wisconsin dairy farms. The Net Farm Income per cow on Farm E is much smaller (3,200 RMB) than on small Wisconsin dairy farms. However, Farm E was in an expansion mode and had cows with very long dry periods. Net Cash Income per cow was 2,600 RMB versus 11,000 RMB in Wisconsin.

This farm was planning to continue its expansion as rapidly as possible because dairying was a good source of income. In fact, they had already purchased most of the materials to build another barn and were awaiting a bulldozer to come and build a trench silo.

5.5 Summary

We will summarize and conclude this chapter by posing and answering a few questions.

Were the Chinese dairy farms profitable?

It appears that Chinese dairy farms were profitable and were increasing the net worth of their owners and managers. Six of the seven dairy farms visited—and four of the five farms reported here—had a positive rate of return on assets. Except for one collectively-owned farm in Heilongjiang (Farm C), all other farms in this study showed similar economic indicators (economic ratios).

Will these Chinese dairy farms expand in the future? If so, what are the challenges to expansion?

Six of the seven dairy farms visited—and all of the five farms reported here—would like to expand. Even the one farm that was losing money (Farm C) wanted to expand!

In the Yunnan Province, there is an important constraint on land and forage available for milk production by dairy cows. However, Yunnan producers use a wide variety of by-products to feed their cows. They take full advantage of the cow's ability to utilize crop residue and other products unfit for human consumption.

In Heilongjiang Province, the land is abundant and forage production could be expanded considerably. Given the right set of economic circumstances, forage production could be doubled or tripled if needed.

Do the small dairy farms in Yunnan resemble the small dairy farms in Heilongjiang?

Farm A in Yunnan was very different from Farm E in Heilongjiang. The manager of Farm A relied on a number of sources of income to support the family. Dairy was the major source of cash income, but still made up only approximately 40 percent of total cash income. On Farm E, dairy provided approximately 80 percent of the total cash income on the small dairy farm.

Do the large dairy farms in Yunnan resemble the large dairy farms in Heilongjiang?

The proximity of the farm to an urban center and the ownership (collectively-owned versus state-owned) appear to influence the economic performance of large farms more dramatically than does the farm's location in Yunnan or Heilongjiang.

5.6 Results: Elements of Nutrient Cycling on Chinese Farms

Accumulation of nutrients in a farming system and the potential loss of nutrients, such as nitrogen and phosphorus, to the environment depends on the balance between imports and exports from the farm. Nutrients are imported onto the farm primarily as purchased supplemental feed for the dairy herd or inorganic fertilizer for crops, and if applicable, through natural fixation of atmospheric nitrogen by leguminous plants. In contrast, nutrients are exported from the farm in the animal products (meat and milk) and cash crops sold. Unless the animal manure is sold to someone off the farm, it is typically applied to crops as a means to recycle the nutrients through the system. As animal density, or stocking rate, increases, the availability of manure nutrients exceeds

crop requirements and lowers the efficiency of nutrient utilization on the farm. Low efficiencies of nutrient utilization are usually associated with high environmental losses and the risk of pollution.

Thus, knowledge of animal density along with utilization of manure on a farm could be used as a rough indicator of nutrient balance and associated risk of nutrient losses to the environment. For the purpose of this study, we calculated "animal density" as the number of dairy animal units divided by hectares of harvested crops (Table 5.2).

Dairy animal units ranged from four on Farm A to 510 on Farm B, and hectares of cropland harvested per year (excluding grassland areas in Heilongjiang) ranged from zero on Farm B to 200 on Farm D.

Calculation of animal density (dairy animal units per hectare of crop land harvested) did not apply for Farm B (see details later), but ranged from 2.2 on Farm D to 20.9 on Farm C. Each of the Chinese farms in this study had a higher animal density than the average Wisconsin farm, which has 1.5 dairy animal units per hectare of crop land harvested.

Feed produced per hectare of cropland is lower in Wisconsin (6.7 ton/ha) because it is assumed that crop rotation includes maize, lucerne and soybeans, compared to double cropping of rice in Yunnan and monoculture of maize in Heilongjiang. Yet, except for Farm D, the Chinese farms in this study were importing more nutrients onto the farm than the average Wisconsin farm.

An analysis of the data in Table 5.2 reveals that farms with higher animal density per unit of cropland were importing a higher percentage of their feed. These farms also had higher manure availability per hectare of cropland (for example, compare Farms A, B, and C to Farms D and E).

Table 5.2. Estimates of animal density, feed sources, and nutrient balance parameters of farms visited in China and of the average 1999 Wisconsin dairy farm

Country:	**China**					**US**
Province/State:	**Yunnan Province**		**Heilongjiang Province**			**Wisconsin**
City:	**Eruyan**	**Kunming**	**Anda**	**Daqing**	**Qiqihar**	**—**
Farm:	**A**	**B**	**C**	**D**	**E**	**F[1]**
Cow number	3	320	180	226	24	63
Dairy animal units (dau)[2]	3.9	510.2	208.6	443.0	36.7	125.3
Feed required (ton/year)	18.1	2190.1	967.8	1893.1	155.6	554.1
Feed produced (ton/ha)[3]	8.3	NA[4]	15.8	12.4	13.9	6.7
Feed Imported (%)[5]	91.0	100.0	87.0	0.0	34.0	5.0
Crop land (ha)[6]	1.04	0.0	10.0	200.0	13.0	85.1
Animal density (dau/ha)[7]	5.8	NA	20.9	2.2	2.8	1.5
Manure availability (kg/ha)	378.0	NA	1468	156	198	104
Manure N losses (%)[8]	77.0	65.0	……. Not determined …….			58
Nitrogen recycled (%)[9]	12.0	18.0	……. Not determined …….			21

[1] Wisconsin Agricultural Statistics. 1999. Department of Agriculture, Trade and Consumer Protection, Madison, WI.

[2] Estimated total body weight of the dairy herd (cows and heifers) divided by 454 kilos. One dairy animal unit (dau) is equivalent to an animal of 454 kilos body weight.

[3] Feed produced on-farm, including estimates of forage and plant residues (straw and cereal bran).

[4] NA=Not applicable.

[5] Estimated percentage of total feed requirements not produced on farm.

[6] Hectares of crops harvested per year, excluding large grasslands (available in Heilongjiang).

[7] Animal Density = number of dairy animal units divided by hectares of harvested crops.

[8] Estimates of manure nitrogen lost while cleaning and storing cow manure.

[9] Percent of manure nitrogen captured (and exported in the case of Farm B) and recycled through crops, assuming that 50 percent of the applied manure nitrogen is taken up by a succeeding crop.

Estimates of nitrogen recycled on crops was 12 percent for Farm A, 18 percent for Farm B, and 21 percent for the average Wisconsin farm.

Calculation of nitrogen balance for crops (inputs as fertilizer and manure application minus output as biomass) indicated balanced budgets for all fields included in this study. Heilongjiang producers indicated that they do not apply manure or chemical fertilizer to pastures. Rates of removal of nitrogen from these pastures appeared to be compensated for by annual return of nitrogen from rainfall (15 kg/hectare/year), biological nitrogen fixation, feces and urine deposited during grazing, and soil mineralization.

Case study 5: Manure handling and management on a peri-urban farm (by Gary Frank)

Groups of individuals were hired to do the manure handling chores. The system observed worked as follows: a couple (man and woman) was in charge of the manure from each barn. There were about 65 cows per barn. They cleaned the yard when the cows were inside and cleaned the barn when the cows were outside. They ended up with 12 to 15 handcart loads of manure per day, which they pushed uphill to a collection point. This amounted to about 1.5 cubic meters of manure per day.

Then they sold the manure to the highest bidder and received half of the proceeds. The other half went to the dairy. There were numerous individuals who had manure trucks and who resold the manure they bought from the dairy to people with vegetable or flower gardens in and around Kunming. The run-off from the cement yards was collected and used by a nursery just down slope from the dairy. They received this runoff free of charge.

The demand for the manure was high, so the manure workers could obtain about 100 RMB ($12.50) per 1.5 cubic meter load from manure-delivery business people. Since they collected about 1.5 cubic meters, they received about 100 RMB per day. Since they were able to keep half of this, they earned about $6.25 per day. This was approximately $2,300 per year, which was more than twice as much as they (two people) could make if they each had a common laborer job.

5.7 Results: Hay and Pasture Management in Heilongjiang

Renovation of hay and pasture

The province of Heilongjiang has a goal of renovating five million hectares annually. That goal was not easily reached. The individuals who rented the hay and pasture land from the state had to follow a set of rules. Hay land was cut once each year and could not be pastured. Only pasture land could be pastured. The local government determined the dates each year that pasturing would start and end. These dates varied depending on the conditions and the judgment of the local officials.

The cost of hay land renovation was 70-80 RMB per mu ($50-60 per acre). That cost was broken down as follows: 20 RMB for seed, 30 RMB for fertilizer (five kilos of urea and 10 kilos diammonium phosphate - DAP); plus 20-30 RMB for tillage. They would like to renovate all the hay land once every 15 years.

The first few years after hay land is renovated it yields about 150 kilo per mu (one ton per acre). The right to harvest renovated hay land is also auctioned to the highest bidder. For the first five years of rental, the local government receives averages of about 15 RMB per mu ($11.25 per acre) per year, depending on current and expected hay prices. During the next five years, the average hay yield drops to approximately 100 kilo per mu. During the last five years, it averages about 65 kilo per mu.

The hay price at the time of this study was 240 RMB per 1,000 kilo ($27 per ton) and the quality was quite poor—seven percent protein, based on statements by Chinese nutritionists. The

hay was either cut using a scythe or a ground-powered mower. These mowers are like the horsedrawn mowers we used to use, and are usually pulled by small, 15 to 20 HP tractors.

Hay harvesting

Since the climate in Heilongjiang Province is dry and the hay is thin, a dump rake was attached to the mower. Someone rode the dump rake to operate it. When the hay was heavy, a separate operation was required for the dump rake. Next a crew of individuals put the hay into small piles. At the time of this study, the cost to cut and pile the hay for drying was 5 RMB per mu for ordinary hay and 8 RMB for heavy hay.

When the hay was dry, it was hand loaded onto a small wagon and hauled to the dairy farm for stacking. This was also done by hand. The power to pull the hay wagons was either a 15 to 20 HP tractor or a horse or mule. We assumed that the same people who were cutting the hay with a scythe were using the animal power to pull the wagons of hay to the dairy farms. The charge for loading, hauling, and stacking was 0.04 RMB per kilo ($4.50 per ton). There did not appear to be a separate charge for distance.

Economic aspects of pasture management

There were two economic entities at work here, the local government and the renter. The renter had to determine how much to pay for the land based on expected hay yield, hay price, harvesting costs, risk and other factors.[17] For example, 100 kilos of hay per mu cost approximately nine RMB to cut, pile, haul, and stack in a dairy farmer's yard. At the time of the study, that 100 kilos would have sold for 24 RMB. Therefore, potential renters would have had 15 RMB per mu available to pay rent, account for the yield and price risk, and pay themselves for managing this enterprise. The amounts that renters have actually bid and paid averaged: 15 RMB per mu during the first five years, 8 RMB per mu during the second five years, and 6 RMB per mu during the last five years and 2 to 3 RMB per mu for non-renovated hay land. So the second economic question is: "What is the internal rate of return to the local government's investment in renovating hay land?" Based on an 75 RMB per mu renovation cost and rents bid and paid, the internal rate on return was approximately six percent. Therefore, if the local government is able to borrow money at less than six percent it should continue to renovate hay land.

5.8 Results: Labor Management on Chinese Farms

On small Farms A and E, the owners and their families provided all the care for their own cows. In contrast, on the large dairy farms (Farms B, C, and D), the farm managers hired individuals to do the various tasks required. The way these tasks were split among workers varied from farm to farm.

The case of Farm B in Yunnan

At the city farm in Kunming, "cow handlers" were responsible for care and feeding of their cows (three handlers per 65 cows); however, they did not milk or clean up the manure from "their" cows. Other individuals were hired to do these tasks.

The "cow handler" wages were determined based on the average production per cow in their "herd." They earned 400 RMB ($50) per month if their herd averaged 18 kilos (about 40 pounds) of milk per cow per day. If their herd averaged more than 18 kilos of milk per day, they earned more, and if their herd averaged less than 18 kilos per cow per day, they earned less.

There were no tractors or skid loaders on the Kunming "city" farm. So the handlers mixed the concentrate feed with the distiller grain by hand, put it in carts and fed it by hand. They also fed their cows corn silage, rice straw, and any green vegetable by-product they could get. We saw celery, lettuce, cabbage, swiss chard, tomato vines, and even some tomatoes being fed to the cows. This was all moved and fed by hand.

[17] Renters did not apply any fertilizer and it was unknown if this was by choice or rule.

Cows were brought to a dry cow facility when they finished their lactation. There they were taken care of by another set of people. When a cow freshened, she was returned to the same set of handlers. The cow spent her entire milking lifetime in the same barn. A veterinarian determined if a cow should be culled and the group of handlers received a replacement heifer as soon as possible, if all was okay.

The case of Farms C, D, and E in Heilongjiang

In Heilongjiang Province the labor management was somewhat different. Each handler was assigned 13 cows. At any one time, about 10 or 11 were being milked. The handler was responsible for the care, feeding, and hand milking of his (we did not see any women cow handlers) cows three times a day. They had a separate veterinarian and AI technician.

When a cow finished her lactation, she was moved to the dry cow barn and was cared for by another set of workers. When the cow freshened, she returned to the same handler. A veterinarian determined whether a cow should be culled and the handler received a replacement heifer as soon as possible.

The handlers were paid 0.08 to 0.10 RMB per kilo of milk harvested per month. Most were paid 0.09 RMB, but could receive more or less based on quality. Handlers earned an average of 400 RMB ($50) per month. In comparison, the amount paid to unemployed workers was 260 RMB per month.

Case study 6: Milking center and milk quality in Heilongjiang (by Gary Frank)

At the time of this study, a milking center was a new concept being funded by a processing plant in hopes of obtaining higher milk quality. The milking center we visited was located in a small village with a high concentration of smallholders (one- to five-cow operations). The milking center had modern milking equipment including a vacuum pump, a bulk tank, and several stanchions. The farmers in the village lead their cows to the milking center and then milked them according to a pre-defined procedure that was posted on the walls. Cows were milked three times a day in early lactation and twice a day in late lactation.

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APPENDICES

Appendix Table A: Change in ruminant population (millions) in China, the US, and the world between 1975 to 2000*

	1975	1980	1985	1990	1995	2000
Buffalo (Totals)						
- China	18.1	18.4	19.5	21.4	22.9	22.6
- US	NA**	NA	NA	NA	NA	0.0***
- World	113.1	121.7	136.2	148.1	159.2	165.0
Buffalo (Dairy only)						
- China	3.0	3.5	3.7	4.4	4.7	4.8
- US	NA	NA	NA	NA	NA	NA
- World	24.1	28.1	33.4	39.7	42.7	47.1
Cattle (Totals)						
- China	56.7	52.5	62.7	79.5	100.6	104.6
- US	132.0	111.2	109.6	95.8	102.8	98.0
- World	1,187.1	1,216.2	1,259.4	1,296.2	1,332.5	1,350.1
Cattle (Dairy only)						
- China	0.7	0.7	1.7	2.8	4.0	4.8
- US	11.1	10.8	10.9	10.0	9.5	9.1
- World	198.5	214.2	220.8	227.6	226.8	221.2
Goats (Totals)						
- China	66.4	80.8	63.4	98.3	123.4	148.4
- US	1.4	1.4	1.6	1.9	1.9	1.4
- World	403.9	462.6	484.6	583.4	664.7	720.0
Goats (Dairy only)						
- China	0.6	0.9	0.9	1.0	1.1	1.2
- US	NA	NA	NA	NA	NA	NA
- World	81.0	92.2	101.0	122.0	137.6	145.6
Sheep (Totals)						
- China	94.7	102.6	95.1	113.5	117.4	131.1
- US	14.5	12.7	10.8	11.4	9.0	7.2
- World	1,046.3	1,096.5	1,118.9	1,206.6	1,092.2	1,057.9
Sheep (Dairy only)						
- China	15.1	16.3	17.7	20.1	27.5	38.0
- US	NA	NA	NA	NA	NA	NA
- World	130.9	10.5	155.8	167.0	174.2	196.5
Contribution of various ruminant species to total milk supply (%)						
China						
- Buffalo	15	16	15	15	13	10
- Cattle	3	3	7	10	11	10
- Goats	3	4	4	4	3	2
- Sheep	78	76	74	71	74	78
US						
- Cattle	100	100	100	100	100	100

* Ruminant species are those listed in Appendix Table A: buffalo, cattle, sheep, and goats (non-ruminant livestock are included in Appendix Table B: pigs, ducks, chickens, and turkeys).

** NA=Data not available. Dave Thomas, personal correspondence: US numbers in January 2002: total sheep-6.7 million, dairy sheep-25,000, total goats-1.3 million; number of dairy goats is not known.

***There were approximately 3500 water buffalo in the US in 2000 - http://ww2.netnitco.net/users/djligda/wblinks2.htm#002.

Appendix Table B: Numbers of non-ruminant livestock (millions) in China, the US, and the world from 1975 to 2000*

	1975	1980	1985	1990	1995	2000
Pigs						
- China	264.0	325.7	313.9	360.9	424.8	437.6
- US	54.7	67.3	54.1	53.8	59.7	59.4
- World	685.7	121.7	793.2	857.6	900.2	908.1
Ducks						
- China	159.3	192.9	223.5	329.7	518.1	611.9
- US	3.4	4.8	6.3	6.3	5.8	6.6
- World	296.0	348.0	400.9	523.7	766.9	884.6
Chickens						
- China	0.7	0.9	1.3	2.1	3.1	3.6
- US	0.9	1.1	1.1	1.3	1.6	1.7
- World	5.9	7.2	8.6	10.6	12.9	14.4
Turkeys						
- China	0.6	0.7	0.6	0.4	0.2	0.2
- US	40.0	52.0	58.5	90.0	88.0	86.0
- World	144.0	200.6	216.3	243.0	230.8	240.4
Ruminant species as a percentage of total animals						
China	47	44	43	46	46	48
US	73	65	69	66	65	64
World	80	78	79	79	78	78

* Non-ruminant livestock includes the animals in Appendix Table B: pigs, ducks, chickens, and turkeys (ruminant species are those listed in Appendix Table A: buffalo, cattle, sheep, and goats).

Appendix Table C: Structure of the meat sector in China and the US in 2000*

	Number of Head (million)		Yield (kg/animal/year)		Total Meat Output (million metric tons)	
	China	**US**	**China**	**US**	**China**	**US**
Ruminants**						
- Buffalo	22.600	—			—	—
- Cattle	104.600	98.000			—	—
- Buffalo and cattle	127.200	98.000	42.3	125.6	5.384	12.311
- Sheep	131.100	7.200	—	—	—	—
- Goats	148.500	1.400	—	—	—	—
- Sheep and goats	279.600	8.600	9.5	12.0	2.654	0.103
Non-ruminants						
- Pigs	437.600	59.400	98.4	143.6	43.058	8.532
- Chickens	611.900	6.600	3.2	7.4	1.943	0.049
- Ducks	3.600	1.700	3.5	9.7	12.500	16.471
Totals					64.444	37.636

* Source: [FAO, 2001].

** Total population including dairy animals (when applicable).

Appendix Table D: Distribution of milk production and consumption in the various agricultural regions of China[1]

Cities and Provinces	1997 Total Milk Output[1]		1999 Total Milk Output[2]				1995 Milk Consumption (kg/person/year)	
	Metric tons	%	Metric tons	%	Metric tons			
					Cow	Non-cow[3]	Urban	Rural
Beijing	222	2.9	241	3.0	240	1	15.06	1.06
Tianjin	129	1.7	129	1.6	129	0	7.05	0.39
Shanghai	239	3.1	259	3.2	259	0	23.72	1.50
Intensive agricultural (cropping) regions in lowland plans (Step 1)[4]								
Hebei	547	7.1	788	9.8	684	104	5.31	0.14
Shandong	799	10.3	613	7.6	356	257	5.53	0.18
Henan	106	1.4	159	2.0	103	56	3.49	0.09
Shaanxi	516	6.7	557	6.9	323	234	3.67	0.49
Jiangsu	117	1.5	163	2.0	162	1	3.84	0.17
Anhui	28	0.4	36	0.4	36	0	2.38	0.09
Zhejiang	86	1.1	91	1.1	91	0	5.07	0.20
Hubei	46	0.6	40	0.5	39	1	0.71	0.03
Jiangxi	35	0.5	52	0.6	52	0	0.82	0.05
Fujian	61	0.8	80	1.0	77	3	4.72	0.25
Guangdong	63	0.8	81	1.0	78	3	1.17	0.08
Hunan	6	0.1	10	0.1	10	0	0.09	0.03
Guizhou	17	0.2	15	0.2	15	0	3.77	0.02
Guangxi	11	0.1	13	0.2	13	0	1.34	0.01
Hainan	4	0.1	NA*	NA	NA	NA	0.04	0.09
Hospitable pastoral regions of the uplands (Step 2)								
Heilongjiang	1949	25.2	1450	18.0	1428	22	1.70	0.28
Inner Mongolia	624	8.1	712	8.8	679	33	5.83	0.70
Liaoning	187	2.4	203	2.5	182	21	5.53	0.25
Jilin	136	1.8	145	1.8	138	7	1.82	0.23
Ningxia	191	2.5	205	2.5	205	0	2.77	0.20
Shanxi	316	4.1	327	4.1	302	25	8.88	0.31
Sichuan	260	3.4	316	3.9	313	3	5.01	0.89
Yunnan	123	1.6	135	1.7	122	13	3.11	0.10
Harsh pastoral regions of the high continental plateaus (Step 3)								
Xinjiang	588	7.6	704	8.7	648	56	12.98	4.11
Zinghai	191	2.5	196	2.4	190	6	13.98	12.80
Xizang (Tibet)	NA	NA	209	2.6	167	42	NA	14.06
China	7748	100.0	8067	100.0	7175	892	—	—

[1] Production data from China Statistical Year Book, 1998, 2000. Consumption data from household survey by State Statistical Bureau (SSB), after Xiurong He and Weiming Tian, 2000.

[2] Including cow, buffalo and small ruminant milk.

[3] Including buffalo and small ruminant milk.

[4] See Chapter 1 for detailed description of the agricultural regions.

* NA = Data not available

Appendix Table E: Farm information sheet—Land and dairy herd characteristics

Province:	**Yunnan Province**		**Heilongjiang Province**		
Farm:	**A**	**B**	**C**	**D**	**E**
Prefecture:	**Eruyan**	**—**	**Suihua**	**Daqing**	**Qiqihar**
County (City):	*	**(Kunming)**	**Anda**	**Daqing**	**Fuyu**
Township:	**Xingzhou**	**—**	**Anda**	**—**	**Yiuyi**
Village:	**Shanbi**	**—**	**—**	**—**	**Denke**
Owner	**Farmer**	**State/City**	**Collective**	**Corporation**	**Farmer**
Labor & Management					
- Family/household	8	—	—	—	4
- Employee	—	68	33	46	—
# cows/worker[1]	0.3	4.7	5.5[2]	4.9[2]	—
Land (mu)[3]					
- Crops	1.0	0.0	150.0	3,000.0	195.0
- Crops (rented)[4]	4.5	0.0	0.0	0.0	0.0
- Fish pond[5]	2.0	0.0	0.0	0.0	0.0
- Grassland	0.0	0.0	6,000.0	27,000.0[6]	0.0
- Pasture (rented)	0.0	0.0	10,000.0[7]	0.0	1,800.0[8]
Total # mu in operation	7.5	0.0[7]	16,150.0	30,000.0	1,995.0
Dairy herd size					
- Milking cows	3.0	320.0	NA	NA	NA
- Calves and heifers	3.0	130.0	NA	NA	NA
- Total herd size	6.0	450.0	NA	NA	NA
- # of animal units[9]	3.9	510.2	NA	NA	NA
Milk output					
- Per farm (kg/year)	15,000	1,820,000	800,000	1,680,000	90,000
- Per cow (kg/cow/year)[10]	5,000	5,687	4,444	7,434	**3,750**
- Per cow (kg/cow/year)[11]	4,500	5,700	4,500	6,000	5,000
Milking/Lactation					
- Method	Hand	Parlor	Hand	Hand	Bucket unit
- Milking frequency	3	2	3	3	2-3[12]
- Lactation length (days)	240	390	260-310	270-330	—
- Cow lifespan (years)	11	5.5	8.0	6.5	>10
- Cow repro. service	AI[13]	AI	AI	AI	AI
- Replacement method[14]	P	HR	HR	HR	HR

* County name unknown.

[1] Calculated as total number of laborers (excluding the manager) reported as working with cows (number not shown) divided by cow number.

[2] On these two farms, one labor unit is responsible for daily milking, feeding, and cleaning of 12-13 cows.

[3] 1 mu = 20 m x 30 m plot = 65 ft x 98 ft = 0.067 hectare or 15 mu = 1 hectare = 2.5 acres or 1 mu = 0.17 acres.

[4] Mu rented from neighbors.

[5] The fish pond and connecting water ways were also a source of "swamp grass," a green forage fed to the cows.

[6] 12,000 mu were flooded in 1998 and were lost indefinitely.

[7] Mu collectively owned by the township and distributed at a rate of 45 mu per cow in normal years or 15 mu per cow in years of flooding.

[8] This peri-urban farm did not have any land base, but occupied 58 mu for offices, buildings and cow paddocks.

[9] One Animal Unit = 1000 pounds of body weight (450 kg). Animal units were calculated based on estimated animal body weights.

[10] Milk output from the farm divided by cow number as reported by the interviewee.

[11] Average milk production per cow as reported by the interviewee.

[12] Cows were milked three times a day in early lactation and two times a day in mid and late lactation.

[13] AI = Artificial Insemination.

[14] Method by which cull cows are replaced: P = Purchase of young cow, HR = Heifer raised on farm.

Appendix Table E: Farm information sheet—Land and dairy herd characteristics (cont.)

Province:	**Yunnan Province**		**Heilongjiang Province**		
Farm:	**A**	**B**	**C**	**D**	**E**
Prefecture:	**Eruyan**	**—**	**Suihua**	**Daqing**	**Qiqihar**
County (City):	*	**(Kunming)**	**Anda**	**Daqing**	**Fuyu**
Township:	**Xingzhou**	**—**	**Anda**	**—**	**Yiuyi**
Village:	**Shanbi**	**—**	**—**	**—**	**Denke**
Owner	**Farmer**	**State/City**	**Collective**	**Corporation**	**Farmer**
Housing/Feeding					
- Type	Pen	Tie/free stalls	Tie stalls	Tie stalls	Tie stalls
- Outside paddock	No[15]	Yes	Yes	Yes	Yes
- Floor	—	Concrete/dirt	Concrete/ dirt	Concrete/dirt	Concrete/dirt
- Bedding		Feed refusals	Rubber mat	Feed refusal	Wood board
- Feed storage		Straw pile	Straw pile/Silo	Hay pile	Hay pile/Silo
Profitability[16]					
- Production cost	0.9	< 2.0	1.0	1.3-1.8	—
- Milk price	1.1	2.4	1.3	1.5	1.25

[15] Despite the absence of outside paddock, cows were taken out daily to graze along roads and fields.
[16] Estimates of production cost (RMB/kg of milk) and milk prices (RMB/kg of milk) as reported by interviewee.