



Research article

What road should the grazing industry take on pastoral land in China?

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Abstract: China has the second largest rangeland area in the world. The pastoral area was regarded as the main red meat (beef and mutton) production area since new China's establishment in 1949. In past decades, the rangeland degradation has become serious in many places and the governments at all levels in China have realized the issues and have made a series of policies to protect rangeland. A key component of the policies is to provide subsidies to herders to switch to intensive livestock production instead of grazing on rangelands. But, is that effective? Can the householders in pastoral areas make more money than those in cropping land and protect effectively the rangeland ecosystem for the future? How to guide those herders in pastoral land to find a suitable way to make a living from producing beef and mutton? The paper reviews the livestock production in the pastoral regions and compares it with that from the cropping regions. We found that the economic advantage of livestock production in pastoral land has long disappeared and that most of the red meat, is now produced in the cropping regions or is imported. Therefore, the government should rethink the role and function of the rangeland in pastoral regions and should encourage and improve pasture-based livestock husbandry to produce organic red meat (green food) and other livestock products while fostering and protecting cultural traditions and better land stewardship.

Keywords: rangeland degradation; cropping regions; green food; pastoralism; red meat production

1. Introduction

China has vast rangelands that are located in the cold and arid area [1]. In past decades, the

pastoral land was the main livestock production base, especially for mutton and beef and other livestock products—cashmere, wool and hides. Economic development meant that the pastoral areas underwent major upheaval [2]. The imposition of the Household Contract Responsibility System (HCRS) as a fundamental policy for rangeland management, meant that millions of householders were able to graze privately owned livestock on State-owned land [3-7]. In China, with the opening-up policy implemented from 1980, household incomes began to rise and urbanization prompted further demand for red meat—a trend observed in other countries as living standards rise [8]. As a result, the herders in pastoral land raised more and more livestock to meet the demand. In 1985, the beef and mutton from pastoral areas contributed 53.3% of the entire supply in the whole country, but in the better-watered cropping regions, it was only 24.8% [9]. Regrettably, livestock production in the pastoral zone has increased at the expense of accelerated rangeland degradation [10]. Overstocking has caused rangeland degradation in China since 1980s [5,11,12]. China is suffering the consequences of rangeland degradation, adding to concerns about sustainability [13].

Moving to the 21st century, China's government has realized the serious environmental problem, in particular dust and sand storms caused by rangeland degradation [14,15]. Since 2002, the State Council has implemented a series of policies for rangeland rehabilitation [16]. The Ministry of Agriculture (MOA) had launched the Protecting Rangeland by Restricting Grazing (PRRG) (*tui mu huan cao*) project in China [17]. The objective was to recover rangeland through grazing bans. But, in pastoral regions, the PRRG project is controversial in terms of rangeland fencing, sustainability and herders' livelihoods [5,18]. There is evidence that it has accelerated the rate of rangeland degradation, at least in some regions [19,20]. More importantly, due to the PRRG, the annual rate of increase in livestock inventory in pastoral land is slower than cropping regions because of rangeland fragmentation and the reduction of area available for grazing. In 2011, the beef and mutton supplied from the pastoral area decreased to 38.7% of the national total (down from an earlier high of 53.3% in 1985), but in the cropping area, it has increased. The cropping areas in the east and south of China have displaced the pastoral area as the main beef and mutton production resource in China [9].

In order to stabilize animal husbandry and herders' income in pastoral land. The MOA had launched another huge project, Rangeland Ecological Compensation Program (RECP) with expenditure of billions of dollars in pastoral land since 2011. The program had paid subsidies to herders if they reduced the livestock number on rangeland. Besides that program, the MOA had also funded the transition to a changed livestock pattern in pastoral land, which encourages the herders to conduct more intensive livestock production (pen feeding) to replace range-dependent pastoralism. The governments want to achieve a "win-win" goal where rangeland conservation is guaranteed while herders' incomes increase. As a result, the scale and the system of livestock production by a myriad of small holders are at a crossroads in the pastoral regions at a time when economic, social, cultural and environmental changes are occurring at an increasing pace [21,22].

Although, the central government is concerned about the environmental benefit, the local governments pay more attention to economic development in pastoral regions [23]. Increasing herders' income, promoting animal husbandry development and protecting environment in pastoral land was the foundation of the program implementation. So, the question arises "Does intensive livestock production under the subsidy policy in the pastoral regions meet the demand of government and herders' that households make as much (or more) money than those in other regions?" To achieve this policy objective, we need to ask "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 regions?”

In this paper, we review the development of beef and mutton production in the pastoral regions and the humid cropping regions in China from 1980 to 2012. We analyze the widening gap in beef and mutton production between the two regions. We also summarize the challenges faced and future prospects for beef and mutton production in pastoral regions in China.

2. Methods and materials

2.1. Study area

The classification system of Ministry of Agriculture in China distinguishes pastoral (agro-pastoral) regions and cropping regions [24,25], We selected as our study sites, typical pastoral regions located in north and northwestern China which produce livestock using rangeland, and cropping regions in northeastern and central China which feed livestock using fodder, crop residues and feed grains. (Figure 1).

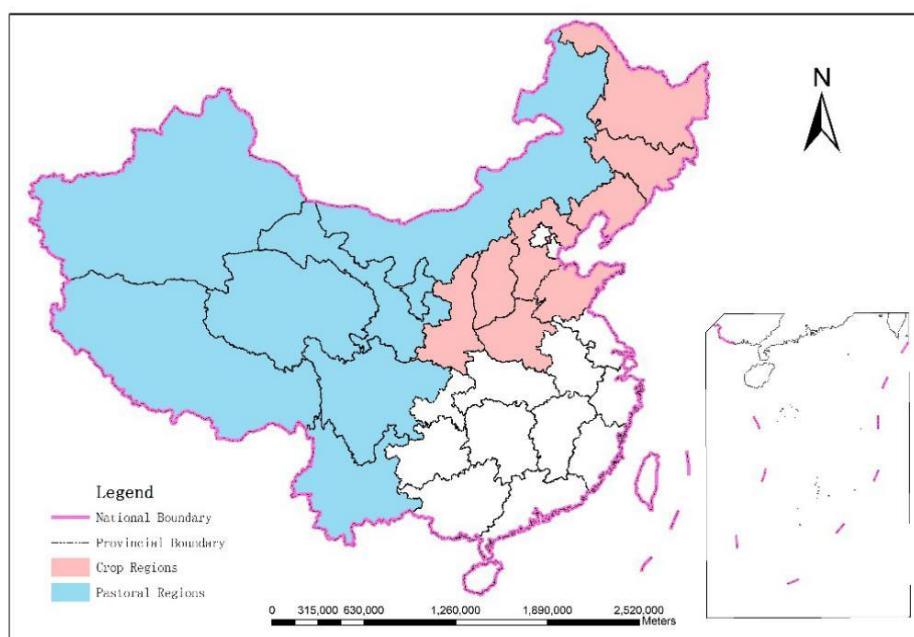


Figure 1. The locations of pastoral regions and cropping regions. Blue zone represents the pastoral regions located in north and northwestern China, including Inner Mongolia, Xinjiang¹, Qinghai, Tibet, Gansu, Ningxia, Yunnan and Sichuan. Pink zone represents the majority cropping regions in northeastern and central eastern China, including Heilongjiang, Jilin, Liaoning, Shandong, Hebei, Henan, Shanxi and Shaanxi.

¹ Uyghur Autonomous Region of Xinjiang but herein called Xinjiang

2.2. Methods

Our time frame (1980–2012) was long enough to detect the trends in each target site. We attempt to explain comprehensively the cause of change. We used turn-off rate (defined below), percentage of breeding females (the core of the herds), the extent of financial support of national projects, the scale of enterprises (policy preferences) and feeding cost (fodder resource). The formula of sheep and cattle turn-off rate is number of livestock sold / (opening year numbers + births – deaths). Not all stock sold are for slaughter. The data analysis was based on samples from each site, the raw data for inventories of sheep and cattle were converted to a percentage. The rangeland ecological rehabilitation fund includes PRRG, RECP and other rehabilitation funds. The cost of feeding livestock contains material and labor cost.

2.3. Data collection

The data on inventories of cattle and sheep are from China Agricultural Statistical Report and National Bureau of Statistics of China [26,27]. The data of ecological rehabilitation funds in pastoral regions are from China Animal Industry Yearbook and the data of national project subsidies in cropping regions are from China Agricultural Yearbook [28,29]. The data of turn-off rate of cattle and sheep are from China Animal Industry Yearbook and National Bureau of Statistics of China [27,28]. The data of cost for livestock production are from China Rural Statistical Yearbook [30]. The inventory of breeding² cows in cropping regions and pastoral regions are from China Agricultural Statistical Report [26]. Data on the inventory of breeding ewes in pastoral regions are from China Animal Industry Yearbook. The scale of cattle and sheep enterprises is derived from the China Animal Industry Yearbook [28].

3. Results

3.1. Development of livestock production in pastoral regions in China

Before 1980, the pastoral areas were the main beef and mutton production base in China (Figure 2). The policies in that period, in terms of rangeland conservation, and animal husbandry development were developed around the notion of producing red meat and livestock products in pastoral areas. Even in 2000, the Inner Mongolia government enacted a policy, “Increasing livestock with increasing forage” [31]. Under these policies, the herders in that region raised more and more livestock on the rangelands, which caused accelerated rangeland degradation [32]. In cropping areas before 1995, the animal husbandry was a household sideline production. The farmers raised a few sheep or cattle for making pocket money. There were few livestock feedlots or breeding farms in cropping regions [33].

However, with the structural readjustment of agriculture in cropping areas and implementation of the grazing ban policy in pastoral area since 2001, the contribution to beef and mutton supply from the pastoral area decreased to 38.7% of that in the whole country in 2011 [9]. The beef and mutton supply from the cropping area increased and while pastoral area production decreased

² By this we mean a female (cow or ewe) of reproductive age used for herd increase.

(Figure 2). The cropping region has replaced gradually the pastoral area as the main beef and mutton production base in China. Some specialized livestock production companies have been formed and operate in cropping regions, in particular in some provinces like Shandong, Henan and Jilin with rich corn, straw and crop residue resources.

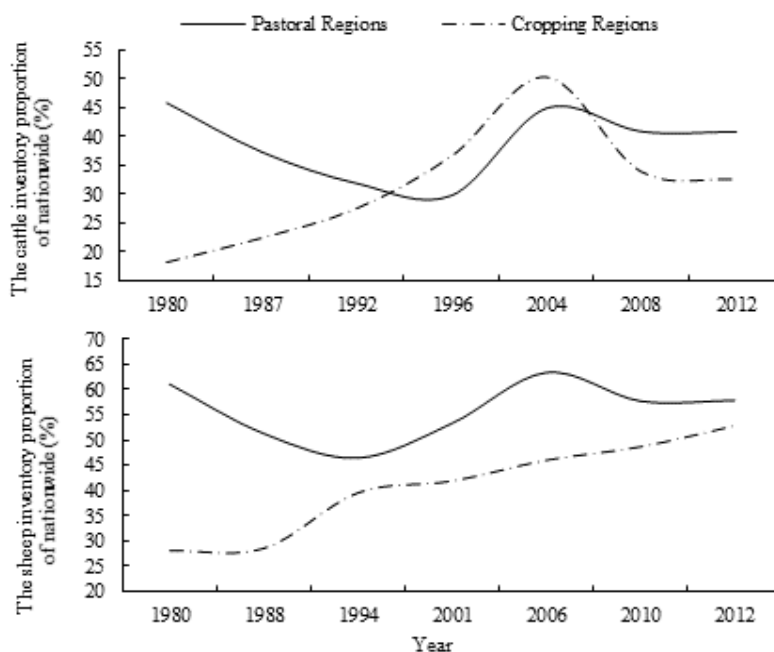


Figure 2. The inventory of cattle and sheep in pastoral regions and cropping regions from 1980 to 2012

3.2. Difference on the turn-off rate in pastoral regions and cropping regions

The gap of turn-off rate between pastoral land and cropping land was influenced by the local livestock breed and the harsh environment [34,35]. In pastoral land, there are yak in the Tibet plateau, Mongolian cattle on the steppe as well as brown cattle in Xinjiang. Such native breeds take more time to reach slaughter weight than the crossbred livestock in cropping areas. As a result, the turn-off rate of cattle and sheep from cropping regions was higher than that in pastoral land from 1999 to 2012 (Figure 3). With the development of animal husbandry in cropping regions, more and more livestock products of beef and sheep are from there.

3.3. Inventory of breeding females (cattle and sheep)

The impact of the breeding females in the livestock production system is often ignored, but breeding females are the basis of developing a livestock enterprise. In the pastoral regions, a number of lactating females are maintained to provide milk for the household (HH) and the surplus milk is converted to hard cheese or to yoghurt. That is why the proportion of females of breeding age in the herd has been more or less constant. While in the cropping region, the objective is to buy animals

(not breed them) and fatten them. Since 2007, MOA had launched a subsidy policy to support the purchase of breeding cows for reproduction in cropping areas [36]. The policy had stimulated the development of a market for breeding females. The proportion of breeding cows has increased from

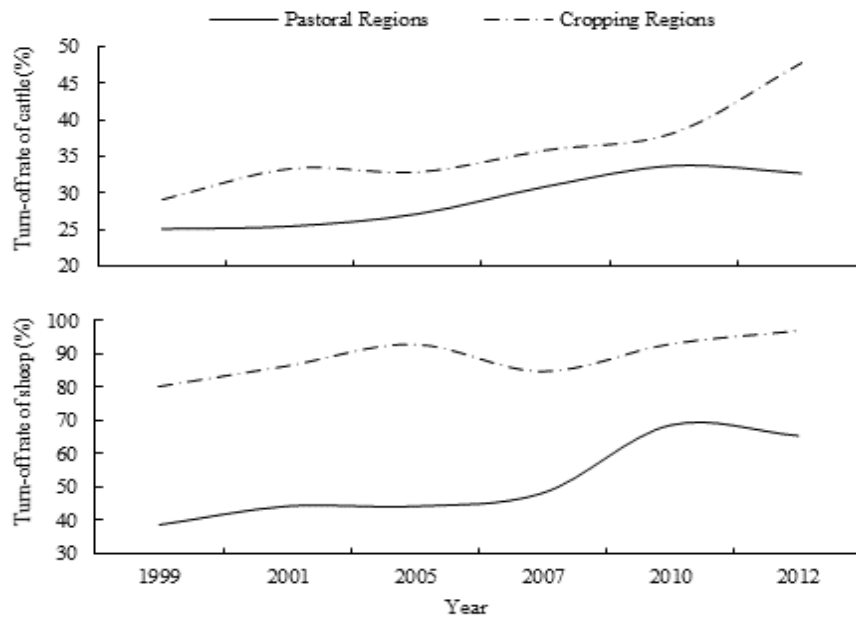


Figure 3. The turn-off rates cattle and sheep in pastoral regions and cropping regions across the country from 1999 to 2012

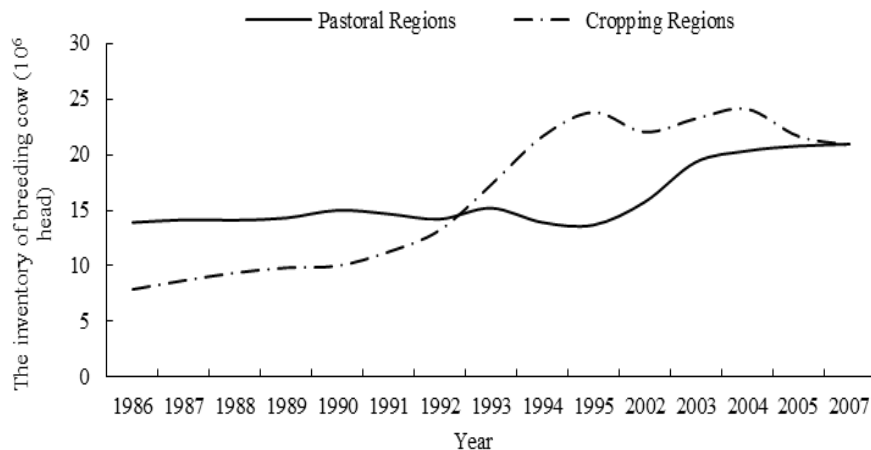


Figure 4. The number of breeding cows in Pastoral regions and Cropping regions from 1986 to 2007

1999 to 2012 because of this subsidy policy. Moreover, with the establishment of more and more beef feedlots in the cropping area in China, the demand for calves has increased. Households now keep more breeding cows to meet the demand for calves. Therefore, the inventory of breeding cows

increased and reached a peak in 2007. But, in pastoral regions, due to the limitation of rangeland productivity and grazing bans, the inventory of breeding females in households increased more slowly. Most of the herders, in particular in Tibet Plateau, retain breeding females on their pasture for a longer time than is common in cropping regions where cows older than six years are culled (Figure 4 and Figure 5).

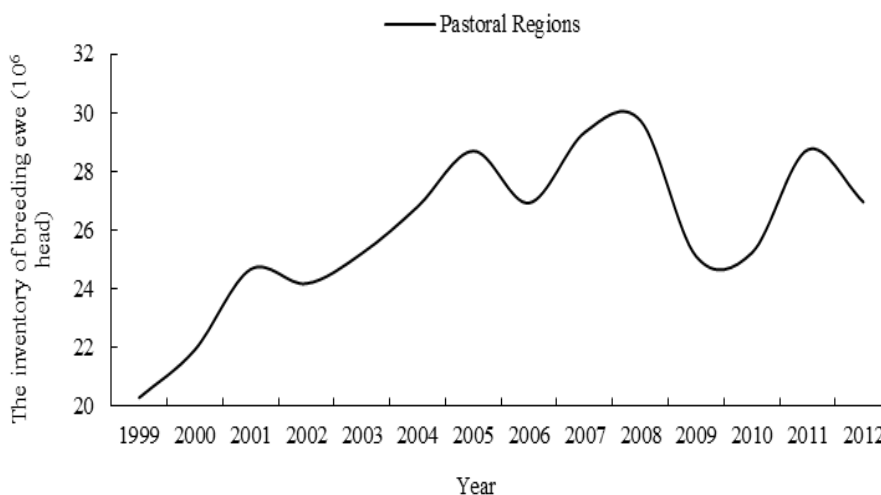


Figure 5. The number of breeding ewes in pastoral regions from 1999 to 2012

3.4. Agricultural policy in China and financial support

Within the context of economic development in China, the governments at all levels provided funds to foster livestock production within their own administrative regions. In the period from 1995 to 2012, the livestock numbers increased by only 17% in pastoral land mainly, because of the implementation of ecological rehabilitation programs, which focused on environmental recovery and reduction of the livestock numbers directly dependent on the rangelands [17,10]. Sheep numbers increased by 21% and cattle numbers increased by 3% over that period in the pastoral land where millions of hectares of rangelands were fenced and subject to grazing bans (Figure 6). Livestock inventories in the cropping region were not constrained by fencing and grazing bans. The inventories of sheep and cattle have increased by 136 and 25%, respectively, since 1990 (Figure 7).

3.5. Differences in scale of cattle and sheep enterprises between cropping regions (Henan) and pastoral regions (Xinjiang).

The policy underpinning the development of animal husbandry between pastoral land and cropping land is different. In pastoral land, such as in Xinjiang, the main subsidies of RECP and PPRG have gone to small households for supporting change away from pastoralism. As a result, the small-scale farm and feedlot for sheep and cattle production increased very rapidly from 2002 to 2011 (Table 1). But, in cropping regions, the MOA and the local governments supported large scale and professional farm and feedlots for red meat production. Taking Henan province as an example,

from 2002 to 2011, the number of sheep farms with over 1000 head and the cattle farms with over 1000 head increased 12 and 15 times, respectively (Table 1 and Table 2).

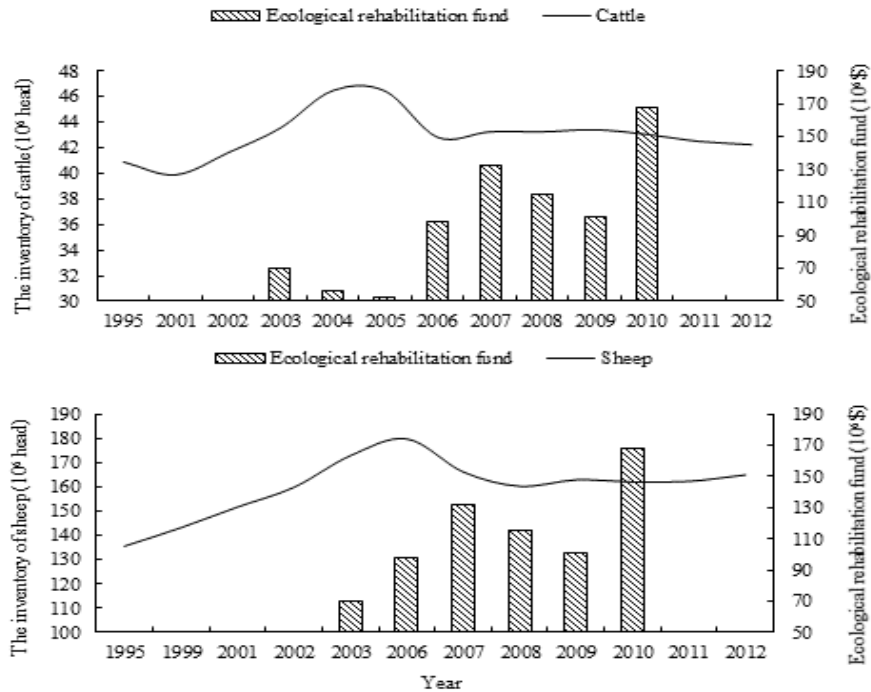


Figure 6. The inventory of cattle and sheep under the subsidies (rangeland ecological rehabilitation fund) in pastoral regions

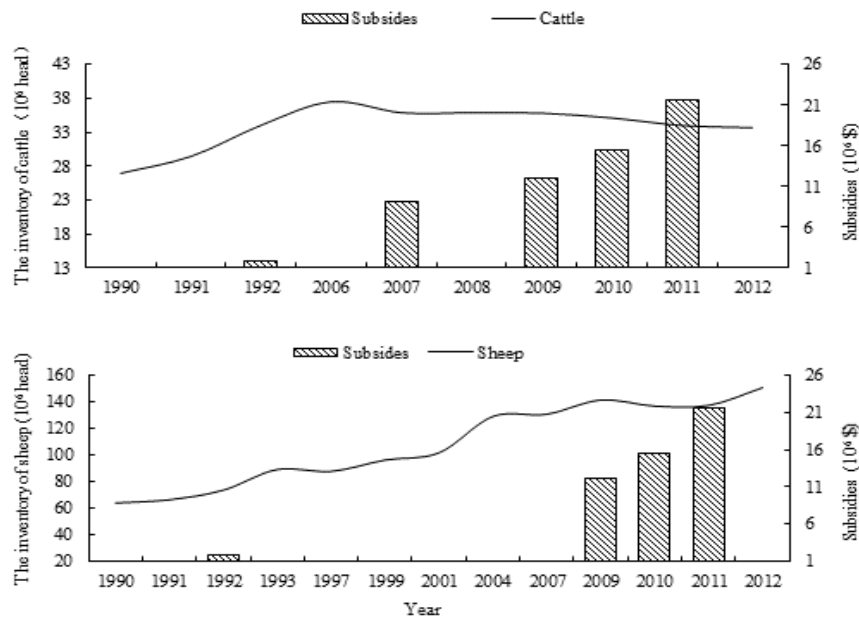


Figure 7. The inventory of cattle and sheep in cropping regions

Table 1. Changes in scale of cattle enterprises in various provinces from 2002 to 2011 (Unit: farm)

Year	Under 500		500–999		More than 1000	
	Xinjiang	Henan	Xinjiang	Henan	Xinjiang	Henan
2002	167202	2800780	45	45	20	12
2007	288152	2610361	96	175	17	59
2009	402939	1586871	47	381	5	146
2011	423765	1375602	91	515	16	175

Table 2. Changes in scale of sheep enterprises in various provinces from 2002 to 2011 (Unit: farm)

Year	Under 500		501–999		More than 1000	
	Xinjiang	Henan	Xinjiang	Henan	Xinjiang	Henan
2002	1096660	6874451	1465	125	290	17
2007	1165603	4382343	2371	734	321	71
2009	1467356	2563209	2504	296	327	82
2010	1450899	2380541	2966	556	401	168
2011	1438479	2027447	3226	606	504	207

3.6. Difference on production cost of feeding cattle and sheep between regions in cropping areas (Henan) and pastoral areas (Xinjiang).

Since 1980, with the opening up policy and implementation of the Household Contract Responsibility System (HCRS) in China, the grain production has been increased continually [37,38]. However, the growing of grain was not profitable. Farmers improve household income by growing fodder to sell to the farm of intensive livestock production. Because beef and mutton production in pastoral area relies on the rangeland and the vagaries of climate, the production cost is higher and the output is less stable than that in cropping areas. In the cropping areas, there is a supply of grain, and a rich supply of crop residues, straw and fodder to support beef and mutton production. Since 1996, MOA has funded the program, Livestock Feeding Based on Crop Straw project in cropping area [39]. The project support famers to make silage from grain straw which reduces the feed cost of beef and mutton (Figure 8). However, the pastoral areas are located at colder and drier areas in China, which are not suited to produce grain or forages. The government encourages herders there to grow sown pasture like alfalfa or fodder crops like oats and to pen feed their livestock. Cost are increasing and at this stage it is not economic and environmentally unwise because it involves converting rangeland to cropland [40].

Under the influence of the grazing ban policy that excludes livestock from large areas of pastoral land and the rising feeding costs to maintain herds/flocks over winter the profit margin is very thin. Environmental concerns in both the pastoral areas and cropping lands have reduced the area of land available for grazing. The supply of beef and mutton on the market is not enough to meet the burgeoning demand from the rising middle class. In recent years, the prices of mutton and beef are continuously rising [41]. The gap between the prices of domestic and international red meats

resulted in the imports (even smuggling) of foreign beef on to the Chinese markets. In 2014, more than 2 million tons of beef was imported from Brazil and Australia, which accounted for 20% of total beef and mutton consumption. China is keen to improve self-sufficiency in food and is exploring ways to increase production of beef and mutton as well as other green foods [38].

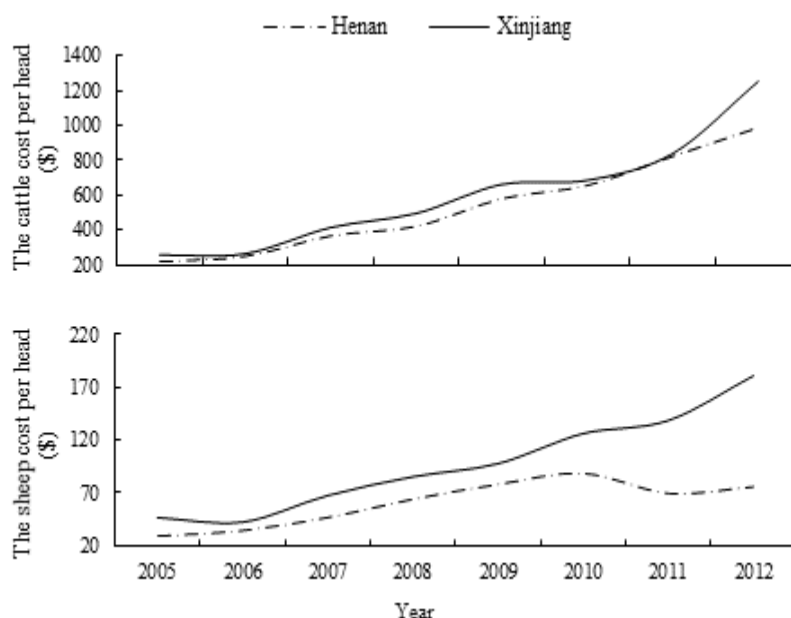


Figure 8. Comparison of production cost of cattle and sheep between Henan (cropping regions) and Xinjiang (pastoral regions).

4. Discussion

Animal husbandry in the pastoral lands plays a key role on rangeland management, economic development and poverty reduction [42]. Comparing the animal breed, cost, policy, etc. in the pastoral land and in the cropping land, we found that there are not enough advantages to develop the more intensive animal husbandry in the pastoral land. To be successful it would depend on planting forage and fodder crops, pen feeding and improving winter housing of livestock. In past decades, the misguided policy of animal husbandry in pastoral land resulted in severe rangeland degradation [43,44]. At present, animal husbandry in pastoral land is at a crossroad, which is squeezed between policies aimed at environmental conservation and regional economic development. Hence the question “what policy on the grazing industry should be government apply in China?”. Since 2011, the central government has paid billions as subsidies to support grazing bans. However, the local governments pay more attention to economic development, especially increasing household incomes. Providing subsidies to livestock owners is one of the ways, but the limited subsidies are inadequate [45,46]. The local governments want a stabilization of society in areas dominated by ethnic minorities. Increasing herders’ income is one of the key measures for achieving social stability. More and more herders are giving up traditional pastoralism and few have tried to switch to more intensive livestock production, but it requires more capital to establish that

livestock production system. Originally, the government thought the transformation of livestock production under HCRS and subsequent policy measures and national programs such as PRRG would benefit both the rangeland and the economy in pastoral land. Despite the policy implementation, the average overstocking rate nationwide was 16.8% in 2013 [47], which means the problem of overstocking is not solved. The main reason is that herders will overgraze the rangeland including (illegally) grazing ban areas as a means of supporting larger herds/flocks.

Monitoring and oversight by the rangeland supervision management officials is spasmodic and ineffective [5]. In the rangeland ecosystem, the balance of energy input and output is essential [48]. However, the livestock products, such as meat, milk, wool, etc. are exported to non-pastoral land, the energy in the products will flow to other places and may not be replaced because the input energy, such as in money, labor, fertilizer, etc. is lower than that in cropping land. Generally, the investment to the rangeland management was very low over a long period of time [49]. Under the situation where output is higher and there is low input year by year, the rangeland ecosystem becomes unbalanced and susceptible to degradation accompanied by lower productivity leading to lower herders' income than those in rural areas of the south and east of China.

Pastoralism is a multifunctional livestock management system which causes ecosystem stresses that extend well beyond the boundaries of the rangelands. Yet, properly managed pastoralism can maintain soil fertility and soil carbon, water regulation, pest and disease regulation, and biodiversity conservation and fire management [50]. Environmental restoration and soil renewal are discussed in the 2017 book by Montgomery [51]. In China, especially in the Qinghai-Tibet Plateau and the Mongolian Plateau, the livestock production is based on pastoralism. Pastoralism not only benefits the rangeland ecosystem, but also is integral to preservation of culture, religion as well as nomadic languages. A new trend is for the herder family to move to settlement points near to town and raise their pen fed livestock using fodder grown on local farms and augmented by crop residues. There is no grazing on the rangeland. This trend toward sedentarization will threaten the nomadic culture.

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 MOA estimates that, on average, Green Food attracts a price premium of 15%, but this is, at best, a rough indicator. In other countries, the premium can be higher [52,53]. Many supermarkets now have special Green Food counters or areas where discerning buyers can get quality-assured products. The higher income consumers the primary concerns about food safety and have the money to pay for safe food [38]. Around 17% of Green Food products are related to livestock and of these a portion comes from pastoral areas where Green Food certification is easier to manage [54,55]. Certification of livestock and their products is more difficult in cropping 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 are often located well away from the production areas leading to long distance transport in unrefrigerated vehicles. The Chinese government could adopt various policies leading to 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 [38]. These concerns need to be more seriously addressed if a premium market is to become a reality on a large scale. The MOA 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 suffers from a shorter list of safety concerns and this comparative advantage should be actively promoted [56].

The agricultural (cropping) land in the central provinces and northeastern provinces with their rich corn source, have replaced the pastoral land and agro-pastoral land as the major red meat production base [57-60]. The red meat production in cropping land is sensitive to the price of corn, labor cost and cost of environment protection measures. Since 2009, China has switched from being a corn exporter to a consistent importer of 3–5 million tons annually and the rural wages began rising from 15 to 20 percent annually [61]. Moreover, the administration of animal disease control phased out “backyard” livestock production and changed to intensive livestock production in feedlots, but the limited land can’t provide enough space for large-scale intensive livestock farms. All these factors have influenced the mutton and beef production in the cropping areas in China.

5. Conclusions

Based on the data presented above, we believe that it is not economical to develop intensive husbandry in pastoral regions. The Ministry of Agriculture(MOA) should change the policy of rangeland management in pastoral regions, in particular the huge subsidy policy, Rangeland Ecological Compensation Program (RECP). Because under this policy the government pays cash to herders who then invest in more livestock or production-related sectors. We suggest that the MOA should focus on the training program for herders in pastoral area because the householder is the base unit for rangeland management and management of that resource is closely related to rangeland health (condition) and to products (milk, meat, wool and hides) from their livestock. The program of capacity building for herders is a long-term strategy and should be implemented in all pastoral area in China. We think that livestock production in the pastoral regions should be environment friendly and long term over utilization should be avoided. To achieve the goal, the governments should strengthen rangeland supervision to control overgrazing, and new and quick monitoring and assessment methods on rangeland health should be developed by researchers. On the other hand, the policy of livestock production in the pastoral regions should focus on producing high quality organic meats that can command a higher price. The production model of organic meats does not incur as much environment damage as intensive livestock production in pastoral area.

Besides the suggestions above, pastoralism should be kept for as long as possible under traditional management by the local ethnic herders. We think that the policy, in terms of social and economic development in pastoral area, should pay more attention to environment protection, culture conservation and ecological tourism instead of animal husbandry development This is of particular importance on the Qinghai Tibet Plateau. The animal husbandry should not be supported as a pillar industry in the pastoral area. The policy, as related to animal husbandry development, should be assessed on environmental and cultural criteria instead of just seeking higher financial returns.

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Conflict of interest

The authors declare that they have no competing interests.

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