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# How do herders do well? Profitability potential of livestock grazing in Inner Mongolia, China, across ecosystem types

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**Abstract.** Livestock production has increased in Inner Mongolia, China, despite widespread documentation of grassland degradation. To begin investigating the relationship that produces these trends, we studied farm-level decisions of herder households. We estimated economic enterprise budgets for 15 counties in Inner Mongolia across five ecosystems in 2009 and 2014 by using household survey data. Six counties decreased livestock stocking rates and had improved profit over time. The remaining counties increased their stocking rates over the period studied and profit decreased for all but one county. Livestock operators who reported negative profit over the 5 years were located across ecosystem types and reported a large number of weather shocks that affected grassland availability. Removing the opportunity cost of land and labour from the economic enterprise budgets resulted in a positive profit for all counties, which may explain why herders continue to increase stocking rates with decreased grassland availability over time.

**Additional keywords:** financial, grazing, semi-arid area.

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## Introduction

The sustainable use of rangelands in Eurasia has been in question for decades (Xiao *et al.* 1995; Thwaites *et al.* 1998; Briske *et al.* 2015; Wang *et al.* 2017). Over the past 60 years, there have been dramatic shifts in economic conditions, with consequent policy changes in rangeland and livestock management, in the Inner Mongolian Autonomous Region (IMAR), China (Ho 2001; Kang *et al.* 2007; Wu *et al.* 2015). Even with these changes, livestock production in the grasslands of Inner Mongolia underpins regional economic stability. Since the late 1940s, the livestock population in Inner Mongolia has quadrupled, even though grassland degradation has increased (Li *et al.* 2007; Robinson *et al.* 2017). Although this may indicate that grasslands have not reached unsustainable levels of grazing, clearly these trends cannot continue. It is understandable that herders individually want to increase the number of livestock they hold because livestock production provides them with a source of revenue through the sale of animals and jointly creates wealth accumulation with the animals they retain. However, more sheep can lower the overall quality of grassland resources and have negative impacts for animal growth over time. This consequently reduces household incomes and potential wealth accumulation for many who are already near or below poverty level (Kemp *et al.* 2013). Unravelling this apparent conundrum of ever-increasing livestock production despite decreasing rangeland quality, and why herders seem to continue to invest resources to do so, requires study of the decisions of herding households.

Households make production choices based on beliefs and perceptions about the relative utility of various livelihood activities. This can include many factors, but here we focus on herd production decisions such as farm costs, benefits, and risks of internal and external factors of production. Some of these factors, for example inputs sourced from markets (feed, hay, infrastructure, etc.) or outputs sold to markets (meat, wool, milk, etc.), are easily quantifiable. Other input factors such as the value of labour and land can be more difficult for households to incorporate into their personal decision-making, especially in developing regions where subsistence livelihoods dominate, and production and consumption activities are inseparable (Singh *et al.* 1986). In this case, we can develop estimates for the opportunity cost of land and labour for analytic purposes (Jacoby 1993), but when markets are truly thin or even missing,

 

it is unclear how households take these factors into account when making production decisions.

Grazing studies in Inner Mongolia often collect data on stocking rates and ecological parameters; however, few report basic information on economic parameters (Li *et al*. 2007; Li and Huntsinger 2011; Kemp *et al.* 2013). Li *et al*. (2007) collected data on input costs of livestock feed from 16 households; the data suggested that household incomes decreased over time while feed input costs increased. Many of the previous studies on livestock production in IMAR recommend a joint management strategy between livestock systems and the ecosystem, but few studies have collected household financial data that might help justify this recommendation. Understanding the financial position of livestock producers in the changing grassland ecosystem allows us to create benchmarks to study household decisions regarding livestock productivity as it relates to ecological health and economic livelihoods.

The research objectives of this analysis were two-fold. First, we estimated economic livestock enterprise budgets at the sheep-unit level to determine how average farm-level profitability across 15 Inner Mongolian counties and five ecosystems changed between 2009 and 2014. To do so, we aggregated a unique, 2-year panel dataset of 850 household herders to the county level to avoid measurement error and variation in individual annual production. Second, we enhanced the 2014 survey instrument by collecting information on household-reported production shocks that may have occurred over the study period. We compared those shocks with profit and financial efficiency levels across time to provide regional benchmarks to facilitate farm-management strategies.

This paper contributes to livestock production and grassland management literature in several ways. First, in a practical sense, we compiled enterprise budgets across Inner Mongolia using a 2-year panel dataset, allowing herders to compare their individual economic estimates to county averages. This can help to direct their management decisions in a positive way that considers farm-level profit goals in conjunction with ecosystem and grassland outcomes. Second, the study evaluated stocking rates differences over the 5-year period, considering changing economic and ecosystem conditions. Third, we examined the implications of considering (or not) the opportunity cost of land and labour in enterprise budgets conducted for developing regions. Although land and labour costs are standard in enterprise budgets in industrialised regions, our data show that Inner Mongolian households likely do not incorporate these important factors of production in their internal calculations.

## Methodology

Financial budgeting is used for management purposes to evaluate past revenues and expenses to plan for the future (Kay *et al*. 2012). Enterprise budgets are a type of financial budget that collects historical farm-level data on revenues and expenses for a specific enterprise to determine enterprise-level profitability. This allows the herder to determine how to allocate resources in an economically efficient manner to guide future decision-making across enterprises. Farms who diversify risk are expected to have enterprises that make positive and negative profit in any given year. This accounts for the cyclicality of enterprises to allow the herder to have a relatively constant profit level compared with high fluctuations across years. Enterprise budgets can be estimated at an individual farm level as well as averaged across farms in a similar region to provide the basis for benchmark analysis. This gives the individual farmer the opportunity to compare their estimates with other farmers in their region. If a farmer is underperforming compared with their peers, they can make the necessary adjustments to improve their financial performance. The aggregate enterprise budget for all $T$ households in county $C$ is defined by:

$$\pi_C = \sum_{t=1}^{T} \pi_t$$

where

$$\pi_t = R_t - E_t \quad (1)$$

where $\pi_t$ is the profit per unit for enterprise $t$, $R_t$ is revenue for enterprise $t$, and $E_t$ are expenses for enterprise $t$. Revenues include all cash and non-cash revenues for enterprise $t$. Non-cash revenues include agricultural products that have been harvested but not yet sold. Typical examples include feed or grain in storage. Expenses comprise operating (variable) and ownership (fixed) cash and non-cash expenses. (Taxes are not included in an enterprise budget because they are calculated based on profit generation at a whole-farm level.)

Enterprise budgets can be used to estimate accounting and economic profit. Accounting profit does not account for opportunity costs of labour and land nor for non-cash (accrual) adjustment values for growing and harvested agricultural commodities, whereas economic profit does. Here, we focus on economic profit and include the opportunity costs to represent the next-best alternative for labour or land, while non-cash (accrual) adjustments are included to account for the financial value of the agricultural commodity as it is growing and harvested.

Most agricultural producers do not personally account for the value of their labour on the farm by paying themselves a salary for their own work in their operation. Rather, they simply make 'withdrawals' from their operating profits when they have necessary expenses. As analysts, when developing an economic budget, we must account for the opportunity cost of that labour because their agricultural labour could be put towards other productive, income-earning activities.

Regarding the opportunity cost of land, in industrialised regions, agricultural producers often have rent or a mortgage associated with their land, and this is included in their operating expenses. However, the land may be fully paid for or rights may have been bequeathed over many generations, as is the case in many developing countries. Like labour, we must include the value of the land used as an input to production as an expense because it is a predominant feed source for their grazing operation. Even if the owner does not explicitly pay rent or a mortgage, the opportunity cost of land should be included in the economic enterprise budget at the value of its next-best alternative use. Traditionally, this is estimated as the current value of the farm if rented out for production.

Additionally, the economic enterprise budget recognises the economic value of products while they are growing in the field and/or stored on-farm after harvest. This can help to account for the changing value of the agricultural product over its life. The commodity may be worth more after it is harvested, but that value is a function of changing market conditions.

In order to examine change over time, we used enterprise budgets in each year as the basis for benchmarking whether or not farms are doing well, which can include financial and production-based measures. Financial benchmarks were compared across ecosystems by studying profit changes across the two survey years. Four benchmark categories were generated. Benchmark A included counties that reported positive profit in 2009 and 2014, which was classified as a 'very good' financial state. Counties that reported a negative profit in 2009 and positive in 2014 were categorised in a 'good' financial state (Benchmark B). A 'poor' financial state (Benchmark C) was allocated to counties that were positive in 2009 and then negative in 2014. 'Very poor' (Benchmark D) financial states described counties that reported negative profit in both years. Other quantitative measures, expense shares and stocking rates, were compared across the benchmark categories to provide further insight into herder's decisions.

We recognise that farm earnings can be idiosyncratic and are a function of many characteristics, including exogenous factors that might have impacted production in previous years. Some of these unobserved characteristics could help to explain some of the variation in our analysis, leaving our comparison of profits between 2009 and 2014 biased through measurement error. However, this is one reason we aggregated our enterprise budget estimates over all (~60) households within a county as in Eqn 1, allowing us to 'average out' some of the measurement error associated with herd-level unobservables.

As a way to help explain our benchmarking results, we examined components of the enterprise budget and other county-level characteristics that might help to provide some explanation as to why certain herders do well. We explored these plausible reasons for each benchmarking performance category. Clearly, other factors may affect production at the county level (other climate data, regional price trends, county-level political/policy reasons, etc.) and these could affect our estimates for 2009 or 2014, but we were unable to account for this in our analysis. Additionally, given our study design, we cannot argue that the relationships we discuss are causally related, nor is there any way for us to test such claims formally. Therefore, the correlations and associations proposed in our results and discussion are presented as proposed hypotheses that can then be more formally tested with additional research.

### Data collected

Livestock enterprise budgets require a large set of historical farm data to provide useful information for management (Kay *et al*. 2012). The present analysis used detailed farm-level data collected from 850 households across 15 counties in Inner Mongolia during 2009 and 2014. The survey sample design used a stratified random sampling strategy to ensure that households were equally represented in each of the five grassland types that exist in Inner Mongolia and the Eurasian steppe more broadly: meadow, typical steppe, desert steppe, sandy grassland, and desert. Grassland types are classified based on biophysical characteristics such as plant species, soil conditions and grass productivity (Wenqiang *et al*. 2014). Within each grassland type, three counties were randomly selected to represent the typical situation within each grassland type. Then in each county, three sumu (towns) were selected that represented the grassland type. In each sumu, 20 households were randomly selected to interview. On average, each county had responses from 50–60 livestock operations.

In spring 2015, the survey was again administered in 850 of the same households, collecting information on 2014 financial and production levels, creating a unique panel dataset. We aimed for 80% coverage of the original households, which remained consistent across all counties. Therefore, we expect minimal bias in our estimates due to loss-to-follow-up. The panel dataset contains detailed information on herding households' factors of production and output for all livestock types owned. The survey additionally collected detailed information on landholdings, assets and other livelihood activities.

An individual enterprise budget was generated for each farm and averaged across all farms within the county to create an average county livestock budget. Livestock enterprise data was collected and calculated for five categories: sheep units (SU), revenue, operating expenses, ownership expenses, and economic profit. These categories are described in detail below.

### Sheep units

Livestock grazing enterprise budgets are generated on a per-head basis, which allows the herder to compare their estimates across similar livestock species. In this analysis, we were unable to calculate a budget for a specific livestock species because inputs to production were collected at the household level rather than the species level. Therefore, we first convert all of a household's livestock holdings to standard SU, as is common in China. The SU conversion factors for different livestock are given in Table 1 (Liu *et al*. 2015; Rao *et al*. 2015; Yuan *et al*. 2016).

### Revenue

Revenue is money generated by the sale of livestock animals and products. Livestock revenue ($R_{ij}$) is calculated following:

$$R_{ij} = \sum_{i=1}^{I} (x_i{}^{*} x_{p_i}) + \sum_{j=1}^{J} o_j \qquad (2)$$

**Table 1. Chinese animal unit conversions (SU)**
Sources: Rao *et al*. (2015); Liu *et al*. (2015); Yuan *et al*. (2016)

| Animal | Sheep units |
|---|---|
| Sheep | 1 |
| Lamb | 0.5 |
| Goat | 0.8 |
| Goat kids | 0.4 |
| Beef cattle | 7.0 |
| Cow | 8.0 |
| Heifer calf | 4.0 |
| Bull calf | 3.5 |
| Horse | 7 |
| Camel | 9 |

where $x_i$ is the number of livestock species $i$ sold, and $x_{pi}$ is the price for livestock species $i$. Livestock species ($i$) included sheep, lambs, goats, kids, cattle, dairy cows, calves, horses and camels. Many of these livestock species provide outputs in addition to their meat when they are sold. These outputs ($o_j$) include wool, cashmere, milk and camel hair.

Two other potential sources of revenue related to grasslands are possible. First, herders that are involved in the Animal–Grass Balance Policy may also receive government compensation for nominally reducing herd levels. We excluded this from our enterprise budget calculations because inclusion would artificially inflate levels of revenue relative to material inputs, and because anecdotal reports and published evidence suggest that the policy is rarely enforced (Kolas 2014), meaning that these payments likely have no binding impact on productivity. Second, some herders may rent out grassland to others. We exclude this revenue because it is unrelated to rearing their own animals. Grassland rented in is included as an expense.

### Operating expenses

Operating expenses are incurred as a result of production. If a livestock-grazing operation sold all of their livestock, this cost would decrease to zero. In this analysis, we included 10 operating-expense categories. A herder can choose to keep their young livestock and raise them as replacements for their herd. In some instances, the herder may choose to purchase additional animals to increase their herd size or to change the genetic composition of their herd. This expense is represented in the budget under the heading *purchased animals* (italics here denote variables included in the enterprise budget calculation), which is calculated for each livestock species and summed to include all livestock species. '*Hired labour* includes payments to non-family members for completing work on the livestock operation. Non-paid labour is represented using the *opportunity cost of labour*, which assumes that each family household labourer works 305 days a year and is paid on average 50 RMB day$^{-1}$ in 2009 and 80 RMB day$^{-1}$ in 2014, these values representing the average reported hired-hand wage rate in each year. Feed expenses tend to be the largest expense for livestock operations. Many households rent additional land to graze their animals, i.e. *rented grassland*, in addition to purchasing additional *hay*, *silage*, *grains*, and *other feeds* to supplement their grazing land. *Gas* and *diesel* fuels are used to run the machinery needed for the grazing operation and on-farm tasks. *Machinery repairs* are the costs reported for repairing the machines used on the operation. Typical machinery includes motors, which are widely used for grazing, mowers, tractors, trucks and other tools needed. The Chinese government has allocated grazing land to herders through a long-term (30+ years), no-cost lease. The herder does not pay rent to the government for this contract land, but we included the *opportunity cost of this land* as a function of the median grassland rental-agreement price (peer-to-peer rental) by county. This allowed us to evaluate how the rental price changes and provided an estimate of what this land would cost if the herder had the opportunity to purchase the land rather than rent it. The last operating expense included was *electricity and water* for the operation.

### Ownership expenses

Ownership expenses are incurred regardless of the intensity of farm production. This includes ownership expenses of long-term assets. We calculated annual ownership expense by using the straight-line depreciation method. Straight-line depreciation is calculated as: (purchase price – salvage value)/useful life; we assumed the salvage value to be equal to zero for the purposes of our calculations. Depreciation captures the loss of the asset value over its useful life. Equipment used for the grazing operation varied between a 15- and 20-year useful life. Motorised equipment typically had a shorter useful life than buildings and structures. Equipment with a reported 15-year life included *motorcycle*, *pickup*, *car*, *tractor*, *three-wheeler* and *other machines* (balers, reapers, etc.). Structures with a 20-year useful life included *shed*, *shed for hay*, *fence*, *well and silos.* With a 5-year time-frame, some survey questions were modified. Specifically, *car* was reported in 2009 and replaced with *pickup* in 2014. Similarly, *sheds* were reported in 2009 and only used for livestock whereas *sheds for hay* were built to store hay long term and provide more stable food sources for livestock during the winter months in 2014.

### Profit

Profit is the amount of money the herder has remaining after they have paid their economic operating and ownership expenses across all enterprises on their farm. Profit can be used to reinvest in the operation or create equity within the firm. A positive profit is preferred; however, there are instances where external factors result in a negative profit. If a herder consistently has a negative profit, it may indicate that alternative management strategies should be considered regarding the enterprises raised on their farm. For example, if a herder observes increases in feed expenses, all else being equal, we hypothesise that they will decrease their stocking rate for later years. This should help to rebuild their long-term feed base and increase profit over time by considering the effects of changing internal and external conditions.

We recognise that operating profits during any single year may represent normal business cycle activities for any one household. Therefore, by averaging 50–60 households to develop county-level estimates, we reduced the measurement error implied by normal operating cycles.

Note that taxes are not included in an enterprise budget because they are not a cost of production. Taxes are a result of generating a positive net farm income at a whole-farm level across all enterprises; one enterprise may result in positive profits while another has negative profits. Therefore, profit here does not include taxes.

## Results

Fifteen livestock-enterprise budgets were estimated, one for each county in our dataset, by using data from Inner Mongolian households in 2009 and 2014 (Appendices 1–5). The average age of principal operators ranged from 43 to 54 years across the 15 counties studied. The livestock operations were 8 km from a major roadway and 54 km from a major city, on average. Financial benchmarks were compared across ecosystems by studying the profit per SU changes across the 5 years. Four

financial categories were generated, from Benchmark A (very good) to Benchmark D (very poor). Grouping the counties by using their profit per SU allowed us to evaluate common economic and production outcomes and identify potential external factors affecting these changes within the benchmark context.

We also compared accounting vs economic profit by using the enterprise budgets with and without the opportunity cost of land and labour included in the calculations. Thin markets imply that the market's ability to absorb land or labour, even if there are willing buyers or sellers, is limited. Resource scarcity drives value, which suggests that if there is no market for a good, its opportunity cost is zero. Our data show some rental activity in Inner Mongolia. Our data also report a value for hired labour by most herders, which suggests that working with livestock is a relatively stable job. However, own true value for households of the opportunity cost for the average herder's land and labour not exchanged in the market likely falls in the range between zero and our observed rental and hired-wage rates. By comparing accounting and economic profit, i.e. the profitability of the farm enterprise as experienced by herders and 'the analyst', respectively, we can evaluate profit margins as they might be thought of, or experienced by, the average herder. This can help us see possible trade-offs between perceived profit and true wealth accumulation at the farm level.

### *Benchmark A: very good counties*

Four counties were categorised in a 'very good' financial state as a result of positive profit in 2009 and 2014 (Table 2), including all counties in the desert ecosystem (Alashanzuoqi, Wulatehouqi, Alashanyouqi). This indicates that specific management practices may be used in the desert ecosystem that are successful across time and could be transferable to other regions with future analysis. The fourth county that reported positive profits was in the meadow steppe ecosystem (Xinbaerhuzuoqi). We hypothesised that profit would increase over time if stocking rates decreased, as demonstrated with other experimental data (Kemp *et al*. 2013). This was observed in three of these four counties: Alashanzuoqi, Alashanyouqi and Xinbaerhuzuoqi. The feed-expense share increased over the same period for these counties, which may explain the decreased stocking rate on the fixed land base. Wulatehouqi increased stocking rate over this period and received a positive profit in 2014, but at a lower level per SU than observed in 2009. This decrease in profit per SU in Wulatehouqi may be attributed to abnormally high feed-expense shares in 2009 in this county. Specifically, 80% of the operating expenses in 2009 were attributed to feed in Wulatehouqi, compared with <20% for the other three counties.

In agriculture, weather plays a large role in yields and profits. We therefore asked survey respondents whether one or more of the following shocks occurred between 2009 and 2014: locust, drought, snowstorm, or other shocks (Table 3). The four counties in the 'very good' financial state reported the smallest occurrence of these shocks during the study time-frame. Recent work has identified a connection between overgrazed grassland in drought areas and an increase in locust outbreaks (Cease *et al*. 2012). Locust shocks occur when overgrazing and droughts occur. Locust shocks were reported by 12% and 20% of the respondents in Wulatehouqi and Alashanyouqi, respectively.

**Table 2. Financial summary across financial states**

SU, Sheep units. Feed expense share = (rented grassland + hay + silage + grain or fine feed + other feeds)/total expense. Opportunity cost of labour share = opportunity cost of labour/total expense. Opportunity cost of land share = opportunity cost of land/total expense. Operating expense ratio = operating expense/total revenue

| County | Ecosystem | Profit (RMB SU$^{-1}$) | | Stocking rate (SU ha$^{-1}$) | | Feed expense share | | Opportunity cost labour share | | Opportunity cost land share | | Operating expense ratio | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 |
| | | | | | | *Very good* | | | | | | | |
| Alashanzuoqi | Desert | 10.82 | 33.69 | 0.37 | 0.30 | 0.22 | 0.31 | 0.62 | 0.40 | 0.08 | 0.16 | 0.87 | 0.81 |
| Wulatehouqi | Desert | 61.03 | 23.06 | 0.56 | 0.67 | 0.81 | 0.57 | 0.02 | 0.23 | 0.10 | 0.12 | 0.58 | 0.88 |
| Alashanyouqi | Desert | 6.65 | 47.85 | 0.27 | 0.23 | 0.18 | 0.36 | 0.63 | 0.16 | 0.13 | 0.30 | 0.91 | 0.72 |
| Xinbaerhuzuoqi | Meadow steppe | 13.49 | 90.69 | 1.38 | 1.24 | 0.11 | 0.14 | 0.42 | 0.31 | 0.30 | 0.25 | 0.85 | 0.64 |
| | | | | | | *Good* | | | | | | | |
| Wushenqi | Sandy steppe | –54.09 | 59.55 | 1.56 | 2.15 | 0.02 | 0.05 | 0.65 | 0.52 | 0.11 | 0.10 | 1.07 | 0.74 |
| Hangjinqi | Sandy steppe | –80.17 | 48.77 | 1.03 | 1.06 | 0.32 | 0.02 | 0.52 | 0.65 | 0.02 | 0.11 | 0.83 | 1.07 |
| | | | | | | *Poor* | | | | | | | |
| Etuokeqi | Sandy steppe | 1.38 | –7.15 | 0.67 | 0.88 | 0.12 | 0.28 | 0.49 | 0.38 | 0.24 | 0.14 | 0.85 | 0.92 |
| Chenbaerhuqi | Meadow steppe | 15.83 | –45.81 | 1.50 | 1.30 | 0.21 | 0.18 | 0.02 | 0.20 | 0.44 | 0.28 | 0.73 | 1.11 |
| Dongwuzhumuqinqi | Typical steppe | 61.31 | –6.23 | 0.70 | 0.78 | 0.14 | 0.20 | 0.40 | 0.42 | 0.25 | 0.16 | 0.62 | 0.98 |
| Sunitezuoqi | Desert steppe | 63.92 | –87.16 | 0.35 | 0.39 | 0.42 | 0.34 | 0.30 | 0.48 | 0.22 | 0.11 | 1.23 | 1.19 |
| Xilinhaote | Typical steppe | 76.58 | –78.40 | 0.89 | 0.90 | 0.50 | 0.37 | 0.25 | 0.35 | 0.13 | 0.12 | 0.68 | 1.22 |
| | | | | | | *Very poor* | | | | | | | |
| Suniteyouqi | Desert steppe | –48.64 | –98.74 | 0.31 | 0.46 | 0.34 | 0.41 | 0.48 | 0.33 | 0.11 | 0.12 | 1.19 | 1.24 |
| Ewenke | Meadow steppe | –85.38 | –13.21 | 2.88 | 2.05 | 0.06 | 0.25 | 0.65 | 0.40 | 0.14 | 0.08 | 1.89 | 0.97 |
| Siziwang | Desert steppe | –6.64 | –108.42 | 0.54 | 0.70 | 0.26 | 0.47 | 0.44 | 0.32 | 0.12 | 0.09 | 1.00 | 1.44 |
| Xianghuang | Typical steppe | –94.04 | –377.08 | 1.00 | 0.85 | 0.42 | 0.40 | 0.43 | 0.44 | 0.11 | 0.11 | 1.36 | 2.14 |

**Table 3. Percentage of respondents reporting a weather and external shocks between 2009 and 2014 grouped by financial state**

| Financial state | Ecosystem | Locust shock | Drought | Snowstorm | Other shock |
|---|---|---|---|---|---|
| | | *Very good* | | | |
| Alashanzuoqi | Desert | 0 | 39 | 8 | 11 |
| Wulatehouqi | Desert | 12 | 28 | 34 | 15 |
| Alashanyouqi | Desert | 20 | 32 | 3 | 5 |
| Xinbaerhuzuoqi | Meadow steppe | 0 | 13 | 92 | 0 |
| | | *Good* | | | |
| Wushenqi | Sandy steppe | 0 | 50 | 86 | 0 |
| Hangjinqi | Sandy steppe | 0 | 71 | 16 | 2 |
| | | *Poor* | | | |
| Etuokeqi | Sandy steppe | 0 | 59 | 3 | 3 |
| Chenbaerhuqi | Meadow steppe | 0 | 42 | 36 | 0 |
| Dongwuzhumuqinqi | Typical steppe | 0 | 3 | 78 | 3 |
| Sunitezuoqi | Desert steppe | 0 | 98 | 65 | 0 |
| Xilinhaote | Typical steppe | 9 | 54 | 48 | 0 |
| | | *Very poor* | | | |
| Suniteyouqi | Desert steppe | 0 | 98 | 15 | 2 |
| Ewenke | Meadow steppe | 0 | 58 | 36 | 0 |
| Siziwang | Desert steppe | 2 | 85 | 68 | 8 |
| Xianghuang | Typical steppe | 0 | 5 | 72 | 2 |

This may further explain the difference in profit potential for Wulatehouqi compared with the other 'very good' financial state counties.

Opportunity cost of labour and land are economic estimates of the potential costs of these items. In economic terms, they are non-cash expenses. This means that the agricultural producer is not writing a physical cheque to pay these items in the form of salary or rent. Rather, they recover these costs through family withdrawals when cash is needed. As these shares increase, the monetary value of the individual's labour and land increases. In general, the 'very good' categories had a larger share for labour in 2009 than 2014, whereas the share for land increased over the same period. This demonstrates that the landowners decreased the value of their labour over that period while land values increased.

The operating expense ratio is an important estimate for managing input expenses for the operation. Specifically, it defines the proportion of revenue that remains after all operating expenses are paid. Ideally, we would observe this ratio at a value of $\leq$0.65, allowing the herder to use the remaining 35% of their revenue to pay ownership expenses and taxes, and to build equity with the remaining profit. It is generally recommended that the herder retain 10–20% of their revenue for equity accumulation each year (Kay *et al*. 2012). Although these were the most profitable counties in the study, they tended to have operating expense ratios >0.60, with the highest reported at 0.91. However, the counties that increased their profit per SU from 2009 and 2014 also improved their operating expense ratio.

### *Benchmark B: good counties*

A 'good' financial state occurred when a farm reported negative profit per SU in 2009 and positive profit per SU in 2014. A change from negative to positive profit indicates that knowledge may have been gained and appropriate management adjustments made. Only two counties (Wushenqi and Hangjinqi) were categorised in a 'good' financial state and both were in the sandy steppe ecosystem. Their profit increased while their stocking rate increased over the 5-year period. This indicates that the herder probably adjusted the number of animals on their grazing land based on the amount of feed available. Interestingly, Wushenqi and Hanjinqi reported the lowest feed-expense ratios of the 15 counties. On closer inspection of the raw survey data, both counties reported a high percentage of herders with forage land in addition to grazing grasslands. This indicates they were able to increase their stocking rates because of the supplemental feed available on their own farm from the forage land. The largest operating-expense share in Wushenqi and Hanjinqi counties was attributed to labour, which shows that they are relying on the resources directly available to them rather than hiring additional labour for their farming and herding activities.

During the 5-year study period, the majority of survey respondents reported one or more weather shocks affecting production. In Wushenqi, 50% of survey respondents reported drought and 86% reported snowstorms. Of the survey respondents in Hangjinqi, 71% of respondents reported a drought and 16% reported snowstorms. Unfortunately, we do not know the year in which these shocks occurred, only that they occurred between data collection in 2009 and the follow-up in 2014. It is possible that shocks were more prevalent earlier and affected later periods less, but we observed only two counties in this Benchmark; therefore, drawing inference is difficult.

### *Benchmark C: poor counties*

A 'poor' financial state occurred when a herder reported positive profit per SU in 2009 and negative in 2014. Five counties were classified in a 'poor' financial state (Etuokeqi, Chenbaerhuqi, Dongwuzhumuqinqi, Sunitezuoqi and Xilinhaote). Within these five counties, four ecosystem types were represented. All but one

county (Chenbaerhuqi) in the 'poor' financial state increased their stocking rate between these 5 years and had a decreased profit per SU in 2014 compared with 2009. The change in feed expense and the opportunity cost of labour shares was mixed. The opportunity cost of land share consistently decreased across time whereas the operating-expense ratio worsened. Chenbaerhuqi decreased stocking rate, which resulted in decreased feed expenses and opportunity cost of land.

These strong negative outcomes across the five 'poor' financial-state counties may be due to a large number of weather shocks reported between 2009 and 2014. Drought was reported in all counties, with the lowest occurrence in Dongwuzhumuqinqi (3%) and the highest in Sunitezuoqi (98%). Snowstorms affected all five counties as well, with <40% reporting in Etuokeqi and Chenbaerhuqi, whereas >48% reported in Dongwuzhumuqinqi, Sunitezuoqi and Xilinhaote. The timing of a drought vs a snowstorm could have serious impacts for the agricultural producer and could explain some of the variation in these results. Of these five counties, Xilinhaote was the only one to report a locust shock, and it had the largest range in profit across the 5 years.

### *Benchmark D: very poor counties*

A 'very poor' financial state resulted from negative profit per SU in both years. Four counties were included in this group (Suniteyouqi, Ewenkeqi, Siziwangqi, Xianghuangqi) and represented three ecosystems. Ewenkeqi and Xianghuangqi decreased their stocking rate over the period and had mixed profit and expense-share results. Ewenkeqi improved negative profit across the 5 years, whereas the opposite held for Xianghuangqi. Herders in Suniteyouqi and Siziwang increased their stocking rates, which did not improve profit per SU.

These 'very poor' financial-state counties experienced the greatest number of weather events during the study period. Drought was reported most frequently in Suniteyouqi county (98%), followed by Siziwangqi (85%) and Ewenkeqi (58%). Only 5% of the respondents in Xianghuangqi reported a drought but 72% reported a snowstorm. Xianghuangqi had the largest range in negative profits of the 15 counties included in the study. Although Xianghuangqi herders decreased their stocking rate, there was relatively little change in their expense shares, which resulted in an overall increase in their operating expense ratio.

### *Assuming zero opportunity costs for land and labour*

Figure 1 shows the average profits in 2009 and 2014 by accounting and economic profits. As discussed above, economic profits varied greatly over the counties, with some years positive, but also many counties showing negative profits on average for a year. Accounting profits, however, were positive for all years and all counties except for one county-year (Xianghuang in 2014). Although the variation in accounting profit broadly matched the variation in economic profit, if herders were looking at this measure alone for understanding the profitability of their operations, they would appear, relative to economic profit calculations, much better off.

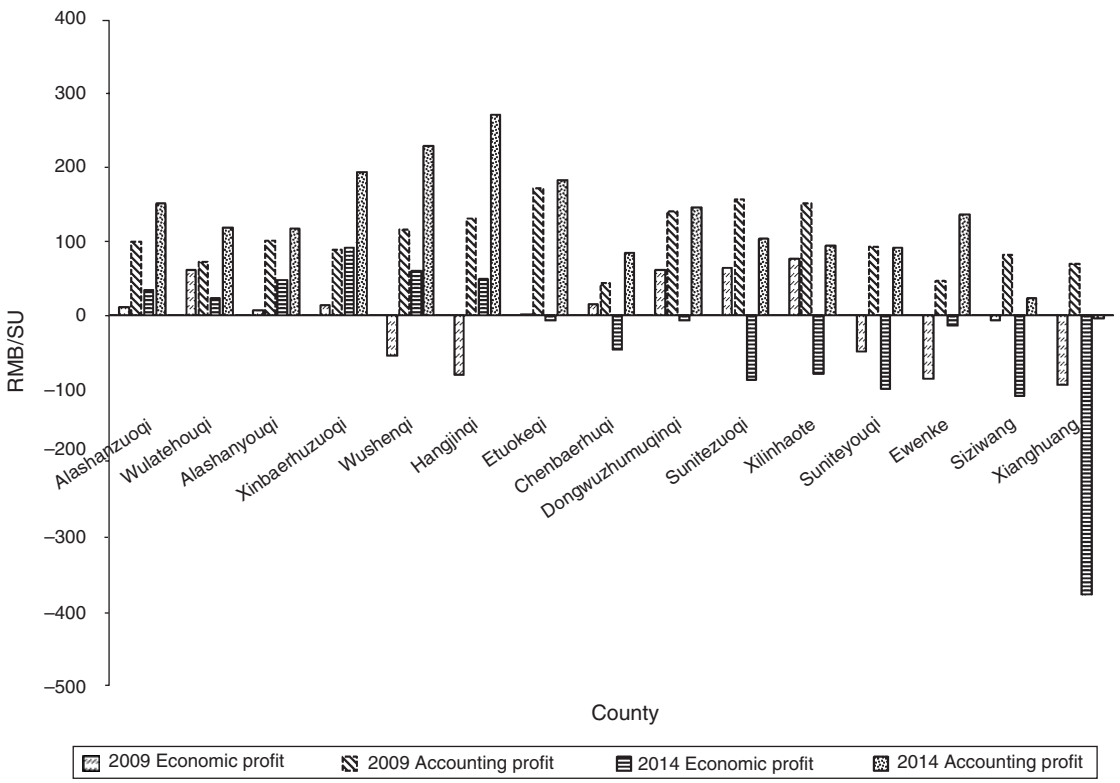


**Fig. 1.** Accounting vs economic profit by county across years. SU, Sheep units.

## Discussion and conclusions

Collecting historical data at the household level allowed us to examine the change in stocking rates and operating expenses over time across ecosystems. We collected data for the same households over a 5-year period to estimate levels to measure this potential change in decision making. Across the 15 counties, six decreased their stocking rates but had improved profit per SU over time. The remaining nine counties increased their stocking rate, which resulted in decreased profit per SU for all but one county. These trends broadly suggest that grassland resources may be limited and that reducing stock rates allows for greater overall productivity, following other results from the literature (Kemp *et al*. 2013; Shang *et al*. 2014; Briske *et al*. 2015; Zhang *et al*. 2015). The herders that jointly increased stocking rates and had a positive profit in 2009 tended to experience decreased feed expenses and opportunity cost of land shares over the 5 years. Jointly, their opportunity cost of labour share and operating-expense ratios increased. This demonstrates that increasing the SU per hectare further constrained the limited resources available, which resulted in negative changes to profit over time, even though the herder may have viewed the additional livestock as wealth accumulation.

This analysis estimated economic livestock-enterprise budgets to provide county-level benchmarks for IMAR herders. If we remove the opportunity cost of labour and land from our enterprise budgets, we observe a very different outcome. In this case, all counties received a positive profit across the years except Xianghuangqi in 2014. This may help to explain why many of these livestock operations are still in business even after seemingly having such large negative profits across the years. Without capturing the value of their labour or the land, it appears that households are making a positive profit, so they are able to continue producing. In the short term, this strategy pays bills, because households can use their livestock as an 'asset savings account'. But how does this affect the long-run profit potential of the livestock operation, specifically as it relates to wealth accumulation? A business becomes more successful as it builds its wealth (equity) base. Livestock operations build their wealth through assets, specifically land and livestock (Kay *et al*. 2012). Because of the long-term lease option in Inner Mongolia, livestock producers can build their wealth only through livestock and saving their profit over time, which eventually becomes the retirement account for the agricultural producer. The opportunity cost of land is included to build a safety net for the opportunity to build equity in the operation. We expect that agricultural producers are capturing this wealth through additional livestock (increased stocking rates), buying other assets that hold long-term value, or contributing to a savings account for retirement.

We also observe that, perhaps unsurprisingly, livestock operations seem quite vulnerable to natural shocks overall. Counties with lower reports of damaging shock events broadly perform better than counties that report high frequencies of shock events. This suggests a broad role for policy to play in protecting or supporting households to buffer the impacts of natural disasters.

The benchmark analysis provides herders in the regions represented in this analysis with a specific goal for financial and production level goals. In industrialised regions, benchmarks are used to compare farm-level performance to similar systems to make performance improvements. Our analysis shows stark contrast between desert ecosystem and typical or meadow steppe herders. This suggests that different recommendations should be made based on ecosystem type, as is common in more industrialised agricultural regions (e.g. USA). Additionally, as credit becomes more readily available in IMAR, lenders may choose to use this information to see whether an individual herder is performing to the level of their peers when making financing decisions.

Although our study population has unique social and political characteristics, our results provide insights into the relationship between farm-level decisions and ecological considerations within rangeland systems, particularly in transitioning economic conditions. This analysis validates previous recommendations regarding how stocking rate decisions are influenced by external factors. As shown in our results, stocking rates changed across time, probably due to feed availability and its relationship with operating-expense shares and profitability. Although decreasing stocking rates across time was not successful for all counties, it allows us to identify stocking-rate programs for target regions. Specifically, livestock operations in the meadow steppe, desert steppe and typical steppe regions had the greatest fluctuation in profit over the past 5 years in addition to the largest reported external weather shocks. These areas would benefit from future additional programming targeting stocking rates and proactive management.

## Conflicts of interest

The authors declare no conflicts of interest.

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**Appendix 1. Sandy steppe ecosystem economic livestock enterprise budgets, 2009 and 2014**

| Item | Etuokeqi | | Hangjinqi | | Wushenqi | |
|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 |
| | | | *Revenue (RMB sheep units$^{-1}$)* | | | |
| Livestock | 271.50 | 387.94 | 262.05 | 479.37 | 208.30 | 367.78 |
| Total revenue | 271.50 | 393.96 | 262.05 | 500.69 | 208.30 | 370.82 |
| | | | *Operating expenses* | | | |
| Purchased animal | 0.00 | 0.06 | 0.00 | 3.20 | 0.00 | 0.59 |
| Hired labour | 9.29 | 11.38 | 6.22 | 10.18 | 10.66 | 6.97 |
| Rented grassland | 6.26 | 8.37 | 7.49 | 17.83 | 1.96 | 0.89 |
| Hay | 0.00 | 6.09 | 0.00 | 1.48 | 0.00 | 6.52 |
| Silage | 0.00 | 0.09 | 0.00 | 3.70 | 0.00 | 0.46 |
| Grain or fine feed | 20.19 | 44.77 | 37.98 | 80.38 | 2.82 | 6.19 |
| Other feeds | 1.34 | 42.53 | 5.26 | 29.55 | 0.40 | 0.54 |
| Gas | 12.05 | 23.18 | 10.19 | 19.74 | 8.41 | 26.69 |
| Diesel | 9.02 | 12.16 | 17.08 | 11.80 | 12.21 | 17.28 |
| Machinery repairs | 0.96 | 17.20 | 3.23 | 15.39 | 1.69 | 24.29 |
| Labour, opportunity cost | 113.32 | 137.79 | 163.38 | 214.54 | 145.13 | 143.05 |
| Land rental (owned) | 56.26 | 51.24 | 47.92 | 8.08 | 25.24 | 26.10 |
| Electricity and water costs | 1.87 | 8.87 | 13.06 | 0.00 | 13.47 | 14.64 |
| Total operating expenses | 203.57 | 363.72 | 311.81 | 415.87 | 221.99 | 274.21 |
| | | | *Ownership expenses* | | | |
| Motorcycle | 2.47 | 1.24 | 3.21 | 2.15 | 2.52 | 1.50 |
| Pickup | | 0.54 | | 5.09 | | 0.81 |
| Car | 15.68 | | 11.30 | | 19.22 | |
| Tractor | 1.63 | 2.07 | 2.34 | 1.72 | 4.47 | 5.10 |
| Three wheeler | 0.52 | 0.05 | 1.00 | 1.13 | 0.34 | 0.00 |
| Other machines | 0.24 | 2.57 | 1.93 | 0.31 | 0.61 | 1.43 |
| Shed | 5.81 | 10.80 | 5.66 | 8.93 | 6.36 | 11.18 |
| Shed for hay | 0.00 | 3.16 | 0.00 | 4.19 | 0.00 | 2.89 |
| Fence | 7.53 | 11.93 | 1.19 | 2.37 | 2.73 | 7.44 |
| Well | 5.34 | 4.62 | 3.32 | 9.62 | 3.52 | 5.71 |
| Silo | 0.32 | 0.41 | 0.46 | 0.54 | 0.63 | 0.98 |
| Total ownership expenses | 39.54 | 37.39 | 30.41 | 36.05 | 40.40 | 37.05 |
| Total expense | 270.11 | 401.11 | 342.22 | 451.92 | 262.39 | 311.27 |
| Profit before taxes | 1.38 | –7.15 | –80.17 | 48.77 | –54.09 | 59.55 |

**Appendix 2. Meadow steppe ecosystem economic livestock enterprise budgets, 2009 and 2014**

| Item | Ewenke | | Chenbaerhuqi | | Xinbaerhuzuoqi | |
|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 |
| | | | *Revenue (RMB sheep units$^{-1}$)* | | | |
| Livestock | 88.47 | 321.91 | 83.64 | 242.50 | 123.21 | 280.39 |
| Total revenue | 88.47 | 325.45 | 83.64 | 243.96 | 123.21 | 282.55 |
| | | | *Operating expenses* | | | |
| Purchased animal | 0.00 | 4.04 | 0.00 | 0.88 | 0.00 | 0.00 |
| Hired labour | 16.24 | 32.82 | 10.39 | 50.48 | 12.42 | 26.95 |
| Rented grassland | 3.11 | 5.18 | 0.92 | 4.98 | 4.07 | 13.00 |
| Hay | 1.76 | 22.79 | 4.97 | 22.99 | 5.87 | 5.94 |
| Silage | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Grain or fine feed | 4.93 | 38.35 | 6.56 | 15.68 | 1.50 | 2.15 |
| Other feeds | 0.50 | 13.67 | 0.12 | 5.84 | 0.28 | 4.53 |
| Gas | 2.75 | 7.98 | 1.90 | 4.33 | 1.32 | 7.39 |
| Diesel | 5.68 | 24.93 | 7.20 | 21.14 | 4.30 | 11.24 |
| Machinery repairs | 0.00 | 11.96 | 0.00 | 11.46 | 0.00 | 7.24 |
| Labour, opportunity cost | 107.80 | 124.79 | 1.26 | 53.88 | 43.89 | 56.14 |
| Land rental (owned) | 24.15 | 25.01 | 26.80 | 76.35 | 30.99 | 46.22 |
| Electricity and water costs | 0.00 | 3.57 | 0.94 | 1.95 | 0.00 | 0.46 |
| Total operating expenses | 166.92 | 315.08 | 61.06 | 269.95 | 104.64 | 181.26 |
| | | | *Ownership expenses* | | | |
| Motorcycle | 0.98 | 2.18 | 0.60 | 0.66 | 0.87 | 0.96 |
| Pickup | | 0.00 | | 0.25 | | 0.04 |
| Car | 0.53 | | 0.90 | | 1.68 | |
| Tractor | 1.72 | 7.78 | 2.16 | 6.67 | 1.31 | 2.62 |
| Three wheeler | 0.00 | 0.08 | 0.00 | 0.23 | 0.00 | 0.06 |
| Other machines | 1.93 | 5.42 | 0.88 | 5.31 | 0.50 | 2.06 |
| Shed | 1.71 | 7.10 | 1.91 | 5.32 | 0.39 | 3.86 |
| Shed for hay | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fence | 0.02 | 0.42 | 0.14 | 0.00 | 0.25 | 0.22 |
| Well | 0.05 | 0.58 | 0.16 | 1.36 | 0.09 | 0.78 |
| Silo | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 |
| Total ownership expenses | 6.94 | 23.57 | 6.75 | 19.82 | 5.09 | 10.59 |
| Total expense | 173.85 | 338.66 | 67.81 | 289.77 | 109.72 | 191.86 |
| Profit before taxes | –85.38 | –13.21 | 15.83 | –45.81 | 13.49 | 90.69 |

**Appendix 3. Desert ecosystem economic livestock enterprise budgets, 2009 and 2014**

| Item | Wulatehouqi | | Alashanzuoqi | | Alashanyouqi | |
|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 |
| | | | *Revenue (RMB sheep units$^{-1}$)* | | | |
| Livestock | 155.06 | 310.19 | 144.69 | 256.73 | 136.31 | 208.41 |
| Total revenue | 155.06 | 312.90 | 144.69 | 257.36 | 136.31 | 210.58 |
| | | | *Operating expenses* | | | |
| Purchased animal | 0.28 | 2.58 | 1.73 | 1.61 | 0.11 | 0.26 |
| Hired labour | 0.00 | 0.45 | 0.26 | 0.58 | 0.00 | 1.68 |
| Rented grassland | 2.22 | 1.14 | 0.56 | 0.14 | 0.00 | 0.00 |
| Hay | 0.00 | 0.00 | 0.00 | 0.55 | 7.25 | 0.10 |
| Silage | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.50 |
| Grain or fine feed | 57.64 | 111.84 | 27.78 | 49.15 | 15.16 | 31.68 |
| Other feeds | 13.19 | 43.17 | 0.00 | 13.81 | 0.00 | 20.06 |
| Gas | 2.95 | 12.72 | 4.38 | 9.98 | 4.97 | 12.96 |
| Diesel | 0.56 | 1.77 | 2.24 | 4.70 | 1.19 | 3.26 |
| Machinery repairs | 0.43 | 6.57 | 0.35 | 9.24 | 0.30 | 7.88 |
| Labour, opportunity cost | 1.53 | 62.38 | 78.38 | 84.15 | 78.02 | 24.11 |
| Land rental (owned) | 9.36 | 32.88 | 10.00 | 33.79 | 16.52 | 45.74 |
| Electricity and water costs | 2.24 | 0.83 | 0.78 | 0.53 | 0.00 | 0.40 |
| Total operating expenses | 90.40 | 276.32 | 126.46 | 208.23 | 123.50 | 150.62 |
| | | | *Ownership expenses* | | | |
| Motorcycle | 2.01 | 1.55 | 2.09 | 1.81 | 2.46 | 1.98 |
| Pickup | | 5.01 | | 6.23 | | 3.97 |
| Car | 0.21 | | 0.39 | | 1.84 | |
| Tractor | 0.07 | 0.11 | 0.69 | 0.93 | 0.00 | 0.06 |
| Three wheeler | 0.12 | 0.37 | 0.09 | 2.07 | 0.18 | 1.25 |
| Other machines | 0.19 | 0.04 | 1.56 | 0.10 | 0.37 | 0.58 |
| Shed | 0.68 | 3.43 | 0.74 | 1.39 | 0.88 | 1.13 |
| Shed for hay | 0.00 | 0.62 | 0.00 | 0.34 | 0.00 | 0.25 |
| Fence | 0.18 | 0.92 | 1.39 | 1.99 | 0.42 | 2.42 |
| Well | 0.15 | 1.47 | 0.47 | 0.57 | 0.00 | 0.47 |
| Silo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total ownership expenses | 3.62 | 13.53 | 7.42 | 15.44 | 6.16 | 12.11 |
| Total expense | 94.02 | 289.85 | 133.88 | 223.67 | 129.66 | 162.73 |
| Profit before taxes | 61.03 | 23.06 | 10.82 | 33.69 | 6.65 | 47.85 |

**Appendix 4. Desert steppe ecosystem economic livestock enterprise budgets, 2009 and 2014**

| Item | Siziwang | | Sunitezuoqi | | Suniteyouqi | |
|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 |
| | | | *Revenue(RMB sheep units$^{-1}$)* | | | |
| Livestock | 158.97 | 219.83 | 217.65 | 295.26 | 198.89 | 331.84 |
| Total revenue | 158.97 | 221.01 | 217.65 | 298.54 | 198.89 | 337.32 |
| | | | *Operating expenses* | | | |
| Purchased animal | 8.58 | 4.47 | 0.00 | 0.00 | 0.20 | 21.67 |
| Hired labour | 8.21 | 9.96 | 2.07 | 0.39 | 0.21 | 0.16 |
| Rented grassland | 2.47 | 2.98 | 5.37 | 12.08 | 3.02 | 1.55 |
| Hay | 6.92 | 52.44 | 13.65 | 79.59 | 28.06 | 58.27 |
| Silage | 0.00 | 0.14 | 1.55 | 0.00 | 2.50 | 0.16 |
| Grain or fine feed | 32.42 | 88.72 | 16.16 | 53.60 | 46.27 | 101.37 |
| Other feeds | 0.00 | 6.81 | 0.01 | 8.59 | 0.24 | 11.52 |
| Gas | 3.77 | 8.63 | 4.07 | 8.82 | 4.78 | 11.65 |
| Diesel | 6.97 | 8.93 | 4.50 | 7.41 | 10.51 | 14.08 |
| Machinery repairs | 0.12 | 4.40 | 0.00 | 6.00 | 0.02 | 6.59 |
| Labour, opportunity cost | 70.50 | 102.29 | 63.35 | 111.00 | 114.34 | 139.87 |
| Land rental (owned) | 18.48 | 28.98 | 29.92 | 79.84 | 26.98 | 50.16 |
| Electricity and water costs | 0.00 | 0.39 | 0.00 | 0.34 | 0.00 | 0.71 |
| Total operating expenses | 158.43 | 319.15 | 140.66 | 367.65 | 237.11 | 417.77 |
| | | | *Ownership expenses* | | | |
| Motorcycle | 1.47 | 1.02 | 1.60 | 1.15 | 2.67 | 1.40 |
| Pickup | | 0.31 | | 2.38 | | 0.34 |
| Car | 1.05 | | 3.77 | | 1.19 | |
| Tractor | 0.29 | 0.01 | 0.23 | 0.02 | 0.38 | 0.06 |
| Three wheeler | 0.18 | 2.68 | 0.49 | 2.37 | 0.94 | 2.81 |
| Other machines | 1.91 | 0.00 | 2.09 | 0.07 | 1.48 | 0.11 |
| Shed | 1.17 | 3.31 | 1.07 | 3.73 | 1.64 | 5.24 |
| Shed for hay | 0.00 | 0.00 | 0.00 | 0.56 | 0.00 | 0.56 |
| Fence | 0.66 | 1.33 | 2.97 | 5.11 | 1.37 | 4.30 |
| Well | 0.43 | 1.62 | 0.80 | 2.59 | 0.72 | 3.42 |
| Silo | 0.01 | 0.00 | 0.05 | 0.07 | 0.05 | 0.04 |
| Total ownership expenses | 7.18 | 10.28 | 13.06 | 18.05 | 10.42 | 18.29 |
| Total expense | 165.61 | 329.43 | 153.73 | 385.70 | 247.53 | 436.05 |
| Profit before taxes | –6.64 | –108.42 | 63.92 | –87.16 | –48.64 | –98.74 |

**Appendix 5. Typical steppe ecosystem economic livestock enterprise budgets, 2009 and 2014**

| Item | Xianghuang | | Xilinhaote | | Dongwuzhumuqinqi | |
|---|---|---|---|---|---|---|
| | 2009 | 2014 | 2009 | 2014 | 2009 | 2014 |
| | | | *Revenue(RMB sheep units$^{-1}$)* | | | |
| Livestock | 221.66 | 315.16 | 291.27 | 292.22 | 196.20 | 268.22 |
| Total revenue | 221.66 | 318.00 | 291.27 | 295.47 | 196.20 | 270.08 |
| | | | *Operating expenses* | | | |
| Purchased animal | 0.00 | 0.00 | 1.24 | 0.00 | 0.00 | 0.00 |
| Hired labour | 0.19 | 0.28 | 10.55 | 32.97 | 13.82 | 41.76 |
| Rented grassland | 20.52 | 56.14 | 20.73 | 40.49 | 5.51 | 12.90 |
| Hay | 53.13 | 93.06 | 52.47 | 49.31 | 7.45 | 19.83 |
| Silage | 0.00 | 0.41 | 0.11 | 0.00 | 0.00 | 0.00 |
| Grain or fine feed | 53.80 | 104.02 | 24.71 | 35.71 | 4.68 | 13.06 |
| Other feeds | 0.00 | 16.40 | 0.00 | 8.27 | 0.00 | 6.89 |
| Gas | 6.17 | 16.95 | 4.72 | 10.11 | 4.94 | 10.20 |
| Diesel | 3.29 | 7.52 | 6.98 | 8.89 | 3.70 | 6.79 |
| Machinery repairs | 1.08 | 7.34 | 1.01 | 1.08 | 2.69 | 2.10 |
| Labour, opportunity cost | 131.22 | 297.22 | 49.74 | 127.19 | 48.61 | 110.47 |
| Land rental (owned) | 32.48 | 75.55 | 25.08 | 44.86 | 30.12 | 41.50 |
| Electricity and water costs | 0.00 | 5.74 | 0.51 | 2.24 | 0.76 | 0.35 |
| Total operating expenses | 301.89 | 680.65 | 197.83 | 361.13 | 122.26 | 265.86 |
| | | | *Ownership expenses* | | | |
| Motorcycle | 2.80 | 2.18 | 1.29 | 1.01 | 1.04 | 0.81 |
| Pickup | | 0.18 | | 0.17 | | 1.30 |
| Car | 1.25 | | 5.65 | | 4.71 | |
| Tractor | 1.82 | 1.49 | 1.67 | 1.26 | 0.90 | 0.81 |
| Three wheeler | 0.02 | 0.69 | 0.07 | 0.34 | 0.01 | 0.19 |
| Other machines | 1.24 | 1.92 | 2.36 | 0.68 | 0.74 | 0.67 |
| Shed | 1.95 | 7.22 | 2.86 | 6.08 | 1.59 | 4.86 |
| Shed for hay | 0.00 | 0.09 | 0.00 | 0.20 | 0.00 | 0.18 |
| Fence | 4.42 | 0.00 | 2.11 | 0.06 | 2.84 | 0.05 |
| Well | 0.20 | 0.64 | 0.77 | 2.95 | 0.77 | 1.57 |
| Silo | 0.10 | 0.00 | 0.09 | 0.00 | 0.01 | 0.00 |
| Total ownership expense | 13.81 | 14.43 | 16.86 | 12.75 | 12.63 | 10.45 |
| Total expense | 315.70 | 695.08 | 214.69 | 373.87 | 134.89 | 276.31 |
| Profit before taxes | –94.04 | –377.08 | 76.58 | –78.40 | 61.31 | –6.23 |