The Livestock Transition, Peri-Urban Agricultural Land Use and Urbanization in China by Ian MacLachlan, Department of Geography, University of Lethbridge, Lethbridge, Alberta, Canada T1K 3M4. E-mail: maclachlan@uleth.ca. 30 May 2015

Presented to 3rd Conference on China Urban Development, East China Normal University, Shanghai, 6 June 2015

Abstract
Rapid urbanization in China is embedded in a modernization process with profound implications for every aspect of its social development. Rising real incomes in urban areas have triggered a sea change in Chinese meat consumption with impacts on human health and obesity via the nutritional transition, on animal welfare and disease as China develops its livestock-handling and slaughter infrastructure, and on the environmental impact of growing numbers of food animals on the landscape. The urban transformation of both coastal China and the western interior is clearly polynuclear, creating a complex urban fringe with a lengthy interface between urban and agricultural land uses. There is enormous potential for residential-agricultural land use conflict in the dynamic rural-urban fringe within the administrative boundaries of expanding cities. Expanding cities encounter a growing peri-urban zone of large-scale intensive livestock feeding operations that are drawn to fast-growing urban markets.

This exploratory paper is based on secondary source materials. The FAOSTAT database published by the Food and Agricultural Organization of the United Nations was used to provide global context. The National Household Survey of the National Bureau of Statistics of China as published in the *China Statistical Yearbook* is used to describe the growth of meat consumption in rural and urban areas. Meat production and livestock counts are broken out by province, SAR and *shi* to illustrate the rural-urban and coastal-interior dichotomies in a regionalized development process divided sharply by the Aihui-Tengchong Line. The principal achievement of this paper is the description of the magnitude and relative suddenness of China's livestock transition as it is manifest in different regions. To show the significance of the livestock transition as a component of China's urban transformation, the paper will conclude with an evaluation of the role of public policy on animal agriculture, the influence of the "dragon head" agribusiness companies over the livestock value-chain and the influence of the urbanization process on meat consumption and livestock production.

Keywords: *Urbanization in China, livestock transition; nutritional transition, meat consumption, polynuclear urban morphology, intensive livestock feeding operations*

On March 16, 2014, the Chinese national government unveiled its urbanization plan for the 2014-2020 period. This plan will place new emphasis on the environment and promises a people-centered approach to city growth with special attention to the needs of the floating population that now constitutes some 20% of the national total. According to the Central Committee of the Communist Party of China and the State Council, urbanization will be the "engine for sustainable and healthy economic growth" that propels the modernization process.

An element of the plan that has received less attention in the press is its emphasis on demand side policies. Quoting from the National New-type Urbanization Plan: "domestic demand is the fundamental impetus for China's development, and the greatest potential for expanding domestic demand lies in urbanization" (Xinhua, 2014). This policy statement could be read in different ways.

1. It could be perceived as a neo-liberal statement of the nation's reliance on domestic demand as the "fundamental impetus" for China's development and a continuation of market-based policies that can be traced back to 1978. This is something of a chicken-egg conundrum. One might fairly ask: is demand the stimulus for urbanization or is urbanization impacting demand?

2. This urbanization plan appears to be a repudiation of Maoist era policies in which the ideological commitment to the elimination of inequality, exploitation, and class stratification meant that service activities and consumption were considered "non-productive" and even "exploitative". Thus commercial activity was discouraged and Chinese cities were transformed from "consumer cities" into "producer cities." Accordingly urban consumption (of food, consumer durables and housing) was sacrificed and the rapid expansion of production was prioritized to economize on the costs of urbanization (Chan, 1994, 72; Lin, 2006, 33-34). Thus the importance of domestic consumption in the new urbanization policy appears to be a major policy reversal.

3. It could also be seen as a contrast to the export-based industrial strategies underlying the creation of the Special Economic Zones in 1980 and recognition that China's enormous urban population and its rising prosperity now present a huge market potential (Wu and Gaubatz, 2012, 122). Greater reliance on a stable domestic market of 1.3 billion would then buffer the unpredictable fluctuations in global markets such as the global financial crisis of 2008.

Variation in the consumption of goods and services is the essence of difference in the quality of life that distinguish rural and urban lifestyles and living standards. The starkest contrasts between the world's most developed urban regions and least developed rural regions are manifest in consumption behavior. Yet until recently, consumption received scant attention from geographers and urbanists. Economic geographers were concerned primarily with the production and distribution of commodities. Production took place in the masculine world of hard labor. Consumption, frivolous, indulgent, and even decadent, took place in the home, largely the province of women who did the marketing for their households. Geographers are coming to recognize that human

consumption is the driving force behind "the economic problem." The drive to consume creates the scarcity that gives rise to the question of what is to be produced and how the factors of production are to be allocated in the process of creating value. An appreciation of rural and urban consumption patterns is vital to an understanding of the economic contrasts that differentiate urban and rural areas. And as China's cities grow ever larger as a result of the market forces unleashed in the reform era, their internal structures become ever more specialized into the process of consumption. "Commercial activity at different scales seems to have permeated every cell of urban tissue in China's large eastern cities" (Wu and Gaubatz, 2012, 243).

While any study of the link between urbanization and consumption could focus on housing or clothing on the material side or on education or health services as intangible goods, this paper will focus on animal source food (ASF). Food is essential to human welfare, it has well established quality and quantity benchmarks to maintain a healthy level of activity, and few consumption processes are more visible or visceral. The act of swallowing food is fairly regarded as the paradigm of consumption. This paper begins with consumer demand for what is arguably the most fundamental commodity in an urban society: food and focuses on the soaring demand for (ASF) in particular. From the demand for ASF, the paper shifts its focus to the production of livestock that are the source of ASF as a case study to exemplify the way that domestic consumption interacts with policy to shape the urbanization process, unleashing urban outcomes that impact other key policy areas.

George Lin has argued that urbanization has taken place in a "peri-urban setting, where a favorable urbanizing environment was created by an entrepreneurial local government, numerous (and dispersed) small-scale and labor intensive export-processing firms, an enormous influx of migrant workers that tripled the size of the local population, and a transitional socialist land disposition system" (Lin, 2006, 29). And it is for this reason that "the growth of peri-urbanism in contemporary China raises important questions about the conventional wisdom that tended to view urbanism as city-based, externally driven, and exclusively affiliated with "urbanites" (Lin, 2006, 30). This paper is motivated by the considerable volume of livestock production (chiefly pigs, poultry and dairy cows) taking place to in peri-urban regions, its impact on urban-centered regions and the close relationship that is created between urban ASF consumption and peri-urban animal husbandry.

The paper begins by documenting the rapid growth in demand for meat as an element of the Chinese diet, most conspicuously in urban areas. Concomitant with the growth in demand for meat is the growth in domestic production of food animals that has a distinctive geography at the national scale. The paper then turns to the drivers of these changes. Growing meat consumption is seen as an outcome of urbanization and rising real income but it has also been encouraged by state food policy. The shifting dietary consumption of meat products is having an impact on agriculture in rural areas, very largely in peri-urban areas. High density confined animal feeding operations (CAFOs) in the fringe areas of China's largest and most rapidly growing areas are growing the fastest

and have the greatest potential to impact urban areas through their obnoxious odours, toxic runoff, and the other outcomes of high intensity animal agriculture.

Livestock Transition & Growing Consumption of Animal Source Foods

First identified in the late 1990s as the "livestock revolution," the rapid growth in the per capita consumption of animal products (meat, poultry, dairy and eggs) has been documented in Asia and Latin America (Delgado et al., 1999). Perhaps the most remarkable aspect of this observation was that the revolution in the consumption of livestock products came at a time when per capita consumption of these foods was levelling off in the United States among other developed countries. China is leading the way among developing countries that are now consuming as much meat per capita as European countries were in the middle 1960s (Figure 1). China's per capita consumption of mutton and goat now exceeds the European Union while its per capita pork consumption surpassed the United States in 2005 and aggregate pork consumption is now more than double the U.S. (Larsen, 2012; FAO, 2015).

Rapid dietary change in the world's less developed countries has been widely attributed to modernization and economic development thus what is described here as "the livestock transition" shares much in common with transition theory more generally and specifically with transitional models such as the urban transition or the nutritional transition in which development is portrayed using a sigmoid curve describing a process of change that begins gradually, accelerates rapidly and then slows to stationarity. In essence this is a Rostovian developmentalist interpretation that sees rising meat production and consumption as outcomes of rising real incomes and higher levels of urbanization (Rostow, 1960). As Mindi Schneider notes, "By posing broad trends as causal rather than correlative, these powerful concepts serve to essentialize an ever-growing desire for meat on a world scale, normalize the industrial systems that fuel those desires, and can even justify the damages and displacements produced in their wake. An increasingly consolidated group of agribusiness firms controls the majority of industrial meat production and processing in the world, and is pushing for further expansion (Schneider, 2014, 4). On the other hand, Clifton Pannell's urban transition has been a powerful concept in understanding urban trends in China since the Revolution and a prototype for the application of the sigmoid curve in development geography (Pannell, 1995; Pannell, 2002).

Animal Source Food Consumption in China

With its massive human and livestock populations, China has experienced the livestock transition more rapidly and more intensively than any other world region (Rae, 2008). In the post-reform period, per capita pork consumption increased rapidly from 8.9 kilos in 1978 (the start of Deng Xiaoping's Open Door Policy) to 35.6 kilos by 2011 (300%). Chicken consumption increased from 1.6 to 12.1 kilos or 656% over the same period (Rae, 2008, 285; FAO, 2015). Thus meat consumption in China has increased at rates far above any other developing country. Per capita consumption of dairy food is also growing rapidly which is a surprise as lactose intolerance is widespread in East Asia (Xiu and Klein, 2010, 463) and until recently, it was believed that dairy foods would never be widely accepted. Among the most worrisome outcomes of dietary change on

such a scale is the growing problem of obesity observed in China which has become the prototype of the nutritional transition (Bonnefond and Clément, 2014; Du et al., 2014; Popkin, 2014).

The Data

Food consumption data is collected by annual surveys of urban and rural households and published in the China Statistical Yearbook (China, 2015). One of the major shortcomings of this data source is that it does not attempt to estimate food consumption that takes place outside the home, not least because respondents are never sure exactly what or how much of different food types they may be consuming in a variety of different restaurant or institutional settings.

> Away-from-home food consumption, however, is a major phenomenon in China today, especially in urban areas. Non-inclusion of away-from-home consumption by urban dwellers makes the reported quantity purchased a significant underestimate of food consumption for urban consumers. Though away-from-home consumption in rural areas would be significantly lower than in urban areas, it is also increasing fast (Zhou et al., 2014, 6-7).

A further source of bias is the tendency for the floating population to be under-represented in surveys of urban food consumers. Thus meat consumption data are "drastically understated" especially in urban areas where away-from-home beef consumption has been estimated to be as high as 40% of total beef consumption in the case of Beijing (Waldron, 2010, 86).

If meat consumption is underestimated, it has been clear for some time that livestock and meat production are seriously overstated at the local level as a result of the emphasis placed on livestock production in the 1990s and the tendency for over-reporting by rural bureaucrats. Both the cattle population and poultry stocks were revised downward by as much as 25% after the Second National Agricultural Census in 1996 (Fuller et al., 2000; Waldron et al., 2007, 11-27; Waldron, 2010, 86-87) and again in 2007.

Drivers in China's livestock transition

In assessing the causal factors underlying the livestock transition, we shall consider the "drivers" of change in the livestock sector in terms of the market or "demand pull" –the factors that encourage ASF consumption and in terms of supply or "institutional and policy push" – the factors encouraging livestock production (Waldron et al., 2007, 6-7; Bingsheng, 2010, 97). The most commonly observed contrast between the green revolution and the livestock revolution is that the former was supply-driven while the latter is demand-driven (ILRI, 2000, 3; Steinfeld and Gerber, 2010, 18237). The green revolution was the product of agricultural research and technological change which increased yields and total output supplying larger volumes of grain (Yapa, 1979). By contrast, the livestock revolution is commonly understood as the outcome of demand-side changes in the size of the market (population growth); individual and family purchasing power (real income growth); and a consumer meat preference associated with urbanization. As Sumberg and Thompson (2013, 8) observe, "The language of "demand-driven production systems" looms large in the story of the Livestock

Revolution….This distinction between a supply (Green) and a demand (Livestock) driven agricultural revolution has often been repeated and is now inextricably linked to debates and discourse around the Livestock Revolution."

Income as a Driver in Meat Consumption

The most conspicuous factor in China's growing consumption of ASF is the income disparity between rich and poor that accounts for differences in the quantity and quality of food consumed as well as dietary structure: the composition of the diet in terms of different food groups (Zhou et al., 2014, 10). The disparity between urban and rural incomes has been expanding steadily in nominal and real terms since 1978 (Figure 2). Indeed, the striking increase in income inequality since the reforms of 1978 have been attributed to state development policies biased in favor of urban residents over rural residents and that privilege the developed coastal regions over the less developed regions of the western interior (Xie and Zhou, 2014). Income can only be a driver in the growing consumption of ASF if this income disparity is manifested in food consumption.

Engel's Law predicts that as income rises, the proportion of income spent on food will fall, even though the actual expenditure on food may be increasing. Put another way, Engel's Law states that the income elasticity of demand for food ranges between zero and one thus we should expect that Engel's coefficient will gradually decline as real income increases.

$$Engel's\ coefficient = \frac{expenditure\ on\ food\ (yuan)}{total\ living\ consumption\ expenditure}$$

The China Statistical Yearbook (2014) publishes Engel's Coefficients for urban and rural areas in a time series that goes back to 1978 (Figure 3). Taking this data set at face value, it is clear that food expenditures as a percent of total urban household expenditures declined from 58 to 36 per cent from 1978 to 2006 when the downward trend became more or less stationary from 2006 to 2013. In rural households, the decline was steeper and more evenly distributed from 68 per cent in 1978 to 38 per cent in 2013. The black line on Figure 3 traces the diminishing difference between rural and urban areas suggesting a convergence in rural and urban Engel's coefficients over time. Thus the implication of proportionate expenditure data is a diminution in the rural-urban difference in what is arguably the most important measure of well-being and the satisfaction of this most important of all basic human needs.

Over this same period, Rae (2008, 284) has argued that the composition of food expenditures has changed, increasing the share of ASF in total food expenditures in urban and rural households. In both urban and rural households, fish, poultry, beef and milk account for a rising share of household spending on ASF while pork (the traditional meat in Chinese diets), eggs and mutton are declining in proportional terms.

The urban-rural contrast in food consumption has at least three components. First, urban incomes are about three times higher than rural incomes thus urban households spend more on food and more on meat than rural households. Second, urban households

tend to spend very much more on food-away-from-home (FAFH) than do rural households. FAFH expenditure in urban China averages approximately one fifth of total food expenditures at the national scale. For the tenth decile of urban income earners, one-third of food expenditures are classified as FAFH (Zhou et al., 2014, 63-64). The growth in urban FAFH consumption is extraordinary: real urban food expenditure on FAFH trebled from 30.5 billion yuan in 1991 to 98.4 billion yuan in 1999 (Ma et al., 2006, 102) and it then quadrupled from 2000 to 2011 (Zhou et al., 2014, 63). This has several implications. FAFH tends to have a higher ASF content than traditional meals served in the home. And FAFH consumption is not captured by the the standard household survey data sources reported by the Statistical Yearbook. For these reasons there is a growing gap between China's livestock production and meat consumption statistics (Ma et al., 2006, 102).

The third component in the urban-rural contrast in food consumption arises from the fact that urban and rural residents differ not only in their average disposable incomes, and their propensities to consume food outside the home as documented above but also in the types of food market environments in which they make their choices for food consumption inside the home. Urban residents increasingly purchase food through supermarkets and department stores while rural residents are more likely to rely on domestic food sources or small scale wet markets in small towns (Rae, 2008, 284-285), a contrast to which we shall return.

State Policy and Supply Push

Notwithstanding the role of urbanization and rising real incomes of a status-conscious "catalyst class" driving changes in attitudes, behaviors and values (Bonnefond and Clément, 2014, 23), the government has also played a key role in encouraging meat consumption and livestock production in China.

Between China's Ministry of Health that is promoting milk as an essential dietary ingredient, and the Ministry of Agriculture's conviction that food quality standards are best served by large scale processing plants integrated with CAFOs, state policy is an important explanatory factor in the growth of meat and dairy production. The Chinese government has promoted both milk consumption and milk supply. In 2006, for example, the government launched a campaign to promote dairy consumption and improve nutrition: "A glass of milk every day can make people stronger" (Lu, 2009). In 2007, the Chinese government announced a major policy initiative to encourage the growth and development of the Chinese dairy industry that included subsidies for converting to more productive dairy cattle breeds, increasing herd sizes, investing in specialized dairy production equipment, for killing diseased cattle and to insure farm animals and to improve access to credit for dairy farmers (Xiu and Klein, 2010, 467).

Until the 1990s public policy encouraged large state-owned or collective pig farms which were often located in suburban locations of large cities. In the 1990s, for example, the Beijing *shi* subsidized state pig farms by 50 yuan for each animal sold to state processing plants. Improved pig supply stemming from large scale private producers has now obviated the need for such an incentive and nearly all producer subsidies have

been discontinued as part of the reform of state and collectively owned agricultural facilities (Bingsheng, 2010, 102-103, 110).

Supermarket Revolution, Corporate Integration and Supply Push

While policy incentives are the clearest and most obvious cause of the growing production of food animals, the growing corporate integration of the animal production value chain from the supply of imported feed to farmers to the supply of portion-ready cuts of meat to consumer creates a supply chain that enhances the supply of meat to consumers. Outside of China's largest metropolitan centers, livestock logistics tend to be informal and the cold chain for meat can be fragmented and unreliable. Thus, traditional wet markets continue their role as the main distribution channel for fresh meat, often sold the same day it was slaughtered (Waldron et al., 2007, 111-112; Pi et al., 2014, 16). As late as 2008, wet markets were still the dominant source of food purchases by urban residents and much of the meat, fruits and vegetables sold in supermarkets and restaurants were originally purchased from wet markets (Rae, 2008, 285). Wet markets function as wholesalers, as institutional food suppliers and retail suppliers to households.

In urban areas there is an increasing demand for diversity, convenience, safety, healthy and semi-processed and ready-to-eat food products (Rae, 2008, 285). With the arrival of the supermarket revolution in urban China (Mei and Shao, 2011), there is growing integration of the value chain all the way from livestock feed importers to livestock producers and of "cold chains" from livestock processors to meat retailers. This high level of integration means that perishable foods are available at a price and quality that is encouraging consumers to try new types of foods in supermarket formats inspired by foreign food retailers such as Carrefour and Wal-Mart and FAFH franchises such as Kentucky Fried Chicken and a host of other ethnic foods.

Cold chains are coordinated by the "dragon head" agribusiness companies, that integrate along the full "length of the dragon" from agricultural inputs to retail sale (Waldron et al., 2007, 57-58; Pi et al., 2014, 22-23; Schneider and Sharma, 2014, 23-26; Sharma, 2014, 17). The iconic exemplar is Shuanghui, China's largest meat processor, and having acquired Smithfield Foods (America's largest pork producer), the world's biggest pork producer. Notwithstanding Chinese government rhetoric that encourages cooperative and contractual arrangements as a means of integrating small producers with the dragon heads, barriers to entry such as unattainable market standards and the high cost of contractual relationships tend to discriminate against small-scale pig producers (Schneider and Sharma, 2014, 17, 29). The Ministry of Agriculture has recognized select dragon head enterprises for privileged financial treatment, special dispensation from tax on profits, and other corporate supports believing that a strong agribusiness sector is a competitive advantage now that China is a member of the World Trade Organization (Waldron et al., 2007, 57-58). The sheep production sector is vertically integrated in similar ways through contractual relationships that see farm households providing labour while the corporate sector supplies weaned lambs, feed, and other livestock services; and when sheep and lambs are finished and ready for slaughter, carcass processing in corporate abattoirs (Waldron et al., 2007, 95).

China's livestock transition: Growing Livestock Production

The direct outcome of the growing demand for meat and dairy products in China has been rapid growth in livestock production, increasing from 15% of total agricultural output in 1978 to range between 30 and 35% over the past fifteen years (China, 2015, Table 12.3). Figure 4 shows the comparatively rapid growth of pigs, sheep and goats in China relative to the human population and the relative volatility of food animal stocks compared with the human population.

Until 1978, livestock production in China was based on traditional small scale "backyard feeding," raising fewer than five pigs a year, a handful of chickens, or a single dairy cow, typically as way for agricultural workers to raise cash in rural areas (Speedy, 2003, 4049S; Huajiao et al., 2008, 251). Comparatively small numbers of pigs and poultry consumed a varied diet of domestic waste products and crop residues, while on-farm lagoons were commonly used to recycle plant nutrients. Pork and chicken played a peripheral role in the Chinese diet; meat was consumed rarely, typically on festive occasions and pigs were generally worth more alive than dead as a means of domestic waste disposal and a source of fertilizer in support of small scale agriculture (Schneider and Sharma, 2014, 12).

Cattle were used primarily as draft animals for cultivation and harvesting crops with beef as an incidental product when animals could no longer provide motive power. Dairy production was largely a subsistence-based farm activity in the grassland regions of north and northwest China for the purpose of domestic consumption. As late as 2002, a considerable number of "one cow households" raised multi-purpose cattle for draft and transportation with dairy and beef production as subsidiary functions to diversify farm output (Waldron et al., 2007, 90).

Based on data current in 2002, about one-third of the sheep and goats marketed for slaughter originated from households producing one to four sheep or goats per year. Thus small scale producers are responsible for a considerable proportion of sheep and goat production. Small scale livestock production is often a marginal operation. Considering the market price of meat, the bone-in dressing yield of the carcass, and the low selling price and low live weights of livestock in China, much of the margin for smaller operations (slaughter households) depends on carcass by-products such as offal, skins, bones and heads. "[I]f household beef cattle production is an indicator…, meat sheep production may only appear attractive to unspecialized households if inputs such as feed and labour are undervalued or not valued at all" (Waldron et al., 2007, 131).

Dairy Production

Commercialization and growth of the Chinese dairy industry can be traced back to the 1980s in a government policy environment that was favourable to milk producers. Growth of small scale producers was encouraged when large scale dairy processors financed dairy farmers and supplied both dairy cows and technical advice in exchange for the supply of milk (Xiu and Klein, 2010, 464-466). In recent years large scale dairy production and processing operations have been developed and the dairy supply chain has

become much more complex with farmers contracting their cows out to "concentration centers" for milking.

As dairy production has increased it has tended to relocate to suburban zones, close to major markets and the urban-based milk processing industry. It has been estimated that between 40% and 50% of China's dairy production is clustered in urban districts and the suburban counties that surround ***shi*** such as Beijing, the open cities of the East China Sea littoral such as Qingdao, Xiamen, and Ningbo, and most provincial capitals. For example, suburban dairy farms produced 54% of the total quantity of milk consumed in Beijing, Tianjin, and Shanghai in 2000 (Ma et al., 2007, 29-30).

Suburbanization of dairy production is driven by two forces. The demand for dairy products is concentrated primarily in suburban areas where it is supposed that consumers tend to prefer fresh milk over soy-based substitutes. Geographical proximity to large suburban markets has been particularly important because the specialized cold chain for the procurement of raw milk is not yet well developed in China and, generalizing from the case of Beijing, the new generation of dairy processing plants are tending to locate in the more distant suburbs of the metropolitan area. Second, government policy incentives for dairy production (concessional loans for capital investment, feed subsidies, the supply of improved breeds, and technical assistance) have been particularly favourable for large-scale dairy producers which are disproportionately concentrated in suburban areas (Zhou et al., 2002, 8; Ma et al., 2007, 30).

The suburbanization of dairy production is largely in the form of dairy cattle concentration centers have capital-intensive state-of-the-art milking parlors accommodating about 200 cows that help to ensure a continuous, reliable, and high quality supply of raw milk for processing. After cows are "dried off" they are returned to the farmer owner until the next calf is born. Small-scale dairy farmers scattered across the countryside own the cows and manage their reproduction while contracting out to concentration centers for modern animal nutrition, milk production and marketing services (Ma et al., 2007, 31; Xiu and Klein, 2010, 466).

After a widely-reported infant formula adulteration scandal in 2008, Chinese consumers lost confidence in the safety of domestic dairy products, inducing the Chinese government to encourage consolidation of the dairy industry. The result of all this has been to accelerate the shift away from traditional, small-scale dispersed livestock production to large-scale, concentrated and standardized farms (Sharma and Rou, 2014, 14-15).

Confined Agricultural Feeding Operations

The large scale production of monogastrics (pigs and poultry) is well suited to intensive confinement agriculture based on a grain and soybean diet and so these two species are are considered together. Confined agricultural feeding operations (CAFOs) were first introduced to China soon after 1978 and by the 1990s, they accounted for 15% of pigs, 25% of egg production, 40% of broiler chickens and 50% of milk (Huajiao 2008, 250).

By 2010, an estimated 66% of China's pork production was based in CAFOs (Herrero et al., 2013, 20889, supporting information, p. 43).

With the reforms and opening up of the Chinese economy, import tariffs on livestock feed commodities such as soybeans were reduced, making large scale pig and poultry farming feasible. CAFOs now make intensive use of commercial feed sources, far beyond China's capacity to supply (Schneider and Sharma, 2014, 21). Thus, China has become a major importer of soybean cake and fishmeal, largely from South America (Wang et al., 1998, 129). Since a large proportion of the feed supply for such intensive operations is imported from overseas and many CAFOs are essentially "landless" with such high density animal production that they can compete effectively with urban fringe land uses. In such locations, however, the challenge posed by CAFOs is the management of livestock manure in peri-urban areas that in sheer volume exceeds the pollution problem from all other urban and industrial sources (Huajiao et al., 2008, 250).

When an epizootic reproductive and respiratory disease drove domestic pork prices up in 2006, the Chinese government brought in a package of subsidies to encourage large-scale pig farms to address food safety concerns and stabilize food prices (Schneider and Sharma, 2014, 13). This policy appears to have been supported by consumer preferences. "From a Chinese consumer's perspective, the industrial approach seems to represent values such as achievement and evolution, as well as quality and safety, since pig production is moving away from low-cost, low-quality, and low-safety family-scale systems" (de Barcellos et al., 2013, 443).

Thus, primary livestock production in China is an industry in the midst of a restructuring process that is sharply divided by the Aihui-Tengchong Line. Dispersed smallholders and backyard production are still common in the western interior while intensive industrial-scale CAFOs have almost completely replaced traditional livestock raising systems in the eastern coastal regions (Bingsheng, 2010, 96-97). Specialist producers tend to be located on the margins of major metropolitan regions of the southeast close to slaughter and processing facilities (Webber, 2012, 23-36; Schneider and Sharma, 2014, 18-20). The poultry sector has also consolidated. In the twenty years ending in 2005, some seventy million small scale poultry farmers withdrew from the industry and in the fifteen years ending in 2011, the number of broiler farms in China had decreased by 75%.

Urbanization and the Peri-Urban Distribution of Livestock Production

For present purposes we are focusing on the urban impact of the livestock transition. The most highly developed and urbanized region along the coastal margin has a relatively small number of large scale livestock producers that are largely dependent on imported sources of feed. Backyard farms of small holders have all but disappeared as off-farm employment is viewed as more remunerative than small-scale pig raising and with higher living standards, rural residents are less tolerant of the foul odours, flies, and contamination that is almost unavoidable.

While the connection between urbanization and meat consumption has been well documented in the case of China, the literature has paid less attention to the spatial

distribution of growth in livestock production which is increasingly found in the peri-urban zones surrounding fast growing metropolitan centers. However, one study has calculated the average density of humans, different species of livestock and tons of cereal grain production and estimated these densities as a function of travel time for urban centers in selected world regions including including China (Gerber et al., 2010). These findings suggest that the densities of pigs and cattle per square kilometer are essentially independent of travel time to urban centers while the human population density tails off about 90 minutes from urban centers. The peak density of poultry on the the other hand is reached at about 60 minutes from urban centers and decreases quite slowly as far away as ten hours from urban centers. This appears to confirm assertions that the peri-urban distribution of poultry (but not pigs) is growing in parts of the world where livestock handling infrastructure and the cold chain for meat production is not fully developed. What are the implications of these trends? According to Pierre Berber and his team of researchers:

> In essence, livestock is moving from a "default land user' strategy (i.e., as the unique way to harness biomass from marginal lands, residues, and interstitial areas) to an "active land user" strategy–competing with other sectors for the establishment of feed crops, intensive pasture, and production units. (Gerber et al., 2010, 63)

The urban transformation of coastal China is clearly polynuclear, creating a complex urban fringe with a lengthy interface between urban and agricultural land uses. There is enormous potential for residential-agricultural land use conflict in the dynamic rural-urban fringe within and between the administrative boundaries of expanding cities. Expanding cities seem likely to encounter a growing peri-urban zone of large-scale intensive livestock feeding operations that are drawn to fast-growing urban markets. Two widely reported episodes show the importance of the relationship between rural and urban land uses and the impact of domestic animals on the human population.

The most widely reported and influential examples of the environmental impact of the livestock transition was the discovery of thousands of dead pigs in the Huangpu River in March 2013. Reportedly dumped in rural areas of Jiaxing City in Zhejiang Province, press reports indicated that the Huangpu River water was contaminated by *Circovirus*. According to Chinese sources, the dead pigs numbered some 2,800 head (Xinhua, 2013) while The Guardian (2013) reported as many as 6,600 head. The Huangpu River dead pigs incident was followed by further pig dumping incidents in the Yangtze and Yellow Rivers. These are clearly mature animals that have succumbed to disease yet the cause of the mortality has not been officially identified. The presence of thousands of animal carcasses in rivers that are key sources of drinking water for large urban centers is important for three reasons. First, it points to the potential for diseased animal carcasses to pose a serious health threat to a large and densely populated urban region. Second, it contributes to growing public concerns about food safety and food animal health conditions. Third, it shows that urban centered regions are not walled cities, they are open systems very much affected by what happens in rural and peri-urban regions.

China’s first national pollution source census (*Zhongguo Wuranyuan Pucha*) was released in 2010. It made two critical findings that added to concerns that were galvanized by the floating pigs incident. First, agriculture is a greater source of water pollution than any other industry. Second, manure from industrial livestock operations was found to be the most important offender (Schneider, 2014, 14).

The second episode was the 2009 ban on pig farming in Dongguan. This is one example of the policy response to such growing environmental challenges. Supported by authorities in 26 of Dongguan's 32 towns, the ban illustrates first, the presence of intensive agricultural activities within the urban boundary of a metropolitan area of 10 million, and second, the competition for land in peri-urban areas. The ban on pig production and the possibility of a ban on chicken production shows the shifting priority being accorded to other value-added industries and environmental quality. According to a local official, the ban was "an inevitable trend of urbanization and industrial restructuring" while a pig farmer complained that the government had not attempted to reduce the environmental impact of local area pig farms by regulating the industry and so reducing pollution problems (China Daily, 2007).

Conclusions

Based entirely on secondary sources, this paper has outlined the key features of the livestock transition, identifying some of the main drivers in the rising human consumption of animal source foods in both urban and rural areas and pointing to the rapid growth in food animal stocks that are supplying this new source of demand. In a country with a weakly developed refrigerated supply chain and a meat market that is concentrated in the large and fast growing coastal cities and considering the importance of imported feed sources for monogastrics, it is clear that confined animal feeding operations have become a controversial feature of the peri-urban landscape. This poses a regulatory challenge to national and provincial governments and underscores the close links between human health, urban growth and intensive animal agriculture. Land use regulation and the land market will play important roles in shaping the peri-urban landscape as urbanization continues in China.

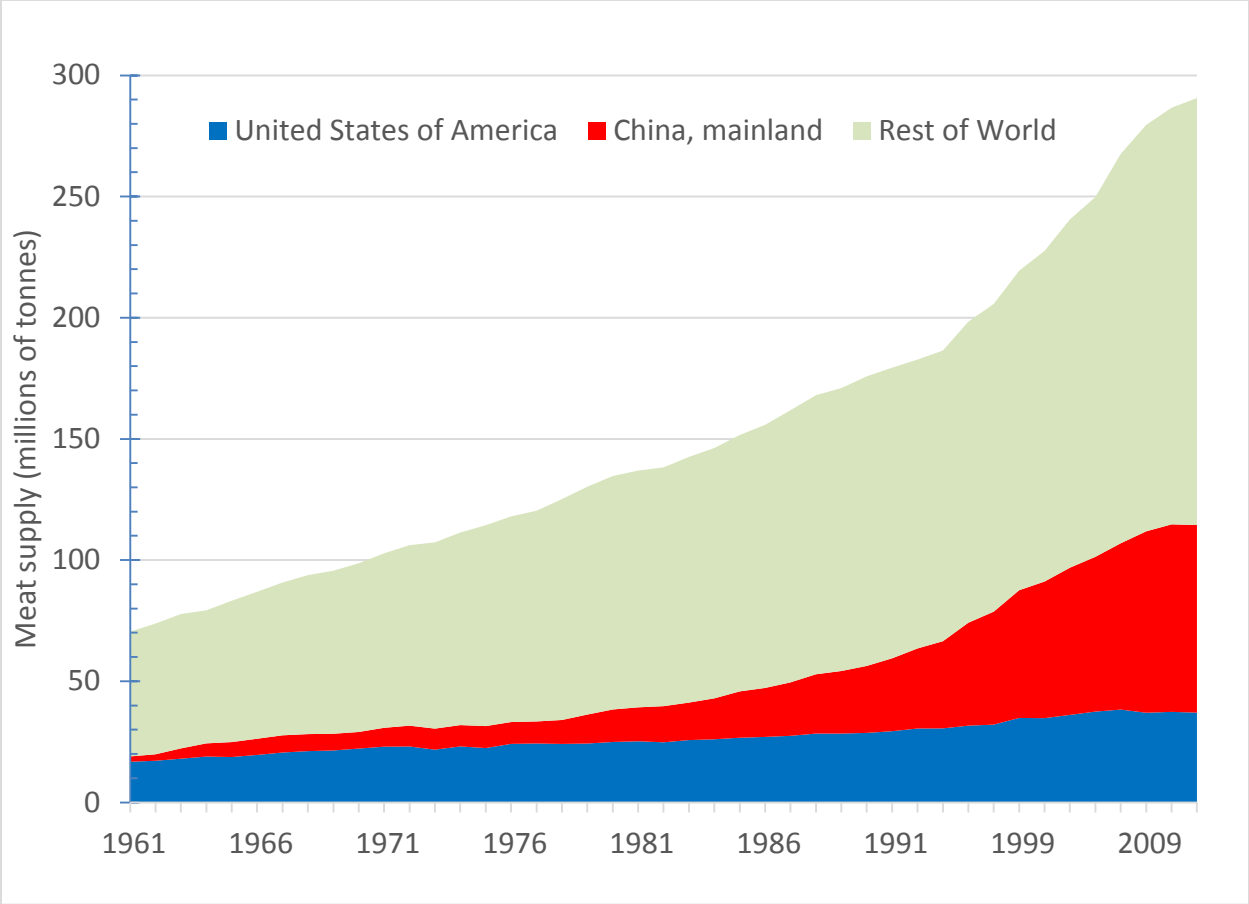

Figure 1: Global meat consumption

Source: Raw data from FAOSTAT-Food Balance

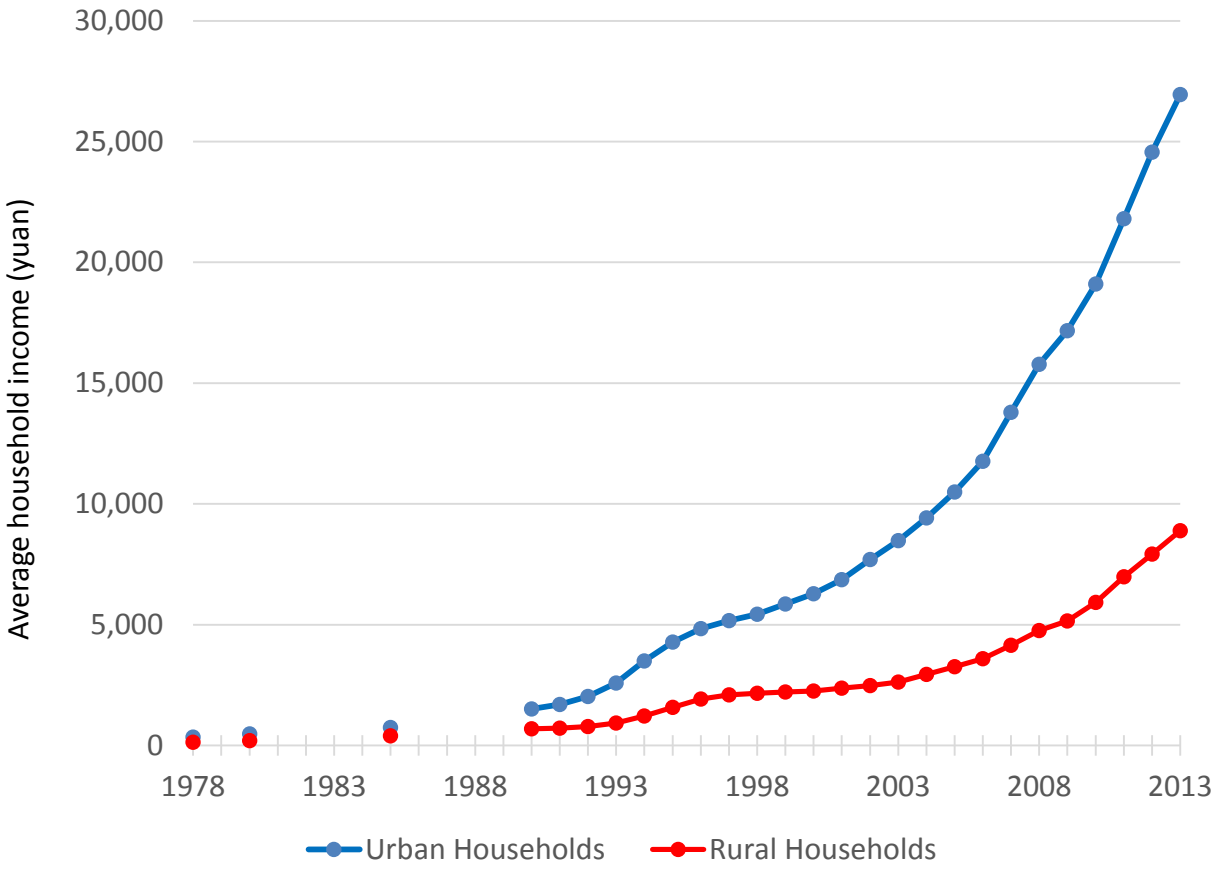

Figure 2: Rural and urban income in China, 1978-2013

Source: China Compendium of Statistics, 1949-2008, National Statistical Yearbook, 2009-2014

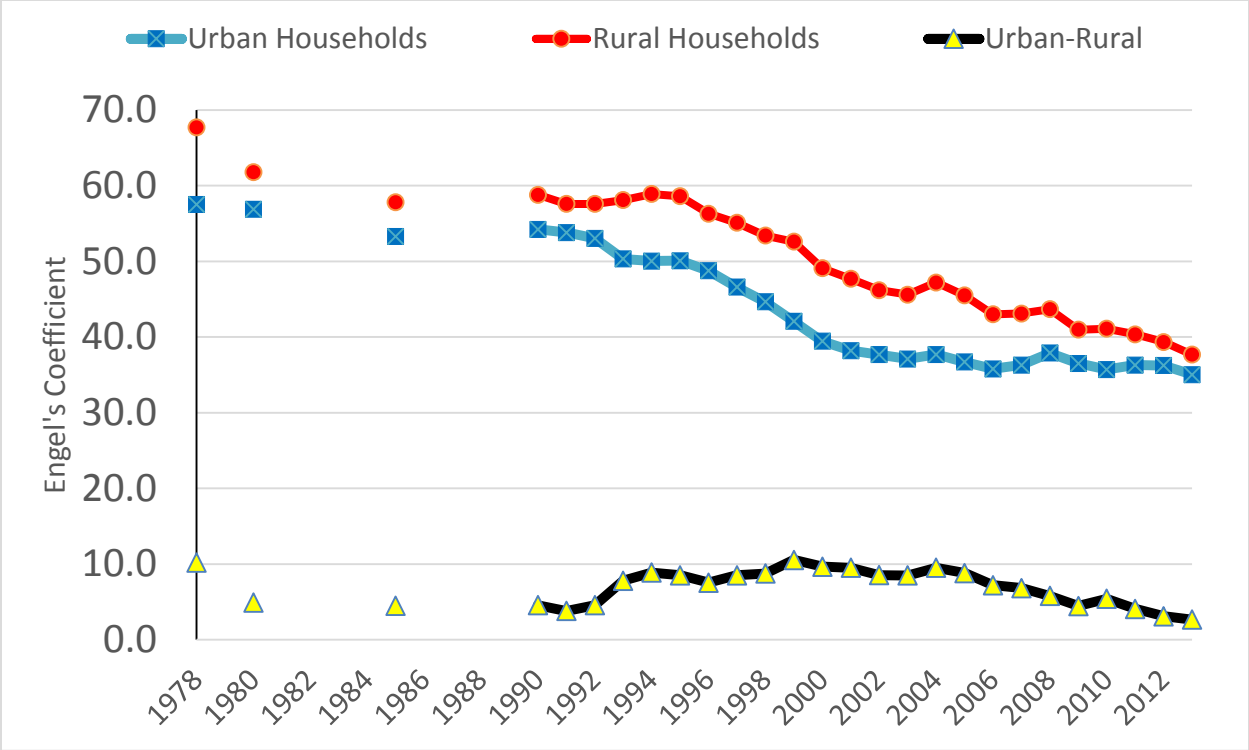

Figure 3: Engel's coefficient for China, rural and urban areas

Source: China Compendium of Statistics, 1949-2008, National Statistical Yearbook, 2009-2014

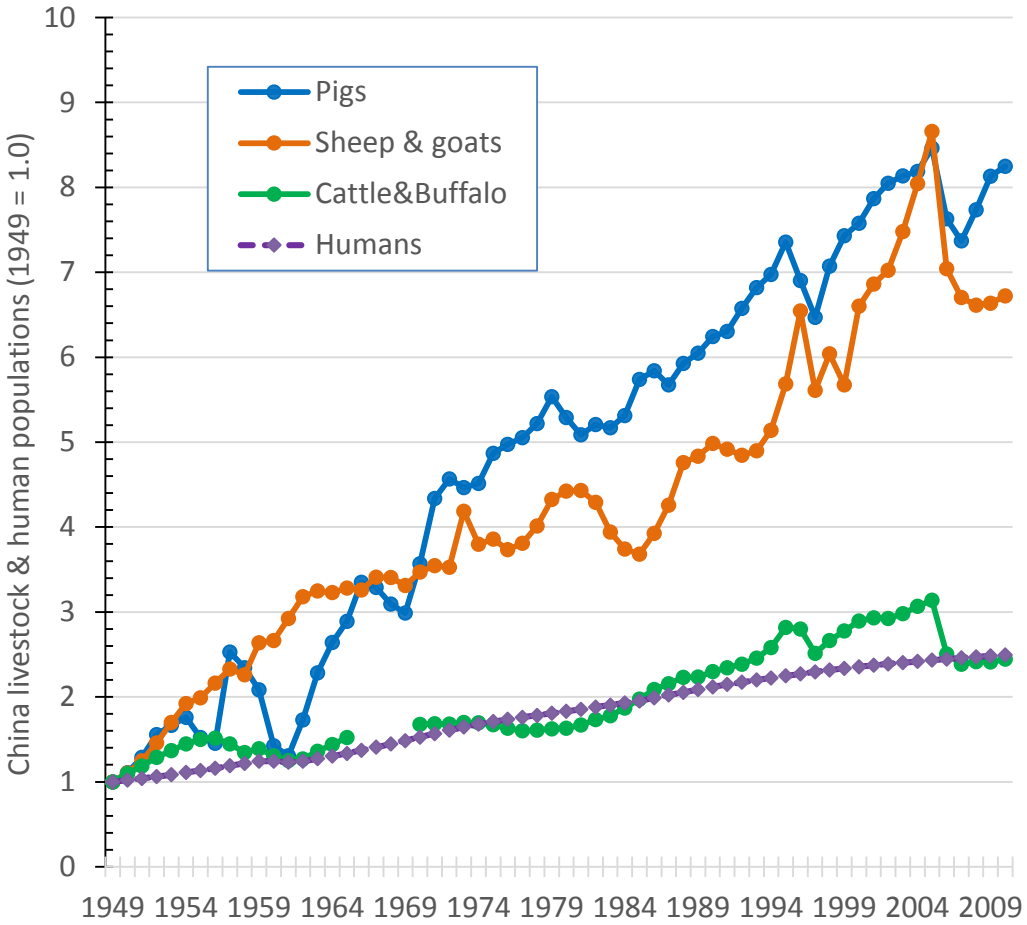

Figure 4: China livestock production by species, 1949-2013
Source: ***International historical statistics*, 1750-2010 edited by Palgrave Macmillan, Ltd**

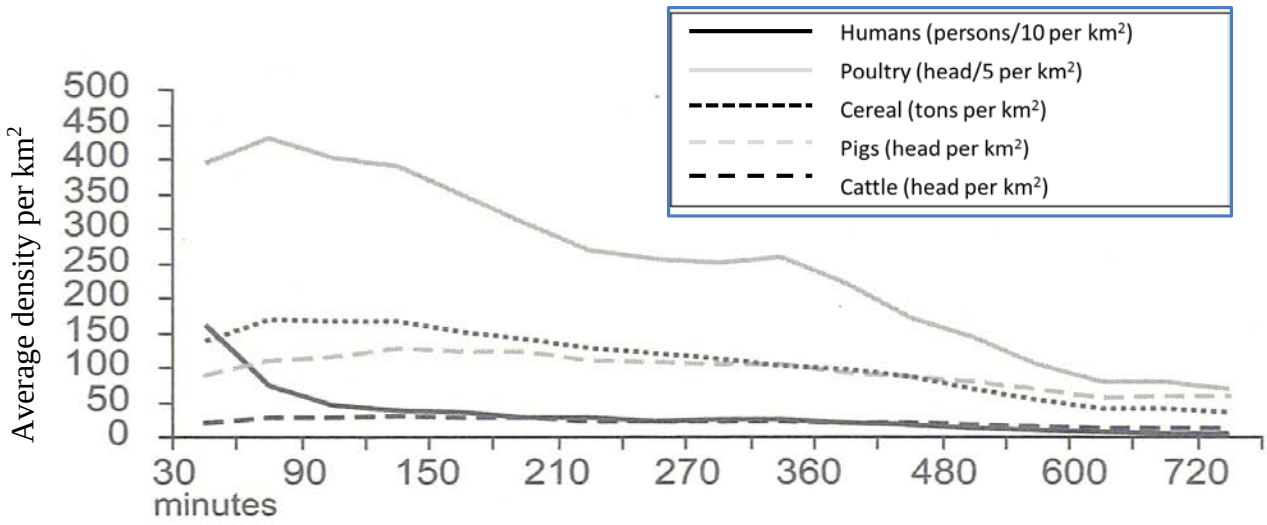

Figure 5: Average livestock density and travel time to selected urban centres

Source: Gerber, Pierre et al. 2010, Livestock in a Changing Landscape, p. 63

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