

Development impacts on beef and mutton production from the pastoral and agro-pastoral systems in China and the economic and cultural factors that influence it

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Abstract

Many factors (some are beyond human control) influence livestock production in the pastoral regions of China. In the study, we analyzed the influence of a rapidly growing economy, the investment policy frameworks in place, and the interplay between ecology, sociology and economy on beef and mutton production in pastoral and agro-pastoral land in China. Production in the more humid crop lands, where feedstuffs are readily available, has shifted the production focus to eastern and southern China. Livestock production in the drier pastoral and agro-pastoral zone has increased too at the expense of accelerated rangeland degradation.

The paper reviews the development of beef and mutton production in pastoral and the agro-pastoral land in China (1980 – 2012). We analyze the impact of economic development, urbanization policy and the rapidly rising demand for red meat created by the emerging middle class, national policy directives, and labor availability, against a backdrop of climate change and rangeland resource degradation. We summarize the challenges faced and prospects for beef and mutton production in pastoral and the agro-pastoral land in China

Key words: *consumer demand, living standards, Green food, GDP, population pressure, red meat urbanization*

Introduction

China has the third largest area of rangeland in the world (Squires et al 2010). The semi-arid lands were the major red-meat production regions, although much of it was local trade and own-consumption. The staple meats of Chinese have traditionally been pork, chicken and sea food. Mutton and beef were less commonly eaten. But there was steady demand for red meat by hotels and restaurants even in the urbanized parts of China and this need was filled by suppliers from the pastoral and agro-pastoral regions. Sales of surplus animals to the meat trade made a great contribution to household (HH) incomes and aided economic development in north and NW China. The meat supply from these sources contributed 30% of red meat production nationwide in the 1999, but this has changed (see below and Higgs 2000)

The position of the pastoral land and agro-pastoral land as a major livestock production base has changed because of the changing agricultural policy, the transition to a market economy and changes in the ecological environment (Akiyama and Kawamura 2007; Givens, 2010; Thornton,

2010). With the rapid economic development in China, since 1980, has come rising living standards of many people who have stimulated demand for red meat. Production in the more humid crop lands, where feedstuffs are readily available, has shifted the production focus to eastern and southern China. Livestock production in the drier pastoral and agro-pastoral zone has increased too at the expense of accelerated rangeland degradation (Brown et al 2008). Recognizing the problem, governments at all levels, have issued a series of policies to limit the livestock number on the rangeland and promote conservation of the environment. At the same time government policy is encouraging farmers or herders toward more intensive animal husbandry that involves sedentarization of pastoral peoples and the encouragement of surplus labor to seek employment elsewhere.

There is a major national campaign toward urbanization as set out in 12th Five-year plan and by 2020 over 80 million will transfer to urban areas across China. As a result, the scale and the system of livestock production by a myriad of small holders are at a crossroads in the pastoral systems and the agro-pastoral systems at a time when economic, social, cultural and environmental changes are occurring at an increasing pace. China is in a transition and the philosophy espoused by the Chinese leadership in the 1980's of 'letting the east coast peoples get rich first' is now a reality. China has a two-speed economy with a widening income gap between the urbanized easterners and the rural westerners. The Central government's "Western Region Development plan" has focused mainly on major infrastructure projects with less attention to rural matters. But that is changing and the improved rail and road networks are opening up the west to promote transport of goods into and out of this vast region. It is now feasible for livestock buyers from east coast cities like Shanghai to source their supply of beef or mutton from as far away as eastern Xinjiang and the Hexi corridor in Gansu (more than 3000 km away) and send it by rail to supermarkets, hotels and restaurants in the Yangtze delta cities.

So the question arises as to 'how to adjust the livestock production pattern and structure for the new market economy and environmental protection measures that are gaining traction in the pastoral land and the agro-pastoral land? It is a crucial question for the long term planning in these lands in which there are few alternative land uses and many households (HH) whose incomes are hovering around the poverty line.

The paper reviews the development of beef and mutton production in pastoral and the agro-pastoral systems in China from 1980 to 2012. We analyze the impact of economic development, urbanization policy and the rapidly rising demand for red meat created by the emerging middle class, national policy directives and labor availability, the price and turn-off rates of livestock, household per capita income, against a backdrop of climate change and rangeland resource degradation in pastoral and agro-pastoral systems. We summarize the challenges faced and future prospects for beef and mutton production in pastoral land and the agro-pastoral systems in China.

Data sources and analysis approach adopted

General

Many factors (some are matters beyond human control) influence livestock production in the pastoral regions of China. In the study, we analyzed the influence of a rapidly growing economy, the investment policy frameworks, interplay between ecology, sociology and economy on beef and mutton production in pastoral and agro-pastoral systems in China. To characterize the rate of economic development in China as a whole and in selected local government areas we analyzed the relationship between GDP per capita and demand for beef and mutton. For investment policy we focused on direct investment to support livestock production and improve rangeland environment.

The proportion of workforce (labor) involved on the pastoral land and the agro-pastoral land was used to analyze the impact. The price and turn-off rates of livestock, household per capita income (and the proportion derived from animal husbandry) were analyzed. For the ecological and climate impact, we used the data of rangeland condition as assessed by the Grassland Monitoring Work Stations. Rainfall and temperature (K index), were used to analyze the relationship to changes in livestock inventories of sheep and beef cattle and the turn-off of beef and mutton from specific counties or regions.

For the study area, we selected different regional scales to demonstrate different trends. We studied the influence of economic trends, including GDP per capita and market demands at national level to give a baseline against which the more detailed regional studies within the pastoral and agro-pastoral areas can be compared. The impact of investment by governments on national project investment aimed at promoting beef and mutton production as was the limitation posed by capacity of the available labor force, including not only producers (herders and farmers) but also the supervisory staff at Township, County and Prefecture level. For the ecological and climate influence, we selected four counties Fu Yun, Ma Qu, Qi Lian and Xi Wuzhumuqin, located in four representative provinces, Xinjiang, Gansu, Qinghai and Inner Mongolia to analyze the influence of changes in grassland condition and climate on livestock production (Figure 1).

Figure 1. The locations of four typical counties within the pastoral zone of China

Data collection

The data of sheep (goats) and bovines inventories and number of household are from National Bureau of Statistics of China <http://www.stats.gov.cn/> and China Animal Industry Yearbook (1980-2012). Beijing: China Agriculture Press; GDP per capita, and Beef, mutton per capita in China, U.S.A, Australia and Brazil are from FAO <http://www.fao.org/home/en/> and China's economic and social development statistics database <http://tongji.cnki.net/kns55/index.aspx>; The data for animal husbandry rangeland investments funded by national finance in China (2001-2010) are from <http://www.digitalgrass.cn/> The data for income per capita from whole and livestock husbandry and population from pastoral and agro-pastoral are from China Animal Industry Yearbook (1980-2012). Beijing: China Agriculture Press; the data of beef and mutton price are from China Agriculture Information Network <http://nongye.sina.com.cn/>; The data on livestock numbers of sheep, cattle and yak in four counties, (Fu Yun, Ma Qu, Qi Lian and Xi Wuzhumuqing) are from the local County Animal Husbandry Bureau (AHB);. The data of annual temperature, annual rainfall are from China Meteorological Sharing Service System (<http://www.cma.gov.cn/2011qxfw/2011qsjgx/>).

In this paper, we use sheep unit (one cattle is equal to four sheep) as the basis for comparing mixed species herds/flocks.

Study area

Overview of pastoral land and agro-pastoral land

In China, there are 108 pastoral counties located in arid, semi-arid and alpine (cold arid) regions. Animal husbandry is a pillar industry and the rangeland occupies over half of the land area in the pastoral counties (1.72×10^8 Ha), which accounts for 70 % of total rangeland area in China. The number of bovines and sheep were 1.44×10^7 and 1.5×10^7 respectively. Note that at the national level, bovines include cattle, yaks and buffalo but at county level they are differentiated. Sheep and goats are combined for the purpose of reporting production and trade in mutton. The turn-

off rates of bovine (including yaks) and sheep were 29% and 62% respectively in 2011. Apart from the pastoral counties, there are 160 agro-pastoral counties that are located in the transition zone between crop production areas and the grazing areas in northern China. The rangeland area in the agro-pastoral counties is $0.71\tilde{A}\text{---}10^8$ Ha, which accounts for 30% of total rangeland area in China. In 2011, the number of bovine and sheep was $1.5\tilde{A}\text{---}10^7$ and $3.8\tilde{A}\text{---}10^7$ respectively, the turn-offs of bovine and sheep were 51% and 90% respectively. The pastoral and agro-pastoral counties are a major livestock production base for grass-fed livestock in the whole country.

Features of four representative counties

Figure 1 shows the location of the four selected counties.

Fu Yun County (lat. $45\tilde{A}^{\circ}00'\sim 48\tilde{A}^{\circ}03'$, Long. $88\tilde{A}^{\circ}10'\sim 90\tilde{A}^{\circ}31'$, alt. 430-3863m a.s.l.) with $2.37\tilde{A}\text{---}10^6$ Ha of rangeland is located in northern Xinjiang, the county has a temperate continental climate. Desert steppe is the dominant rangeland type. The number of cattle and sheep stock was $2.8\tilde{A}\text{---}10^5$ and $4.9\tilde{A}\text{---}10^5$ in 2012 (Statistical Bureau of Fu Yun County).

Qi Lian County (Lat. $37\tilde{A}^{\circ}25'\sim 39\tilde{A}^{\circ}05'$, Long. $98\tilde{A}^{\circ}05'\sim 101\tilde{A}^{\circ}02'$, alt. 3500m a.s.l.) with a typical alpine climate is located in north-western QingHai Province. The rangeland area is $1.12\tilde{A}\text{---}10^6$ Ha. Yak and Tibet sheep are the dominant livestock on the alpine rangeland. The numbers of yak and sheep were $1.65\tilde{A}\text{---}10^5$ and $1\tilde{A}\text{---}10^6$ stock respectively in 2012 (Statistical Bureau of Qi Lian County).

Ma Qu County (Lat. $33\tilde{A}^{\circ}06'\sim 34\tilde{A}^{\circ}30'$, Long. $100\tilde{A}^{\circ}45'\sim 102\tilde{A}^{\circ}29'$ alt. 3300-4806m asl) with a high-cold climate is located in eastern Tibet Plateau and has $8.9\tilde{A}\text{---}10^5$ ha of alpine meadow. The numbers of yak and sheep were $2.12\tilde{A}\text{---}10^6$ and $5.1\tilde{A}\text{---}10^5$ in 2012 (Statistical Bureau of Ma Qu County).

Xi Wuzhumuqin Banner (Lat. $43\tilde{A}^{\circ}57'\sim 45\tilde{A}^{\circ}23'$, Long. $116\tilde{A}^{\circ}12'\sim 119\tilde{A}^{\circ}31'$ alt. 835-1957m asl) is located in eastern Inner Mongolia, with a temperate continental sub-humid and semi-arid climate, the rangeland area is $2.2\tilde{A}\text{---}10^6$ ha, Steppe is the dominant vegetation type. In 2012, cattle and sheep numbers were $3.68\tilde{A}\text{---}10^5$ and $8\tilde{A}\text{---}10^5$ respectively (Statistical Bureau of Xi wuzhumuqin County).

Results

Impact of the development process and cultural change

Spatial and temporal distribution of beef and mutton production in China from 1980 to 2012 had many changes because of the economy and policy development. The status of bovine and sheep production in modern China can be categorized as falling into one of three phases.

Phase 1 (prior to 1980). The inventories of bovines and sheep remained stable and this continued into the early years following the reform and opening policy that came into effect in the 1980s.

Phase 2 (1988-2007). With the extension of Householders Contract Responsibility System (HCRS) policy nationwide and the rapid development of economy (Hua and Squires, 2015) the farmers and herders raised more livestock to meet the rising demand for red meat brought on by rising living standards.

Phase 3 (2007-2012). The number of bovine decreased and sheep increased because of the policy of national grazing ban and rising cost of fodder (Ma, 2012; Yang et al, 2013). In 2012, the total

number of beef and sheep was 1.03×10^8 and 2.85×10^8 in China (Figure 2). The proportion of bovines and sheep also changed over time. The ratio of bovine/sheep was 1:2, 2:5 and 2:5 in the period of 1980-1988, 1988-2007, and 2007-2012 (Figure 3).

Figure 2. The number of bovines (including yaks and buffalo) and sheep (and goats) national wide from 1980 to 2012

Figure 3. The change of ratio of bovine/sheep from 1980 to 2012

The inventory of sheep nationwide decreased from 1999 to 2012 but sheep numbers in pastoral and agro-pastoral regions increased during the same period. In contrast, the inventory of sheep decreased in the agricultural (cropping zone) region. Overall, the inventory and turn-off of sheep from the agricultural region was higher than that in pastoral and agro-pastoral region (Figure 4 and Figure 5). From 2008, the turn-off of sheep in agricultural region has decreased and was close to the number in pastoral and agro-pastoral region.

Figure 4. The inventory of sheep in pastoral region, agro-pastoral region and agricultural region across China from 1999 to 2012

Figure 5. The turn-off rates sheep in pastoral region, agro-pastoral region and agricultural region across China from 1999 to 2012

The inventory of bovines in the agricultural region decreased between 1999 and 2012 and it was higher than that in pastoral and agro-pastoral region. There were fewer bovines in the agro-pastoral region but the turn-off was greater than that in the pastoral regions (Figures 6,7)

Figure 6. The inventory of bovines in pastoral region, agro-pastoral region and agricultural region across China from 1999 to 2012

Figure 7. The turn-off rates of bovine in pastoral region, agro-pastoral region and agricultural region across China from 1999 to 2012

The supply of marketable red meat from the pastoral and agro-pastoral regions has increased. Before 1980, the beef and mutton for market and for 'own-use' were mainly produced in the pastoral regions but since 1990s beef and mutton on the market came mainly from the agro-pastoral land as farmers there responded to increased demand for beef. In the agro-pastoral zone arable land was available to grow fodder crops to fatten animals prior to sale. No such opportunity presented itself to herders in the pastoral zone and they were often forced to carry over young stock beyond three years before they reached a marketable weight (Figure 7).

Figure 8. The supply of marketable mutton from various regions in China

Factors Impacting beef and mutton production in China

China has the most rapid rate of economic development in the world. The rapid economic development has brought the huge changes to people's lives, to the environment as well as to society structure as more and more people live in urban centers. There has been a major cultural change in just a decade or so. Development has not been even across China and disposable incomes are still low in many parts away from the east coast as indicated by the differences in minimum monthly wages across China.

In the pastoral land, the inventory of sheep decreased as the GDP per capita increased, but the reverse was true for cattle numbers (Figure 9). Urban dwellers showed a clear preference for beef, fueled by the growth in popularity of hamburgers and other beef-based fast foods. More and more beef and mutton have been produced in the agro-pastoral land for the reasons outlined above (Figure 10).

Figure 9. The relationship between GDP per capita and beef/sheep in pastoral land

Figure 10. The relationship between GDP per capita and cattle/sheep in agro-pastoral land

Changes in GDP per capita are rapid. We sought to compare the rate of beef and mutton consumption over time in China with the situation in other countries. We selected Australia and USA to be representative of developed countries, and China and Brazil as representative of the developing countries with a view to analyzing the relationship between GDP per capita and beef and mutton production from 1980 to 2012. The improvements of living standard in China stimulated demand for beef and mutton, as indeed it did in both Australia and USA (for example) during their earlier development phase which started earlier and took longer to achieve.

Population is another factor that influences red meat production and demand. The pressure of huge population and the rising demand for grass-fed beef and mutton will impact rangeland and lead to accelerated rangeland degradation as herders try to capitalize on higher demand and better prices. In China, there are significant correlations between beef and mutton and the population increase during 10 years ending 2012 (Figure 11).

Figure 11. The relationship between population and cattle/sheep in China

National financial support to beef and mutton production in pastoral and agro-pastoral lands is a complicating factor. Within the context of economic development in China, the government at various level (national provincial, local) provided funds to foster livestock production. Since 2001, the National government invested huge sums to rangeland management and livestock production in the pastoral and agro-pastoral areas through such projects as 'Return Grazing land to Grassland land, 'Grain for Green, Grassland Ecological Subsidies Program, Nomadic Population Settlement Program, etc. The total investment was about 2 billion dollars from 2000 to 2012, the average annual growth rate in expenditure was 11%. The number of sheep and beef across the whole country increased (with fluctuation) from 2001 to 2008, but in the period 2008 to 2010 livestock numbers decreased, because of the implementation of ecological protection programs, which focused on environmental recovery and reduction of the livestock numbers on the rangelands nationwide. Sheep numbers decreased by 14% and cattle numbers by 24% over that period (Figure 12) in the pastoral land where millions of Ha were fenced and subject to grazing bans (Huang and Wang, 2004; Brown et al 2008). Impact on

livestock inventories in the agro-pastoral region (Figure 13) was less severe because it was not the prime target for fencing and grazing bans.

Figure 12. the relationship between national project funds and cattle/sheep in pastoral land

Figure 13. the relationship between national project funds (Constant \$ values) and cattle/sheep in agro-pastoral land

From 1999 to 2011, the number of people in the pastoral regions showed a slight decline, but the number of sheep and bovines increased. There was a negative correlation between average per capita income and per capita income from animal husbandry and population ($R^2 = -0.319$ and $R^2 = -0.128$) (Figure 14). But in the agro-pastoral region, both the number of cattle and sheep and the number of population increased, especially, the relation between population and average per capita income was significant ($R^2 = 0.661^{**}$) as shown in Figure 15. The decline in the number of HH in pastoral areas outward migration so fewer HH are tending more livestock. The increase in number of HH in agro-pastoral areas may be due to the fact that as children grow up they establish new HH (and new herds) within the village.

Figure 14. Relationship between average per capita income (and from animal husbandry) and population in pastoral region

Figure 15. Relationship between average per capita income (and from animal husbandry) and population in agro-pastoral region

The turn-off rates of sheep and cattle in the agro-pastoral region were higher than that in the pastoral land. The relationship between turn-off rates of sheep and average per capita income from animal husbandry were higher than cattle in pastoral land ($R^2 = 0.391$) However, the relationship between turn-off rates of cattle and average per capita income from animal husbandry were significant in agro-pastoral land ($R^2 = 0.840^{**}$) as shown in Figure 16.

Figure 16. The turn-off rates and the average per capital income from livestock in the agro-pastoral land

The market demand is for younger animals that were fattened quickly. This was possible in the agro-pastoral areas where forage/fodder crops could be grown and warm pens provided to feed the stock on conserved feedstuffs including silage, hay and crop residues. It also means that more breeding females could be maintained. Better nutrition of the breeding female led to higher birth weights and assured survival of neonates that could grow to slaughter weight within the shortest time (one year for sheep and two years for cattle).

In the pastoral areas there is a crisis each winter and many livestock lose 30% of their bodyweight between November and March each year (Squires et al 2010). It also means that younger animals do not reach slaughter weight until at least three years of age. Herders traditionally kept fewer breeding females and had more castrated male animals to ensure survival of the herd over a harsh winter.

The market price is a very important factor influencing livestock production. The impact of market price of beef and mutton production were different, but the market price of beef had the greatest influence and HH increased cattle inventories in response. The correlation coefficients were 0.729 and 0.725 in pastoral land and agro-pastoral land (Figure 17), respectively. Changes to the market price of mutton had little impact on sheep production in pastoral land. Even in the agro-pastoral land, the impact was also slight.

Figure 17. The number of cattle in pastoral and agro-pastoral region from 1999 to 2012 and the relationship between market price and beef cattle inventories

Case study: Relationship between climate change and livestock production in four counties in NW China.

We analyzed the situation in four counties in different parts of China (see Figure 1). The chosen counties were representative of conditions beyond their immediate boundaries.

Changes in climate and livestock inventories

In *FuYun County*, at an altitude of 430-3863 m asl, the temperate desert steppe is the dominant vegetation type. Forage yield has decreased since 1980, with a more rapid decline since 2000. The numbers of cattle and sheep increased with an annual growth rate of 2% and 1% from 1980 to 2012. The climate is changing to “warmer and wetter” (Figure 18), which is good for improving forage production, and this benefits beef production. For sheep production, the number of sheep has decreased since 2008 ($R^2 = -0.009$, $R^2 = 0.016$ for cattle) (Pu et al 2010).

In *Qilian County*, at an above average altitude of 3500m asl there are alpine steppes. The ruminant livestock numbers have increased since 1980 despite the reduction in rangeland productivity. By 2012, the number of bovines and sheep increased with an annual growth rate of 0.5 % and 1% respectively. The climate is changing to “warm and dry”, which is not good for yaks that thrive under cool conditions. The Tibet sheep has strong adaptive capacity for dry and warm weather. As a result, the number of sheep increased at a faster rate than yak ($R^2 = -0.371$, $R^2 = -0.325$) (Ma 2005).

In *Ma Qu County*, at an altitude of 3300-4806 m asl which has a vast alpine meadow that has degraded from 1980s to 2006 (Qi, Li and Chen, 2006; Squires et al 2009). After 2006, the quality of rangeland is recovering because of many rangeland ecological programs. From 1980 to 2012, the number of sheep and cattle increased with an annual growth rate of 1% and 3% respectively. Meanwhile, the climate is changing from “cool and wet” to “warmer and dryer” (Han and Zhu, 2007). The yak number increased a little higher than sheep ($R^2 = -0.272$, $R^2 = -0.147$) (Chai, et al 2012; Qi et al 2006).

There is temperate steppe in *Xiwuzhumuqing Banner* at an altitude of 835-1957m asl. The situation of rangeland is similar to that in Maqu. The rangeland condition was better after 2005. The number of bovines and sheep increased with an annual growth rate of 0% and 1% respectively from 1980 to 2012. However, the sheep and bovines number has decreased after 1990s. The climate is changing to warmer and dryer, that has an impact on grass growth, livestock production as well as reducing snow disaster. The cattle numbers significantly decreased under the influence of warmer and dryer weather ($R^2 = 0.438$ *) However, the sheep population has remained steady (Liu et al 2010) (Figure 18).

Figure 18. The change of cattle numbers in four counties

Figure 19. The change of sheep numbers in four counties

Figure 20. There are trends in the climate in four counties especially FuYun as indicated by the ratio $P/(T \text{ above } 0^\circ)$.

Biomass change over time in the pastoral land

The rangeland quality can also influence the livestock production. Figure 21 shows that the various rangelands, involving alpine meadow (AM), temperature steppe (TD) and temperature desert (TS) have changed from 1980 to 2010. In general, the biomass of alpine meadow was increasing but the proportion of usable biomass may be declining as toxic and/or unpalatable plants come to dominate and the biomass of temperate steppe and temperate desert was decreasing.

Figure 21. Changes of rangeland productivity in pastoral land. Apart from alpine meadow, the trend in forage biomass is downwards

Discussion

With the development of society, economy and environment in the pastoral zone in China, the function of rangeland has also changed from a production-base for grass-fed livestock to support millions of subsistence households to the present where environmental conservation has become the government's focus. Rangeland degradation in pastoral region and agro-pastoral region is very serious (Squires et al 2009a; 2010b). According to the official figures from the Ministry of Agriculture the overstocking rate in these regions are 34.5% and 36.2 % respectively but on many sites overstocking is more serious (Squires et al 2009a; 2010b).

The changes in both supply and particularly demand for red meat (see above), has led to the need to re-structure livestock production systems. In China, the main source of beef and mutton is not in the pastoral regions despite their vast area as livestock inventories there continue to decline to a level that provides subsistence to pastoral HH and some saleable surplus to meet growing demands for goods and services for which cash payment is required (Brown et al 2008). According to Brown, Waldron and Longworth (2008) only 13% of the beef and 34% of the mutton in the Chinese market is from the 6 provinces that make up the pastoral zone. Most red meat is sold in the low value, mass market for undifferentiated beef (up to 85% of the market) and < 2% to the premium 5-star hotel and restaurant trade. Prices received by pastoral zone producers are determined primarily outside the region.

In 2012, the total beef and mutton production in the more humid agricultural and agro-pastoral regions was 2.82×10^6 ton, which accounted for 27 % of total beef and mutton production nationwide. The shortfall is made up by imports of frozen red meat from Australia, South America etc. The situation of high overstocking rates and low beef and mutton turn-off in pastoral regions should receive more attention from policy makers. There is a need to improve HH livelihoods to bridge the growing gap between rich and poor and the disparity between urban and rural areas of China. Millions of people in the drier, more remote regions in western China are on or about the poverty line. The Poverty Alleviation Bureau works closely with the Ministry of Agriculture to implement the National programs and provide support to farmers and herders whose livelihoods suffer in the interests of the environmental rehabilitation projects that are being implemented.

National programs (mentioned above) provide cash subsidies to farmers and herders who forego cropping or grazing for periods of time – thus allowing natural regeneration to occur but more needs to be done to facilitate the production of grass-fed “green” food products that can be produced without chemicals and which will meet the approval of a more discerning buying public. A premium price should be paid to producers of organically-grown red meat from the pastoral and agro-pastoral regions. Government has a role in promoting such an approach and ensuring that producers receive the price differential and that this does only accrue to the re-sellers. Re-structuring of the livestock industries to cater for the growing demand for ‘green food’ such as organically produced red meat while focusing on the ecological function of rangeland is the way of the future as China moves rapidly to a highly urbanized society by 2030. The Green Foods Office within the Ministry of Agriculture estimates that, on average, Green Food attracts a price premium of 15%, but this, at best, a rough indicator. In other countries the premium can be higher (Kumm 2002; Hermansen 2003). Many supermarkets now have special Green Food counters or areas where discerning buyers can get quality-assured products. The higher income consumers have the primary concerns about food safety and the money to pay for safe food. Around 17% of Green Food products are related to livestock and of these some come from pastoral areas where Green Food certification is easier to manage. Certification of livestock and their products is more difficult in agricultural areas because of the existing high levels of contamination with chemicals, the multiple stages involved, the greater number of specialized HH involved in fattening and the difficulties associated with livestock slaughtering and processing plants that must be located well away from the production areas. The Chinese government could adopt various measures to meet the demand for ruminant livestock products. The first of these is through a generic advertising and promotion campaign to encourage people to eat more red meat. A second way is to ensure quality and food safety. Food safety concerns revolve around hygienic production (not always assured in small HH scale feedlots), and processing practices. These concerns need to be more seriously addressed if a premium market is to become a reality on a large scale. The Ministry of Agriculture has a purpose-built Food Safety and Quality Center that is charged with managing and coordinating the plethora of industry and company standards that exist for meat products. There is still a long way to go to overcome the lack of coordination, sophistication and adoption of industry-wide standards. Fortunately the grass-fed livestock suffer from a shorter list of safety concerns and this comparative advantage should be actively promoted (Verbeke and Viaene 2000).

Although the consumption per capita of beef and mutton in China is on the increase and is likely to rise higher, there is a big gap between China's consumption and that of other developed countries, such as US and Australia. According to the experience of animal husbandry development in developed countries, the rangeland-livestock production system based on grass-fed animals can optimize utilization of otherwise wasted forage resources and ensure nutrient and energy cycling (Kumm 2002). This means the livestock production system can promote the people's welfare and benefit society. Therefore, it is the important problem for China is how to balance livestock production and grassland environment (Yu et al 2004).

The impact of China's economic development on livestock production has been profound. Infrastructure such as high speed rail and high grade highways, rural electrification, almost universal coverage for mobile phone reception has made it possible to gain better access to markets and to market intelligence (prices, interest rate changes). Development of rural credit, improved educational opportunities and social services has transformed rural communities. Sedentarization of some formerly semi-nomadic groups has been controversial but has brought the full suite of health, education and social services within the reach of many. As the traditional users of the pastoral lands (usually ethnic minorities) become too old to work they must leave the running of their livestock enterprise to a younger better-educated generation. This is at a time of rapid change, as China

transitions to market economy, and the land users face many challenges to improve livelihoods, conserve biodiversity and ensure land protection. Outward migration is occurring at a rapid rate from some pastoral areas and this accounts for the reduction in the number of HH referred to above (Ma 2012). In one sense this is good as the human pressure on the land (fewer mouths to feed from the degraded landscape) is reduced but it is the better educated, more entrepreneurial ones who are migrating to the cities.

In our study, the rapid economic development stimulated the domestic demand of beef and mutton. However, the huge demand of beef and mutton in China is also pressure to environment, in particular rangeland and other pastureland. According to the pattern in the EU, US and Australia red meat consumption will decline when the GDP per capita reaches 2.83×10^4 \$. In 2012, the GDP per capita in China was 0.62×10^4 \$, which is much lower than the 5×10^4 \$ in US. Therefore, the demand for beef and mutton, especially beef, will persist for a long time. Most of this demand will be met by imports. Faced with the huge demand of beef and mutton in China, the supply of beef produced nationwide doesn't meet the people's demand. In addition, the cost of fodders and improved management, and low price of imported beef also present challenges for the beef production in China. As a result, the imported beef, in particular high quality beef, occupied the domestic market (Xia et al 2009; Cao 2010). Moreover, the poor quality of the beef produced in China limits the competitiveness in the international market (Li 2009).

Climate factors (and augmentation of CO₂ and other GHGs) interact with land-type attributes to affect forage (including shrub) production and type and severity of invasive plant competition. Similarly, land-type and climate factors affect many components of the grazing system, potential forage utilization, animal production per head (live weight gain and wool cut), choice of breed, enterprise type, animal husbandry and supplementation requirements, calendar of operations, and the impact of grazing on resource components such as cover, soil erosion, fire frequency and pasture species composition. More and more scientists realized the negative role of livestock production in relation production of CO₂ and CH₄ (http://www.bsas.org.uk/animal_briefs/methane-from-ruminant-livestock). Livestock farming is responsible for 8-18% of the world's greenhouse gas emissions. Methane produced by ruminants (animals with a four-part stomach, including cattle and sheep) is a major contributor to the problem. It is a well-known fact that poor quality forage/fodder generates more of these gases per Kg feed consumed than from good quality, nutritious feed sources. Production of beef and mutton in the pastoral and agro-pastoral areas in China is from small-holders, operated as family enterprises and are very diverse (Li 2008; Hua & Squires 2015). Small farms that combine various crops and animals remain the backbone of agriculture and animal husbandry and will sustain the livelihoods of millions of households in China within the foreseeable future. The natural resource base, with its reservoir of plants and animal populations, will be expected to provide the bulk of the food required to support the increasing human population. Small holders have contributed to this need in the past and will do so in the future. But as long as small holders are not an organized and active interest group, livestock and related sector policies will be driven by actors who may have interests that conflict with those of the small holder. Thus, building capacity of producers to act on their own behalf is important to improve producer's welfare. However, prospects for livestock sector-based organizations are limited as long as livestock remains a secondary occupation or livelihood source for them.

Producers who garner their primary livelihood from livestock are more likely to invest in livestock-focused organizations, but regrettably, there is a problem of widely dispersed HH in these pastoral districts where pure grazing is the main land use. Additional physical or financial capital is needed for the introduction of a new livestock enterprise, but thereafter replacements may be home bred. Human capital in the form of husbandry knowledge and skills is also needed. Technological innovations should be appropriate to the resource base, while access is needed to market outlets and

input delivery systems. Rural development programs must be demand-driven since only the land users themselves, with appropriate organizational and technical assistance, have the information necessary to identify solutions that will suit them and which they will 'own' (Delgado et al 2001).

Acknowledgment

We gratefully acknowledge the special financial support for Agro-scientific Research in the Public Interest (No.201003061) and Key [Laboratory](#) of Grassland System (Gansu Agricultural University) (CYZS-2011013) and national key technology R&D Program (2012BAC01B02-4).

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