

# **Does Diversification Translate into Improved Livelihoods? Evidence from Pastoral Households in the Altay and Tianshan Mountains of Xinjiang, China**

Chuan Liao, Christopher B. Barrett and Karim-Aly S. Kassam<sup>\*</sup>

Cornell University

December 2014 revised version

## **Acknowledgements**

This research was supported by the China Scholarship Council, the Towards Sustainability Foundation, and the Sigma Xi Grant. Xinjiang Agriculture University was a base of operations and provided logistical support. This research would not have been possible without the participation of 159 pastoral households. Not only did they share their knowledge, they also offered food and accommodation. We are deeply indebted to all these people for their kindness and generosity. We also thank Shazhou An, Batu, Haerken, Yongwei Tian, Kadeerbieke, Jianaer, Chao Li, and Yeerbo for their facilitation and translation in the field, and Steve Morreale, Pat Sullivan and three anonymous reviewers for helpful comments on earlier drafts. Any remaining errors are our sole responsibility.

---

<sup>\*</sup> Liao and Kassam: Department of Natural Resources, Fernow Hall, Cornell University, Ithaca, NY, 14853, USA. Barrett: Charles H. Dyson School of Applied Economics and Management, Warren Hall, Cornell University, Ithaca, NY 14853 USA. Liao is corresponding author at [cl824@cornell.edu](mailto:cl824@cornell.edu), tel: (1) 713-822-0959, fax: (1) 607-255-0349.

## **ABSTRACT**

Diversification is routinely promoted to improve poor rural peoples' livelihoods. However, policy recommendations for livelihood diversification developed based on evidence from crop-cultivating sedentary rural societies may not work for the mobile pastoral communities, where socio-ecological conditions predetermine livestock herding as the preferred livelihood strategy. Using survey and semi-structured interview data collected from 159 households in the Altay and Tianshan Mountains of Xinjiang, China, this study applies cluster analysis to identify six distinct livelihood strategies: pastoralists, agropastoralists, crop farmers, wage labourers, hired herders, and mixed smallholders. Although pastoralism is least diverse by considering sources of income, it is significantly more diverse in ecological dimensions in terms of spatial movement, land use pattern, and livestock portfolio. Patterns of livelihood diversification and their relationship with household incomes indicate that pastoralism, although preferred, is unattainable for 55 per cent of households given their meagre asset endowments and government policy pressures toward sedentarisation. The results strongly suggest that livelihood diversification does not improve welfare for pastoral households. Future development interventions should promote policies that enable households to regain flexible access to pastures and to help correct the imbalance of opportunities that exists in northern Xinjiang.

Key words: pastoral households; livelihood; diversification; cluster analysis; Xinjiang; China

## INTRODUCTION

The development studies literature has heavily emphasised the benefits of diverse livelihoods for rural populations (Bird & Shepherd, 2003; Ellis & Bahigwa, 2003; Ellis & Mdoe, 2003; Ellis et al., 2003; Bouahom et al., 2004; Freeman et al., 2004; Babulo et al., 2008; Ansoms & McKay, 2010; Soltani et al., 2012). A representative statement by a leading scholar in the field states that livelihood diversification is ‘the process by which rural households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living’ (Ellis, 2000a: 15). Livelihood diversification is beneficial to the rural poor because it can reduce risk and stabilise income flows and consumption (Barrett et al., 2001), and lead to improvements in quality of life, wealth accumulation, and food security (Coppock et al., 2011). A substantial amount of empirical evidence has shown that livelihood diversification can be an effective poverty reduction approach for rural communities in developing countries (Ellis, 1998, 2000a; Abdulai & CroleRees, 2001; Block & Webb, 2001; Smith et al., 2001; Carswell, 2002; Niehof, 2004; Bezu et al., 2012).

The merits of rural livelihood diversification are, however, debatable and likely vary across contexts. Although a considerable body of empirical evidence indicates that diversification can facilitate improved standards of living, the connection from livelihood diversification to increased incomes or other manifestations of higher quality of life is hardly automatic. Diversification might occur as both voluntary and involuntary responses to crisis, which can either diminish or accentuate rural inequality (Ellis, 2000a). Given context-specific factors such as poverty, policy pressures, and the overarching socio-political setting (Scoones, 2009), the process of diversification can be a struggle for survival rather than an opportunity for improvement (Ellis, 1998; Sen, 1999). Therefore, diversification cannot be assumed by policy makers to be desirable for the rural poor. As we show in this paper, diversification is not always effective. In certain settings, the socio-ecological context strongly favours a particular income-generating activity and specialisation according to comparative advantage pays. Misguided, even

if well-intentioned, efforts to induce rural peoples to diversify their livelihoods can harm households in such locations.

Arid and semi-arid lands (ASAL), which cover 41 per cent of the terrestrial earth surface (Blench, 2001), are such locations. The multiple socio-ecological challenges of life in these places have long favoured pastoral livelihoods that revolve around extensive livestock herding (Dong et al., 2011). Given heterogeneous distribution of natural resources in space and time, mobility is the key to ensure access to forage and water throughout the landscape (Butt et al., 2009; Moritz et al., 2010; Moritz et al., 2013). To pastoralists, a major concern is flexible access to different pastures in seasonally variable times of need, rather than fixed control of a specific piece of land with varying forage productivity. Therefore, scholars working in different pastoral contexts throughout the world have routinely concluded that future development activities must be built on the foundation of the livestock economy instead of seeking ways to replace it (Sandford, 1983; Little 1992; Banks, 2001, 2003; Fratkin & Roth 2005; McPeak et al., 2011).

The above policy recommendations have been rarely recognised in western China, where policy makers exhibit little awareness of lessons from other parts of the world. Pastoral policies currently implemented in western China are largely driven by the environmental crisis argument (Harris, 2010), which obscured the impacts of policies on pastoral livelihoods and welfare in Inner Mongolia (Humphrey & Sneath, 1999; Sneath, 2000), Tibet (Bauer, 2005; Fischer, 2008; Zhao, 2007; Yeh, 2013), and Xinjiang (Banks, 2003; Zukosky, 2007; Nie, 2006). Justified by the (contestable) argument that pastoralism is economically inefficient and environmentally unfriendly (Du et al., 2004; Han et al., 2008; Li et al., 2008), the government has implemented a series of ecological restoration and sedentarisation initiatives aimed at addressing pasture degradation (Xinhua, 2007). However, such policies may exacerbate resource degradation, threaten livelihood security, and disenfranchise marginalised people (Yeh, 2009). Empirical evidence from northern Xinjiang clearly indicates that while pastoralists generally acknowledged the environmental crisis, it is pasture fencing and sedentarisation policies that forced them from their traditional livelihoods and into townships where they struggle to establish a new viable means of survival (Liao et al., 2014a).

This study investigates livelihood diversification among Kazak pastoral households in the Altay and Tianshan Mountains of Xinjiang, China. Beyond offering important new insights on

an understudied population and location, we offer novel explorations of the relationship between livelihood diversification and household incomes in a pastoral setting. Using a combination of qualitative and quantitative methods, we first contextualise livelihood diversification in this ancient pastoral society. Then we quantify the degree of diversification and identify the factors that influence households' choice of livelihood strategy. The results clearly indicate that livelihood diversification hardly translates into higher incomes or better standards of living in northern Xinjiang. Even when other livelihood strategies are available, households with adequate assets choose pastoral production based on extensive livestock herding as virtually their only source of income, while those who lack these assets diversify into other less desirable livelihood strategies and exhibit considerably greater poverty.

The remainder of the paper proceeds as follows. First, the concept of livelihood diversification is contextualised in the Altay and Tianshan Mountains of northern Xinjiang, China, where Kazak pastoralists are the dominant rural population. Second, the study areas, data collection and analytical methods are presented. Third, livelihood portfolios including assets, income sources, and livelihood strategies identified by cluster analysis are demonstrated. Fourth, details of the identified six livelihood strategies are explored, including income diversity, ecological diversity, superiority of livelihood strategies, and barriers to adopt preferred strategy. The broader socio-ecological factors that influence livelihood diversification in the pastoral communities are discussed towards the end of this paper.

## **LIVELIHOOD DIVERSIFICATION CONTEXTUALISED**

While livelihood diversification theory generally works in sedentarised rural societies based on crop cultivation, some of its fundamental assumptions may not hold firmly in the pastoral society of northern Xinjiang. As argued by Ellis (1998: 29), 'diversification is an infinitely heterogeneous social and economic process, obeying a myriad of pressures and possibilities in the rural economy.' While abundant empirical evidence indicates that most rural crop cultivating households derive some income from activities other than primary agriculture (i.e., 'non-farm' activities) and/or away from their own farms (i.e., 'off-farm' activities) (Barrett et al., 2001), applying such dichotomous concepts of on-farm/off-farm or farm/non-farm fails to capture the diversity of income sources in a pastoral society. This is because 'on-farm' activities

include both crop cultivation and livestock herding, which are at the opposite ends of Kazak pastoralists' preference scale. Kazak pastoralists' knowledge relates primarily to searching for greener pastures across heterogeneous landscapes throughout the year. Their diversification is spatio-temporal, based on seasonal migration, rather than occupational, based on the deployment of diversified assets to diverse activities. The ecological settings endow Kazak pastoralists with comparative advantage in extensive livestock herding and their culture has refined the art of animal husbandry to reinforce their ecological endowments. These endowments reflect diversity in terms of altitudinal range and ecological niche. However, the Kazaks hold no comparative advantage, especially relative to sedentary Han Chinese farmers, in crop cultivation (Liao et al., 2014b).

The literature on the rural non-farm economy, as those on livelihood diversification, routinely finds that non-farm occupations prove more remunerative for rural populations (Ellis, 2000b; Abdulai & CroleRees, 2001; Haggblade et al. 2007), and that poor households indeed seek non-farm diversification opportunities whenever possible (Barrett et al., 2001; Block & Webb, 2001; Barrett et al. 2005). However, these assumptions do not hold for the Kazak pastoralists for two primary reasons. First, livestock prices are attractive enough to pastoralists in northern Xinjiang that there is little motivation for them to engage in non-farm activities. Second, and relatedly, since most non-farm activities revolve around cities or towns dominated by the Han Chinese, entry into these activities is a challenging task for the Kazaks who can barely speak Chinese and have little interaction with the non-pastoral world and thus do not know the social customs of their prospective clients and suppliers.

Another rationale for diversification is as an effective risk minimisation strategy (Ellis, 2000b; Abdulai & CroleRees, 2001). However, in rangeland ecosystems routinely in disequilibrium, biophysical conditions such as precipitation, temperature, and soils allow few land use options other than mobile livestock herding (Ellis & Swift, 1988; Behnke, 1993; Sullivan & Rohde, 2002; Gillson & Hoffman, 2007; Barrow et al., 2007; Nori, 2007). Occupational diversification typically requires sedentarisation, which merely magnifies the perils of pastoralism. Instead, livestock species diversification by mixing browsers and grazers that are complementary in their use of rangeland resources appears a more effective risk minimisation strategy in this setting.

Pastoral households in northern Xinjiang diversify assets, incomes, and activities mostly due to ‘push factors’ – because they are compelled by adverse circumstances – rather than ‘pull factors’ that attract them to an improved standard of living (Liao et al., 2014b). The Twelfth Five Year Plan of China explicitly expressed the intention to ‘civilise’ the pastoralists of Xinjiang by settling them and transforming their livelihoods (National Development and Reform Commissions, 2011). Under the overall national plan, specific ecological restoration, sedentarisation, and development projects have been initiated in western China (Ma, 2008; Nie, 2006). These policies represent ‘push factors’ as disadvantaged indigenous peoples have become compelled to diversify their livelihoods in the face of further economic disenfranchisement and social marginalisation. Yet these efforts have brought few if any environmental benefits (Yeh, 2009), as they were based on locally-inappropriate equilibrium theories of rangeland resource dynamics that discourage the communal use of pastures and traditional rangeland management practices. Given these challenges, pastoralists in Xinjiang have responded by accepting sedentarisation, diversifying their income sources, and, where feasible, even emigrating to other countries (Cerny, 2010; Fernandez-Gimenez & Le Febre, 2006).

## **STUDY AREAS, DATA COLLECTION, AND ANALYTICAL METHODS**

### **Study Area**

The Xinjiang Uyghur Autonomous Region (XUAR) is situated in northwestern China, spanning over 1.6 million square kilometres at the centre of the Eurasian landmass. Its physical geography is commonly characterised as ‘two basins within three mountains’. As the most remote region from any oceans in the world, water vapour from the sea almost disappears after it travels such long distances and crosses mountain barriers. This is the basic condition that leads to the arid and semi-arid climate in Xinjiang (Li, 1991).

Pasture lands are the basis of pastoral livelihoods in Xinjiang. The steppe and meadow pastures mainly distributed in mountainous regions are used for summer grazing. The vast Gobi desert is also used by pastoralists, especially in winter (Zhang, 2007). Livestock herding in northern Xinjiang is practiced on a seasonal basis. In general, pastoralists spend 2.5 to 3.5 months on summer pastures each year, mainly on meadows/steppes above 2000 metres. Winter grazing lands are mostly in the Gobi desert areas with an elevation lower than 800 metres. These

lands can be grazed for 2.5 to 3.5 months per year. The spring/fall pastures serve as the transitional zone between summer pastures and winter grazing lands. These transitional pastures are mainly steppes located in the semi-arid areas. Pastoralists generally spend 1.5 to 2.5 months on these pastures in both spring and fall (Liao et al., 2014a).

We conducted fieldwork in the Altay Mountains of Altay District and the Tianshan Mountains of Ili Prefecture in northern Xinjiang, where pastoralism is the major livelihood strategy. Traditionally, livestock herding activities were organised in the unit of tribes. Each tribe had its own winter, spring/fall, and summer pastures, which were exclusive to other tribes. Although the pastures were shared by all tribe members, the livestock were owned by individual households. Changes started in 1960s, as pastoralists were forced to 'hand in' their livestock and herd for the communes. In mid-1980s, decollectivisation spread to these remote areas of China, and livestock and pasture lands were assigned to individual households according to the number of family members (Banks, 2003). Therefore, we assume that each household had the same per capita asset endowments prior to subsequent diversification.

## **Data Collection**

A burgeoning literature in development studies is based on field data collection using a combination of qualitative and quantitative methods, which is thought to be able to generate more effective policy interventions than reliance on either set of methods on its own (White, 2002; Ellis & Mdoe, 2003; Ellis & Bahiigwa, 2003). In view of these considerations, our data collection in the field adopted mixed methods in which the quantitative aspects focused on asset, activity, and income factors at the household level, while qualitative components were devoted to capturing the broader socio-cultural contexts of livelihood diversification.

Selection of households was made on the basis of representativeness of different rural livelihoods along the annual pastoral migration corridors, namely overwintering villages, transitional pastures, and summer pastures. Such gradients also reflect the ecological differences, as overwintering villages are usually established in the lowlands close to Gobi desert, while summer pastures are mostly montane meadows situated at higher elevations, with transitional pastures in between.

To achieve these sampling goals, we first recorded the coordinates of the participant household using a Geographic Positioning System (GPS) instrument, and then asked standardised survey questions regarding demographic background, household assets, cash-generating activities, and income from each source. In addition, we asked open-ended questions in terms of the perceptions of change in income strategies and activities, human welfare, pasture conditions, land tenure, and pastoral policies. The questions were asked in Chinese, and translated into Kazak by a local facilitator fluent in Chinese and Kazak. Responses were recorded in field notebooks and major themes were summarised and post-coded.

We collected data from 159 pastoral households at individual homes including houses, huts, yurts, and tents in the summer of 2011. Ninety-six of them were in Altay District, covering four counties, including Aletai, Fuhai, Buerjin, and Habahe (Figure 1a). Sixty-three of them were in Ili Prefecture, covering six counties, including Zhaosu, Tekesi, Gongliu, Xinyuan, Nileke, and Yining (Figure 1b). Kazak households accounted for 91 per cent of our sample, while the remainder are all Mongol households. Within-sample variation is therefore not due to ethnic differences among study subjects.

Figure 1 here

It is worth pointing out that our data collection strategy was not intended to make inferences about the larger pastoral populations from which the samples were selected. The purpose of sampling is to capture a range of livelihood patterns along pastoral migration routes that probably contain a substantial proportion of rural pastoral households in northern Xinjiang. We make no claims of statistical representativeness for Altay and Ili as a whole from the 159 sampled households.

## **Analytical Methods**

In empirical work, livelihood strategies are often identified via a series of rules that separate the sample into pre-defined groups (Ellis & Bahiigwa, 2003; Ellis & Mdoe, 2003; Ellis et al., 2003; Freeman et al., 2004; Barrett et al., 2005). A variety of approaches exist, based on rules stemming from different theoretical foundations. Among these approaches, an iterative, data-driven approach based on cluster analysis is gaining popularity (Petrovici & Gorton, 2005;

Brown, et al., 2006; Jansen, et al., 2006). This is a statistical data reduction method for classifying a large number of multivariate observations into smaller and tractable subgroups characterised by maximising intra-group homogeneity and inter-group heterogeneity (Everitt et al., 2011). In this approach, some latent common characteristics within the data allow one to put individual observations into subgroups based on similarity along some specific parameters.

Following the lead of previous papers that used cluster analysis for livelihoods classification, we conducted the analysis based on the share of income<sup>1</sup> from different sources to identify different livelihood strategies in northern Xinjiang. More specifically, we performed k-means cluster analysis to assign each household into a distinct group based on their share of income from each source. The k-means method uses the local structure of the data to delineate clusters by iteratively minimizing the within-group sum of squared errors<sup>2</sup>. Since cluster analysis is a heuristic classification procedure rather than a statistical test, we used the Simple Structure Index, which is a good indicator of the best partitioning of the data (Borcard, 2011), as the criterion for selecting the optimal k value in addition to common sense check.

Further validation of the identified clusters was achieved by comparing how these groups of households differ from each other regarding their total household cash income. We also conducted t-tests to examine the ecological diversity of livelihood strategies. In addition, we performed stochastic dominance analysis to establish statistically which clusters yield superior income draws relative to others. Built upon such an ordering among observed livelihood strategies, we further conducted binomial regression to tease out the factors that were associated with the adoption of distinct livelihood strategies, with the objective of identifying the correlates of access to the most remunerative strategy.

## **LIVELIHOOD PORTFOLIOS**

---

<sup>1</sup> Income is a proxy for living standards, which are subject to variation in environmental conditions that are beyond the control of individuals. The inherent flexibility of pastoralism is geared toward overcoming such uncertainty. In face of the environmental challenges, they increase their movement frequency to obtain enough water and fodder to minimize adverse impacts. Therefore, sources of income can be used as a viable input for livelihood strategy analysis in this context.

<sup>2</sup> This is measured with respect to the Euclidean norm of the cluster means across the vector of variables used as defining characteristics. Since k-medians cluster analysis yielded qualitatively identical results in these data, we omitted those results.

## **Household Assets**

Ownership of or access to assets that can be used for income-generating purposes is the basis for the poor to establish viable means of survival (Moser, 1998). In northern Xinjiang, the key to pastoral production involves various types of livestock and lands. Cash income from livestock sale directly supports the survival of pastoralists under harsh environments. Keeping different types of livestock including cattle, sheep, goats, horses, and camels allows the pastoral households to maximise the utilisation of pastures while minimising adverse impacts of environmental fluctuations. A combination of hay fields close to the Gobi desert, summer pastures in montane meadows, and transitional pastures in between serves as the ecological basis of livestock herding in northern Xinjiang.

### ***Land***

There are three types of lands owned<sup>3</sup> by the households in our study. The first type is pasture land, which is directly associated with the pastoral livelihoods. Pasture lands can be further divided into two types, including summer pastures on the montane meadows and transitional pastures closer to overwintering villages. Summer pastures serve as the places for fattening livestock, while transitional pastures provide forage in spring and fall when summer pastures are covered by snow. For our sample as a whole, only 69 per cent of households claim ownership over pasture lands. Due to various reasons such as mining, tourism development, pasture fencing, and sedentarisation, pastoralists gradually lost access to pasture lands.

Hay fields are another important type of land that is crucial to livestock production, serving as the source of fodder for winter consumption. These lands are usually situated in places close to the desert with minimal impact from snow in winter. Some of these lands are used for free range, while others serve as sources for fodder harvest. About 77 per cent of households in our sample own hayfields. Since the utilisation of pastures and hayfields involves constant movement and their boundaries are fuzzy among households, we focused on discrete ownership rather than continuous land size measures.

---

<sup>3</sup> Land ownership in this study does not mean that households privately own the land, but rather that they have 50 years' land tenure. According to the Chinese land law, all lands in China are owned by the state, while individuals only have the right to use them. Land sales are prohibited, but the right to use land can be transferred in the form of rent and bequest.

As an increasing number of pastoralists are adopting a sedentary lifestyle, they start to cultivate cash crops around their settlement. About 32 per cent of households in our sample own crop fields. Compared to pastures and hayfields, crop fields can be easily quantified in terms of sizes. Among these households who own crop fields, the average size is 27 mu<sup>4</sup> (about 1.8 hectares).

### ***Livestock***

The livestock portfolio maintained by the sampled households mainly consists of cattle, sheep, and goats, as well as a small number of horses and camels (Table 1). Each type of livestock plays a different role. In general, cattle, sheep and goats are sold for cash, while horses and camels are kept for transportation.

Table 1 here

Livestock ownership in our sample is highly unequal. The distribution of livestock owned by individual households follows a Poisson rather than a normal distribution, with more households situated at the lower end (Figure 2). Almost 40 per cent of them have less than 15 livestock units<sup>5</sup>, while less than 15 per cent own more than 60. This indicates that most households maintain their livelihoods based on a very limited number of livestock.

Figure 2 here

Herd diversification is an important strategy adopted by pastoralists to minimise risk exposure, since a mixture of large and small ruminants, grazers and browsers can optimise the utilisation of available resources (Nori, 2007). In this paper, we used the Shannon-Weiner Diversity Index<sup>6</sup> to measure livestock diversity. Individual household livestock diversity in these two regions is displayed in Figure 3. Among the 159 households, 20 of them have an index of zero, indicating no diversification whatsoever. Seven of them do not possess any livestock, while

---

<sup>4</sup> 1 mu = 666.67 square metres

<sup>5</sup> 1 livestock unit = 1 cow = 1 horse = 0.8 camel = 6.5 sheep or goats (Chilonda & Otte, 2006)

<sup>6</sup> The Shannon index has been a popular measure of diversity. It is calculated as

$$H = \begin{cases} -\sum_{i=1}^r p_i \log p_i, & \text{if } p_i > 0 \\ 0, & \text{if } p_i = 0 \end{cases}$$

where  $p_i$  is the proportion of characters belonging to the  $i$ th type of livestock in the  $r$ -string of interest ( $i=1,2,\dots,r$ ).

another 13 own a single type of livestock. The livestock diversity distribution in Altay exhibits more households towards the higher end, while in Ili more fall at the lower end. This corresponds with the fact that no camels were raised by any Ili pastoral households. Therefore, its average livestock diversity index (0.58) is about 20 per cent lower than Altay (0.70). A Kolmogorov-Smirnov test indicated that the differences between these two distributions are statistically significant (p-value = 0.013).

Figure 3 here

Herding livestock for others is gaining increasing popularity in recent decades. While the average number of self-owned livestock is 28.7, the number of hired-herded livestock is about 15.8 (Figure 4). Although only 30 per cent households in our sample are engaged in hired herding, the number of livestock of which they take care is usually large, with an average of 64 livestock units.

Figure 4 here

These numbers echo the complaints of some respondents that ‘there are too many livestock from households who do not herd in person.’ The extra livestock pressure has significant adverse impacts on the quality and quantity of forage on pastures. Although traditionally some poor pastoralists tended livestock for wealthy households to gain a share of the herd, nowadays more and more pastoralists work as hired herders to earn cash. A small number of households have already become ‘professional hired herders.’ They own very few livestock, but herd a large number for others to earn minimal herding fee. A substantial amount of these hired-herded livestock are owned by crop farmers, sedentarised pastoralists, and even Han Chinese settled in villages and townships.

### **Sources of Income**

Based on our interviews notes, we enumerated six sources of income. In decreasing order of importance, these are: livestock, crop, wage, herding fee, government subsidy, and small business (Table 2). Household cash income was either indirectly estimated or directly reported from the interviews. Respondents reported the number of livestock they sold each year and the

size of crop fields they cultivated. Based on local prices<sup>7</sup> of livestock and crops around the fieldwork period, income from these two sectors was estimated. Herding fees were calculated according to the number of livestock herded, the length of time they herd for others, and the herding price for each kind of livestock<sup>8</sup>. Other sources of income (wage, subsidy, and small business) were directly reported by respondents.

Table 2 here

We do not have data on household autoconsumption. According to our interviews, however, most households consume a very small portion of their livestock or crop. Meat is considered a luxury that is mainly sold to earn cash, and cash crops are aimed at regional markets rather than for household consumption.

The details of each cash income source are presented in Table 2. The most important source is livestock. Average income from this sector is about 38000 yuan. About 77 per cent of households depend on livestock sale to sustain their livelihoods. For those engaged in this sector, the average is more than 49000 yuan.

The second most important income source is from crop cultivation, in which 30.2 per cent of households are engaged. Popular crops cultivated in the study areas are cash crops, mainly beans and melons. However, crop cultivation is not the Kazak people's comparative advantage, especially under harsh environmental conditions that require intensive labour input and capital investment. For those households involved in crop production, cash income from crop is less than half of that from livestock.

About 17 per cent of households are engaged in wage labour. The average income from this sector is 4839 yuan, but for those who are involved in this sector, their average income is about 28500. There are two types of wage income. The first type involves employment in the government or other public organisations. Respondents belonging to this group have relatively stable income, but the monthly wage is usually low as they are mostly hired as janitorial staff, security guard, or bottom-level office personnel. The second type is more common, which is

---

<sup>7</sup> In 2010, the price was about 1100 yuan for a lamb, 2500 yuan for a calf, and 5000 yuan for a horse. The average income from one mu of crop field is 800 yuan.

<sup>8</sup> In 2010, the price for herding one cattle is 50 yuan/month, the price for herding a sheep/goat is 8 yuan/month.

based on temporary contract, or even daily agreement, including construction and farming work for private individuals.

More than a quarter of households take care of others' livestock to earn herding fee. This has become prevalent, especially in recent years. Except for a small proportion of hired herders who take care of others' livestock throughout the year, most of them only work for others during the warm season from May to September. Some hired herders expressed concerns about theft of livestock, for which they are responsible. Loss of even one animal requires compensation that takes them several months to make.

Households that depend on government subsidy to maintain their livelihoods account for 12.6 per cent of the sample. Some households receive subsidy from the poverty reduction program financed by both central and regional government. The eligibility is determined by the per capita household income. Another type of subsidy is due to the government's occupation of pastures for the implementation of ecological restoration and tourism development projects.

About 20 per cent households run a small business as a source of income. The most common business involves selling fresh milk and processed milk products, either to tourists or aggregators from dairy companies. Another form of small business is running a small grocery store in the yurts, because access to grocery items is very limited on the remote pasture lands.

## **Livelihood Strategies**

Based on the Simple Structure Index and common sense check, we identified six distinct livelihood strategies as the optimal fit in the cluster analysis. The summary statistics of the identified strategies are shown in Table 3.

Table 3 here

**Pastoralists** are both the highest earners and the largest group among the six clusters, representing almost 45 per cent of the entire sample. More than 95 per cent of their income is from livestock, while the other sources are negligible. Their dominant reliance on livestock makes them the wealthiest group. They earn over 68000 yuan annually, roughly 2.5 times as much as the poorest cluster and 36 per cent higher than the sample mean of the other five groups.

The second livelihood strategy, **agropastoralists**, is a combination of livestock herding and crop cultivation. They are the second largest and wealthiest group, representing about 20 per cent of the whole sample. Livestock revenue, the most important income source for this cluster, constitutes over 60 per cent of their cash income. This is followed by crop revenue, which accounts for almost 20 per cent of the total.

The distinguishing feature of the **wage labourer** group, representing 7.5 per cent of the sample, is their dominant reliance on wages as a source of income: almost 90 per cent of their total. This cluster is the only one that gains no income from livestock. Their income from other sources is also minimal. Although wage labourers are the third wealthiest group, their income is still about 15 per cent less than the sample average.

Households in the **hired herder** cluster derive 93.2 per cent of their income from herding fees. Their cash income from livestock sales is minimal, but their work is similar to pastoralists in terms of herding livestock. A major difference is that hired herders do not own most of the livestock they herd. Although this cluster accounts for less than 5 per cent of the entire sample, all other clusters have some (far less specialised) engagement in herding livestock for others. As an emerging source of income, hired herding is getting more prevalent. Hired herders earn a mean income of 37300 yuan, which is 30 per cent less than the sample average.

**Crop farmers** represent 13.8 per cent of the entire sample. On average, they receive more than 70 per cent of their cash income from crop sales, which is almost four times as much as agropastoralists, for whom crop revenue is the second most important source of income. About 10 per cent of crop farmers' income is from livestock sales, which is much less than the agropastoralists who derive more than 60 per cent from this source. Another key distinction between crop farmers and agropastoralists is average household income level. Crop farmers only earn 55 per cent of what agropastoralists do on average, and about 40 per cent less than the sample average. Income from other sources is minimal for this cluster.

The households classified as **mixed smallholders** earn the least income compared to other clusters, only 47 per cent of the sample average. They are heavily dependent on government subsidies to maintain their livelihoods. This cluster also relies on earnings from small business. About 20 per cent of their cash income comes from selling milk products and grocery items, while none of the other clusters derive more than 5 per cent from this source. The

remaining 20 per cent of their income is generated either from livestock sales or herding fees. Mixed smallholders are not engaged in crop cultivation or wage labour at all.

## **LIVELIHOOD DIVERSIFICATION ANALYSIS AND DISCUSSION**

Results of cluster analysis indicate a system in transition and decline. Those who maintain herds – pastoralists and agropastoralists – are clearly better off, as reflected by average household income. But those who are without sufficient livestock are in trouble. Although those who found jobs, the wage labourers, are next best off, their group average income is 16 per cent less than the sample mean and 33 per cent less than the pastoralists. The clear implication is that maintaining viable herding is the key to poverty reduction in the pastoral areas in northern Xinjiang. We further investigated the details of the observed livelihood diversification by 1) exploring the relationship between income diversification and annual household income; 2) contrasting the ecological diversity of pastoralist and non-pastoralist households; 3) estimating livelihood strategy superiority; 4) examining the household characteristics that are associated with the adoption of each livelihood strategy; and 5) explaining the broader socio-ecological factors that predetermine the diversification process.

### **Income Diversification**

We investigated the relationship between income levels and income diversification as measured by Shannon Index (Figure 5). The result indicates a clear and statistically significant ( $p$ -value = 0.052) negative association between households' income diversity and their annual income, where wealthier households tend to have less diversified income streams. Insofar as population growth and government policies compel increased income diversification, reduced welfare might be inevitable. Heavy reliance on livestock herding as a pastoralist is clearly the most remunerative livelihood strategy. Although other choices are available, they offer less income to pastoralism. As a result, the more diversified households' annual cash income is much less than those who are capable of maintaining livestock herding.

Figure 5 here

The relationship between income diversity index and livelihood strategy is also illustrated in Figure 5. Agropastoralists and crop farmers are the two most diversified groups, with a mean index of 0.74 and 0.63, respectively. Compared to other groups, agropastoralists and crop farmers are more dependent on crop cultivation as a source of income. These households are partially or entirely sedentarised around their crop fields, which allows them to engage in other income-generating activities around their fixed settlement. Mixed smallholders are the third diversified group, with a mean index of 0.44, reflecting their diversified income sources including small business, subsidy, and herding fee. A large proportion of households in this group are sedentarised largely due to the ecological restoration policy. As a result, minimal subsidy as compensation for giving up herding has become an important income source for them. In contrast, wage labourers and hired herders are far less diversified. They are much more engaged in their dominant sources of income – wage and herding fee, resulting in low diversity indexes around 0.2. Their choice of livelihood strategies, however, is largely involuntary. Due to their meagre asset holdings appropriate to livestock herding, these households became proletarianised and started to work for others, thus falling into these livelihood strategies even though they might have wished to remain as pastoralist households.

In contrast to the above five clusters, pastoralists, the wealthiest group, have the lowest income diversity index at 0.15, as they are predominantly focused on livestock herding. It makes sense that successful and wealthy pastoralist households do not diversify; however, it is worth noting the diversity within the pastoralist group, especially the bottom 20 per cent of households. They earn less than 30000 yuan on average, which is only 55 per cent of the sample average. Our interviews with these households indicate the lack of adequate assets largely result in their poor performance. We found cases in which crop farmers realised it was no longer viable to cultivate cash crops due to poor water access and degrading land quality, thus they attempted to return to pastoralism. However, minimal livestock holdings and pasture lands limited their success and made them struggle at the bottom of this seemingly remunerative livelihood strategy. There are also cases of recently married couples struggling with livestock herding, since they inherited very small livestock holdings and pasture lands from their parents. Therefore, asset endowment is a key factor that determines whether livestock herding can be a viable and profitable livelihood strategy.

## **Ecological Indicators of Livelihood Diversity**

The above findings reveal that pastoralism, as the most desirable livelihood strategy, has the lowest diversity by considering sources of income. However, we hypothesise that pastoralism is ecologically diverse, as it is a livelihood strategy that is highly adapted to the specific context characterised by heterogeneous resource distribution across space and time. Accordingly, we proposed five ecological indicators to examine livelihood diversity, including migration distance, migration times, the number of pasture types used in annual herding activities, the elevation difference between overwintering villages and summer pastures, and livestock species diversity. T-tests were performed to examine the differences between the pastoralist group and the other four non-pastoralist groups (Table 4).

Table 4 here

Spatially, the pastoralist households are engaged in more active migration. Their average migration distance is nearly 145 km from overwintering villages to summer pastures. In contrast, non-pastoralist households, which are far less specialised in livestock herding, only move 81 km on average. In addition, pastoralist households move their yurts over 20 times a year, which is about 2.5 times as frequently as the non-pastoralist households.

In terms of pasture land use pattern, the average number of pasture types used by pastoralist households is 2.82 throughout the year. This is largely because the majority of them are engaged in four-season rotational grazing by using transitional grazing areas between overwintering villages and summer pastures. In contrast, the non-pastoralist households use 2.18 types of pastures on average, due to the fact that most of them only conduct two-season rotational grazing which omits the transitional grazing practices.

In the mountainous context, the migration activities are inherently associated with elevation change, as people move from overwintering villages in the Gobi desert to summer pastures in the mountains. A comparison between the two groups reveals that the pastoralist households are engaged an average elevation change of 2300 m, which is almost twice of the non-pastoralist group. Presumably, pastoralist households need to make use of resources in different ecological zones across a wide altitudinal range to cope with the high spatio-temporal variability in the herding environment.

In addition to spatial and land use diversification, we also examined livestock species diversity of these two groups. The results indicate that pastoralist households keep a more diverse portfolio of livestock than non-pastoralist households. In fact, the mixture of different livestock species is an effective diversification strategy that is more commonly adopted by pastoralists to make better use of pastures with herbaceous and woody plants.

The above comparison indicates that pastoralist households exhibit higher ecological diversity than those who diversify into other livelihood strategies. Their engagement in extensive herding allows for efficient use of rangeland resources in different ecological niches throughout the year. In addition, combining grazers with browsers not only enhances the households' resilience to environmental stress such as drought and the proliferation of plant species that are unpalatable for certain livestock species, but also contributes to rangeland ecosystem sustainability. Such ecological diversity also results in a continuous redistribution of livestock grazing pressure while reducing the chance of overgrazing and rangeland degradation throughout the landscape (Liao et al., 2014a).

### **Livelihood Strategy Superiority**

The distinct groups identified by cluster analysis enable us to order the different livelihood strategies adopted by the pastoral households in northern Xinjiang by stochastic income distributions. Mean cash income varies dramatically across strategies, ranging from 25593 yuan per household per year for mixed smallholders to 68016 yuan for pastoralists.

We compared the income distributions of different strategies at the household level using stochastic dominance analysis. The cumulative household income density lines for each livelihood strategy group were first plotted (Figure 6). Then we tested for the stochastic dominance between each pair of livelihood-specific income distributions<sup>9</sup>. The cash income distribution of pastoralists and agropastoralists appear to first-order stochastically dominate the other four strategies. Wage labourers' income distribution first-order stochastically dominates

---

<sup>9</sup> According to the assumptions of stochastic dominance, a particular livelihood strategy first-order stochastically dominates another strategy if and only if, for every possible income level, the strategy has a lower cumulative density, reflecting a greater likelihood of gaining higher incomes. A particular livelihood strategy second-order stochastically dominates another if the area to the left of its cumulative density line is larger (Whitmore, 1978).

that of smallholders and hired herders. In addition, second-order dominance can be inferred for pastoralists over agropastoralists.

Figure 6 here

Given the innocuous assumption that households are income risk averse and prefer more income to less (Davidson & Duclos, 1997), the stochastic dominance analysis implies that the pastoralism is the strongly preferred livelihood strategy over all others, with agropastoralism second most preferred, then the wage labour strategy. The mixed smallholder livelihood strategy is dominated by all the others, making it the least desirable. Yet government policies expressly aim to advance the mixed smallholder livelihood strategy through sedentarisation and encouragement of diversified livelihood activities.

### **Barriers to the Adoption of the Preferred Livelihood Strategy**

Evidence from stochastic dominance analysis suggests the possibility of significant barriers that impede some households from deriving most of their income from livestock. In order to test for patterns in the adoption of different livelihood strategies, a binomial logit regression was conducted on livelihood strategy as a function of household characteristics. Although agropastoralists earn 60 per cent of their cash income from livestock, they are diversifying their sources of income. In addition, agropastoralists' income distribution is second-order dominated by pastoralists'. Therefore, agropastoralists are combined with wage labourer, crop farmer, hired herder and mixed smallholder to form a non-pastoralist group to compare with the pastoralist group in our regression<sup>10</sup>. Key household level variables of these two groups are summarised in Table 5, including livestock units owned by the household, livestock unit herded for others, household pasture land and hayfield ownership, the size of crop fields cultivated by household, and whether the household is relocated into resettlement villages.

Table 5 here

The logit regression parameter estimates are presented in Table 6. Five household characteristics are identified as statistically significant factors associated with being unable to derive a large share of income from livestock sale.

---

<sup>10</sup> We lack adequate degrees of freedom to estimate a multivariate probit.

## Table 6 here

First, livestock ownership is strongly positively correlated with maintaining pastoralism as one's livelihood strategy. The non-pastoralist households own 17.7 livestock units on average, only about 40 per cent of what the pastoralist households do. Such a limited number can hardly support minimal autoconsumption, not to mention generating enough livestock for sale. What makes the situation worse is that once a family member gets seriously sick, livestock must be sold to cover medical treatment expenses. After selling livestock, it is extremely difficult to recover the original stock size. Such struggle is also commonly observed in other pastoral communities globally (Krishna, 2010). For most of the non-pastoralist households, owning such a small number of livestock precludes a viable means of survival based on herding, which forces them to seek other sources of income.

Second, the non-pastoralist households are more engaged in hired herding for others. They herd five times more of others' livestock than the pastoralist households do. Hired herding is a low profit but high risk job. Loss of even one sheep will cost them much more than what they earn. However, hired herding is becoming common, especially for newly married couples who inherit few livestock or pastures from their parents. With no resources at hand, they have no choice but to herd for others. And once they get stuck in hired herding, it becomes difficult to develop their own herd.

The third correlated factor is pasture land ownership. Less than half of the non-pastoralist households have their own pasture lands, while almost 95 per cent of pastoralist households do. Loss of access to pasture lands forces some households to seek other sources of income. As strict ecological restoration policy from central government to be implemented in the near future, more pasture lands will be fenced for conservation purposes. Although the government promotes 'obvious pasture quality improvement' (National Development and Reform Commissions, 2011), the livelihoods and welfare of pastoral households have not been adequately addressed. Compensation from government can hardly support those households who give up herding.

Fourth, landholdings for crop cultivation are negatively related to the practice of pastoralism. The non-pastoralist households cultivate more than 14 mu farmland, while the pastoralist households only have 0.85 mu on average. Since crop cultivation is labour intensive and fixed in space, especially in places suffering from poor infrastructure facilities and

unfavourable climate, non-pastoralist households need to stay in their villages to take care of their crops throughout the year. As a result, they are stuck in crop cultivation, which is less remunerative than herding.

The last correlated factor is whether the household is relocated into a resettlement village. By the time the fieldwork was conducted, more than 15 per cent of sample households had been relocated into the newly built resettlement villages, while almost another 20 per cent households had agreed to move into resettlement villages and purchased a house with government subsidy. Among those relocated households, almost 80 per cent had given up livestock herding. With limited nearby lands, which are usually of poor quality, reduced livestock holdings are inevitable outcomes from sedentarisation through resettlement.

### **Broader Socio-Ecological Context of Livelihood Diversification**

In addition to the household characteristics that explain the choices of livelihood strategies, the broader socio-ecological context predetermines the observed livelihood diversification process. Qualitative investigation of pastoralists' risk perceptions revealed a series of ecological challenges to the adaptation of pastoralism, which include pasture degradation, frequent drought, snowstorm, and overgrazing (Liao, et al., 2014b). Pasture degradation considerably threatens livestock herding, as reduction in forage availability directly affects the viability of livestock herding. A correlated factor to pasture degradation is frequent drought, which not only affects forage availability, but also causes a lack of drinking water for both humans and livestock. Another factor is snowstorms, which cause substantial livestock deaths in winter. On top of these environmental challenges, pastoralists are also aware of the issue of overgrazing and the imbalance between forage demand and supply on the pastures. Such ecological imbalance is exacerbated by hired herding, which is increasingly being practiced as those settled in townships hire pastoralists to herd livestock for them.

Recent pastoral policies also discourage extensive livestock herding. Ecological restoration of pastures by fencing is increasingly affecting pastoralists. Particularly, the restoration policy has targeted certain areas in northern Xinjiang as permanently prohibited grazing areas, where ecological restoration projects will be given priority over pastoral livelihoods (Xinhua, 2011). However, the minimal subsidy the state provides as compensation

hardly supports those who are forced to give up herding. In addition, due to a burgeoning tourism industry in northern Xinjiang, pastoralists are being forced to relocate to remoter areas and are only allowed to herd livestock in restricted areas. The mining industry has been booming recently as well, which is devastating the landscape, blocking migration routes, and contaminating rivers.

Furthermore, pastoral sedentarisation pushed by the government strongly affects pastoral households' livelihood choices. During the implementation of these sedentarisation policies, new houses ranging from 60 to 90 square metres with a 3 mu yard were sold at a subsidised rate, with pastoralists paying 50 per cent of the cost. In addition, a 50 mu hayfield was given as a bonus for purchasing a house in the resettlement villages. Almost all respondents complained, however, that the subsidised houses are of poor quality. In addition, the hayfields are insufficient to support a viable herd of livestock, and these lands often suffer from high aridity and alkalinity. Although the local government did not revoke the land tenure of the newly sedentarised households, relocation far away from their traditional overwintering bases ensures that they effectively give up their hayfields.

The ongoing livelihood transition in northern Xinjiang, from heavy dependence on mobile livestock herding to relying on other livelihood strategies, reflects the explicit aim of the central government's Twelfth Five Year Plan, which is a proletarianisation process largely driven by the state. By dispossessing traditional pastoral livelihoods, the Chinese state aims to sedentarise pastoralists and transform them into modern ranchers expected to produce large quantities of dairy products and meat using an industrialised approach. However, only the first half of this plan – sedentarisation – is being actively pursued, while the second half – intensifying and modernising livestock production – is left behind without corresponding investment and planning. Poor implementation of the Twelfth Five-Year Plan resulted in diversification into other livelihood strategies that can barely translate into improved livelihoods.

## **CONCLUSIONS**

In this paper we examined the livelihoods of pastoral households in the Altay and Tianshan Mountains of Xinjiang, China. Cluster analysis was applied to let the data speak for themselves in the identification of livelihood strategies. Via k-means cluster analysis, six distinct

strategies were identified, including pastoralists, agropastoralists, crop farmers, wage labourers, hired herders, and mixed smallholders. The results show that although pastoralism is the most remunerative and the stochastically dominant livelihood strategy, only 45 per cent households are currently able to derive a large share of income from livestock. We also find evidence of negative association between households' income diversification and annual income.

Our analyses indicate that different access to, or endowment of, assets is strongly associated with the choice of income-generating activities and corresponding livelihood strategies. We identified five factors statistically significantly associated with the inability of non-pastoralist households to derive income predominantly from livestock. First, a limited number of livestock owned by non-pastoralist households makes it impossible to generate enough for sale. Second, non-pastoralist households are largely stuck in hired herding, which is less profitable and more risky. Third, loss of access to pasture land tenure makes extensive livestock herding infeasible. Fourth, the non-pastoralist households are more engaged in crop cultivation, which requires intensive labour and sedentarisation. Finally, the non-pastoralist households suffer more from the negative impacts of relocation in the government's newly built resettlement villages. In addition to household characteristics, the broader socio-ecological context heavily influences observed patterns of livelihood diversification. Pasture degradation, frequent drought and snowstorms, and overgrazing make it more challenging to maintain extensive herding. Government ecological restoration policies, economic development, and livelihood transformation discourage livestock herding and facilitate a diversification process that has not translated into improved livelihoods in northern Xinjiang.

Our findings in northern Xinjiang underscore that development interventions such as livelihood diversification in the pastoral areas must be based on contextualised analysis. In fact, rather than a livelihood strategy with the least diversity as measured by sources of income, we argue that pastoralism is highly diverse in ecological dimensions. Pastoralist households are significantly more diverse in terms of spatial movement, land use pattern, and livestock portfolio. Such ecological diversity allows pastoralists to make better use of the rangeland resources constantly in disequilibrium. Therefore, policy recommendations for livelihood diversification developed based on evidence from sedentary rural societies founded on crop cultivation may not work well for the mobile pastoral communities, where the socio-ecological conditions predetermine livestock herding as the preferred livelihood strategy.

In order to safeguard standards of living for marginalised populations in remote regions, it is necessary to ensure continued access to pastures and hayfields so that more households can get engaged in mobile livestock herding, which is the preferred livelihood strategy. It is imperative to remove constraints to, and expansion of opportunities for, ecological diversification, because these policies will give households more capabilities to improve livelihood security and to raise living standards. Policy makers must recognise the barriers to the adoption of the more remunerative livelihood strategy, pastoralism, based on the ecological and cultural comparative advantage of pastoralists. The implementation of the ecological restoration and pastoral sedentarisation programs are working against the interests of these peoples. Future pastoral policies should promote policies that enable poorer households to regain access to pastures and hayfields and to help correct the imbalance of opportunities that exists in northern Xinjiang. Households routinely expressed strong motivations to maintain livestock herding as their core livelihood strategy because it makes the most sense to the pastoral households ecologically, economically, and culturally.

## REFERENCES

- Abdulai, A., & Crole Rees, A. (2001). 'Determinants of income diversification amongst rural households in Southern Mali', *Food Policy*, 26(4): 437–452.
- Ade Freeman, H., Ellis, F., & Allison, E. (2004). 'Livelihoods and Rural Poverty Reduction in Kenya', *Development Policy Review*, 22(2): 147–171.
- Ansoms, A., & McKay, A. (2010). 'A quantitative analysis of poverty and livelihood profiles: The case of rural Rwanda', *Food Policy*, 35(6): 584–598.
- Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., & Mathijs, E. (2008). 'Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia', *Agricultural Systems*, 98(2): 147–155.
- Banks, T. (2001). 'Property Rights and the Environment in Pastoral China: Evidence from the Field', *Development and Change*, 32(4): 717–740.
- Banks, T. (2003). 'Property Rights Reform in Rangeland China: Dilemmas On the Road to the Household Ranch', *World Development*, 31(12): 2129–2142.
- Barrett, C. ., Reardon, T., & Webb, P. (2001). 'Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications', *Food Policy*, 26(4): 315–331.
- Barrett, C. B., Bezuneh, M., & Aboud, A. (2001). 'Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya', *Food Policy*, 26(4): 367–384.
- Barrett, C. B., Bezuneh, M., Clay, D. C., & Reardon, T. (2005). 'Heterogeneous Constraints, Incentives and Income Diversification Strategies in Rural Africa', *Quarterly Journal of International Agriculture*, 44(1): 37–60.

- Barrow, E., Davies, J., Berhe, S., Matiru, V., Mohamed, N., Olenasha, W., & Rugadya, M. (2007). 'Pastoralists' species and ecosystems knowledge as a basis for land management', *IUCN Eastern Africa Regional Office Policy Brief*, (3).
- Bauer, K. (2005). 'Development and the enclosure movement in pastoral Tibet since the 1980s', *Nomadic Peoples*, 9, 1(2), 53–81.
- Behnke, R. (1993). *Range ecology at disequilibrium: new models of natural variability and pastoral adaptation in African savannas*. London: Overseas Development Institute.
- Bezu, S., Barrett, C. B., & Holden, S. T. (2012). 'Does the Nonfarm Economy Offer Pathways for Upward Mobility? Evidence from a Panel Data Study in Ethiopia', *World Development*, 40(8): 1634–1646.
- Bird, K., & Shepherd, A. (2003). 'Livelihoods and chronic poverty in semi-arid Zimbabwe', *World Development*, 31(3): 591–610.
- Blench, R. M. (2001). Pastoralism in the New Millennium (Animal Health and Production Series, 150). Rome: FAO.
- Block, S., & Webb, P. (2001). 'The dynamics of livelihood diversification in post-famine Ethiopia', *Food Policy*, 26(4): 333–350.
- Borcard, D. (2011). *Numerical ecology with R*. New York: Springer.
- Bouahom, B., Douangsavanh, L., & Rigg, J. (2004). 'Building sustainable livelihoods in Laos: untangling farm from non-farm, progress from distress', *Geoforum*, 35(5): 607–619.
- Brown, D. R., Stephens, E. C., Ouma, J. O., Murithi, F. M., & Barrett, C. B. (2006). 'Livelihood strategies in the rural Kenyan highlands', *African Journal of Agricultural and Resource Economics*, 01(1): 21-36.

- Butt, B., Shortridge, A., & WinklerPrins, A. M. (2009). 'Pastoral herd management, drought coping strategies, and cattle mobility in southern Kenya', *Annals of the Association of American Geographers*, 99(2), 309–334.
- Carswell, G. (2002). 'Livelihood diversification: increasing in importance or increasingly recognized? Evidence from southern Ethiopia', *Journal of International Development*, 14(6): 789–804.
- Cerny, A. (2010). 'Going where the grass is greener: China Kazaks and the Oralman immigration policy in Kazakhstan', *Pastoralism*, 1(2): 218–247.
- Coppock, D. L., Desta, S., Tezera, S., & Gebru, G. (2011). 'Capacity Building Helps Pastoral Women Transform Impoverished Communities in Ethiopia', *Science*, 334(6061), 1394–1398.
- Chilonda, P., & Otte, J. (2006). 'Indicators to monitor trends in livestock production at national, regional and international levels', *Livestock Research for Rural Development*, 18(8): 117–117.
- Davidson, R., & Duclos, J.-Y. (1997). 'Statistical Inference for the Measurement of the Incidence of Taxes and Transfers', *Econometrica*, 65(6): 1453–1465.
- Dong, S., Wen, L., Liu, S., Zhang, X., Lassoie, J. P., Yi, S., ... Li, Y. (2011). 'Vulnerability of Worldwide Pastoralism to Global Changes and Interdisciplinary Strategies for Sustainable Pastoralism', *Ecology And Society*, 16(2): 1-23.
- Du, M., Kawashima, S., Yonemura, S., Zhang, X., & Chen, S. (2004). 'Mutual influence between human activities and climate change in the Tibetan Plateau during recent years', *Global and Planetary Change*, 41(3–4), 241–249.

- Ellis, F. (1998). 'Household strategies and rural livelihood diversification', *Journal of Development Studies*, 35(1): 1–38.
- Ellis, F. (2000a). *Rural Livelihoods and Diversity in Developing Countries*. Oxford; New York, NY: Oxford University Press.
- Ellis, F. (2000b). 'The Determinants of Rural Livelihood Diversification in Developing Countries', *Journal of Agricultural Economics*, 51(2): 289–302.
- Ellis, F., & Bahiigwa, G. (2003). 'Livelihoods and Rural Poverty Reduction in Uganda', *World Development*, 31(6): 997–1013.
- Ellis, F., Kutengule, M., & Nyasulu, A. (2003). 'Livelihoods and Rural Poverty Reduction in Malawi', *World Development*, 31(9): 1495–1510.
- Ellis, F., & Mdoe, N. (2003). 'Livelihoods and Rural Poverty Reduction in Tanzania', *World Development*, 31(8): 1367–1384.
- Everitt, B. S., Landau, S., Leese, M., & Stahl, D. (2011). *Cluster Analysis, 5th Edition*. Oxford: Wiley-Blackwell.
- Fernandez-Gimenez, M. E., & Le Febre, S. (2006). 'Mobility in pastoral systems: Dynamic flux or downward trend? ', *The International Journal of Sustainable Development and World Ecology*, 13(5): 341–362.
- Fischer, A. M. (2008). 'Subsistence and Rural Livelihood Strategies in Tibet - under Rapid Economic and Social Transition', *International Association of Tibetan Studies. Journal*, 4, 1–49.
- Gillson, L., & Hoffman, M. T. (2007). 'Rangeland Ecology in a Changing World', *Science*, 1136577(53): 315–315.

- Han, J. G., Zhang, Y. J., Wang, C. J., Bai, W. M., Wang, Y. R., Han, G. D., & Li, L. H. (2008). 'Rangeland degradation and restoration management in China', *The Rangeland Journal*, 30(2), 233–239.
- Harris, R. B. (2010). 'Rangeland degradation on the Qinghai-Tibetan plateau: A review of the evidence of its magnitude and causes', *Journal of Arid Environments*, 74(1), 1–12.
- Humphrey, C., & Sneath, D. (1999). *The end of Nomadism? society, state, and the environment in Inner Asia*. Durham, NC: Duke University Press.
- Jansen, H. G. P., Pender, J., Damon, A., Wielemaker, W., & Schipper, R. (2006). 'Policies for sustainable development in the hillside areas of Honduras: a quantitative livelihoods approach', *Agricultural Economics*, 34(2): 141–153.
- Krishna, A. (2010). *One illness away: why people become poor and how they escape poverty*. Oxford; New York: Oxford University Press.
- Li, J. (1991). *Xinjiang Climate*. Beijing: China Meteorological Press.
- Li, X. L., Yuan, Q. H., Wan, L. Q., & He, F. (2008). 'Perspectives on livestock production systems in China', *The Rangeland Journal*, 30(2), 211–220.
- Liao, C. (2012). 'Chasing water and grass to live: Livelihood strategies, migration patterns, and risk perceptions of pastoralists in Xinjiang, China', Master thesis, Cornell University, Ithaca, N.Y.
- Liao, C., Morreale, S. J., Kassam, K.-A. S., Sullivan, P. J., & Fei, D. (2014a). 'Following the Green: Coupled pastoral migration and vegetation dynamics in the Altay and Tianshan Mountains of Xinjiang, China', *Applied Geography*, 46:61–70.

- Liao, C., Sullivan, P. J., Barrett, C. B., & Kassam, K.-A. S. (2014b). 'Socioenvironmental Threats to Pastoral Livelihoods: Risk Perceptions in the Altay and Tianshan Mountains of Xinjiang, China', *Risk Analysis*, 34(4): 640–655.
- Ma, L. (2008). Study on the Optimum Herdsmen's Settlement and Countermeasures in Xinjiang. *Xinjiang Agricultural Sciences*, 6, 044. (in Chinese)
- Moritz, M., Scholte, P., Hamilton, I. M., & Kari, S. (2013). Open Access, Open Systems: Pastoral Management of Common-Pool Resources in the Chad Basin. *Human Ecology*, 41(3), 351–365.
- Moritz, M., Soma, E., Scholte, P., Xiao, N., Taylor, L., Juran, T., & Kari, S. (2010). An integrated approach to modeling grazing pressure in pastoral systems: the case of the Logone floodplain (Cameroon). *Human Ecology*, 38(6), 775–789.
- Moser, C. O. N. (1998). 'The asset vulnerability framework: Reassessing urban poverty reduction strategies', *World Development*, 26(1): 1–19.
- National Development and Reform Commissions. (2011). 'New Policies for Returning Rangeland to Grassland', [http://www.sdpc.gov.cn/xwfb/t20110831\\_431891.htm](http://www.sdpc.gov.cn/xwfb/t20110831_431891.htm) (accessed 10 March 2012).
- Nie, A. (2006). 'On the Settlement of Nomads: a Case Study of Queergou Town', *Journal of Xinjiang University (Philosophy, Humanities and Social Sciences)*, 4, 022. (in Chinese)
- Niehof, A. (2004). 'The significance of diversification for rural livelihood systems', *Food Policy*, 29(4): 321–338.
- Nori, M. (2007). 'Mobile livelihoods, patchy resources & shifting rights: approaching pastoral territories', *Thematic Paper for the International Land Coalition, ILC*.

- Petrovici, D. A., & Gorton, M. (2005). 'An evaluation of the importance of subsistence food production for assessments of poverty and policy targeting: Evidence from Romania', *Food Policy*, 30(2): 205–223.
- Scoones, I. (2009). 'Livelihoods perspectives and rural development', *Journal of Peasant Studies*, 36(1), 171–196.
- Smith, D. R., Gordon, A., Meadows, K., & Zwick, K. (2001). 'Livelihood diversification in Uganda: patterns and determinants of change across two rural districts', *Food Policy*, 26(4): 421–435.
- Sneath, D. (2000). *Changing Inner Mongolia: pastoral Mongolian society and the Chinese state*. Oxford University Press on Demand.
- Soltani, A., Angelsen, A., Eid, T., Naieni, M. S. N., & Shamekhi, T. (2012). 'Poverty, sustainability, and household livelihood strategies in Zagros, Iran', *Ecological Economics*, 79(0): 60–70.
- Sullivan, S., & Rohde, R. (2002). 'On non-equilibrium in arid and semi-arid grazing systems', *Journal of Biogeography*, 29(12): 1595–1618.
- White, H. (2002). 'Combining Quantitative and Qualitative Approaches in Poverty Analysis', *World Development*, 30(3): 511–522.
- Whitmore, G. (1978). *Stochastic dominance: an approach to decision-making under risk*. Lexington Mass.: Lexington Books.
- Xinhua. (2007). 'Hu Jintao proposes Scientific Outlook on Development for tackling China's immediate woes, challenges', [http://news.xinhuanet.com/english/2007-10/15/content\\_6883135.htm](http://news.xinhuanet.com/english/2007-10/15/content_6883135.htm) (accessed 10 March 2012).

- Xinhua. (2011). 'Complete prohibition of grazing in the eight pastoral scenic spot in Xinjiang', [http://news.xinhuanet.com/2011-06/18/c\\_121552444.htm](http://news.xinhuanet.com/2011-06/18/c_121552444.htm) (accessed 10 March 2012).
- Yeh, E. T. (2009). 'Greening western China: A critical view', *Geoforum*, 40(5): 884–894.
- Yeh, E. T. (2013). *Taming Tibet: landscape transformation and the gift of Chinese development*. Cornell University Press.
- Zhang, X. (Ed.). (2007). *Vegetation Map of the People's Republic of China*. Beijing: The Geological Publishing House.
- Zukosky, M. L. (2007). 'Making Pastoral Settlement Visible in China', *Nomadic Peoples*, 11(2), 107–133.

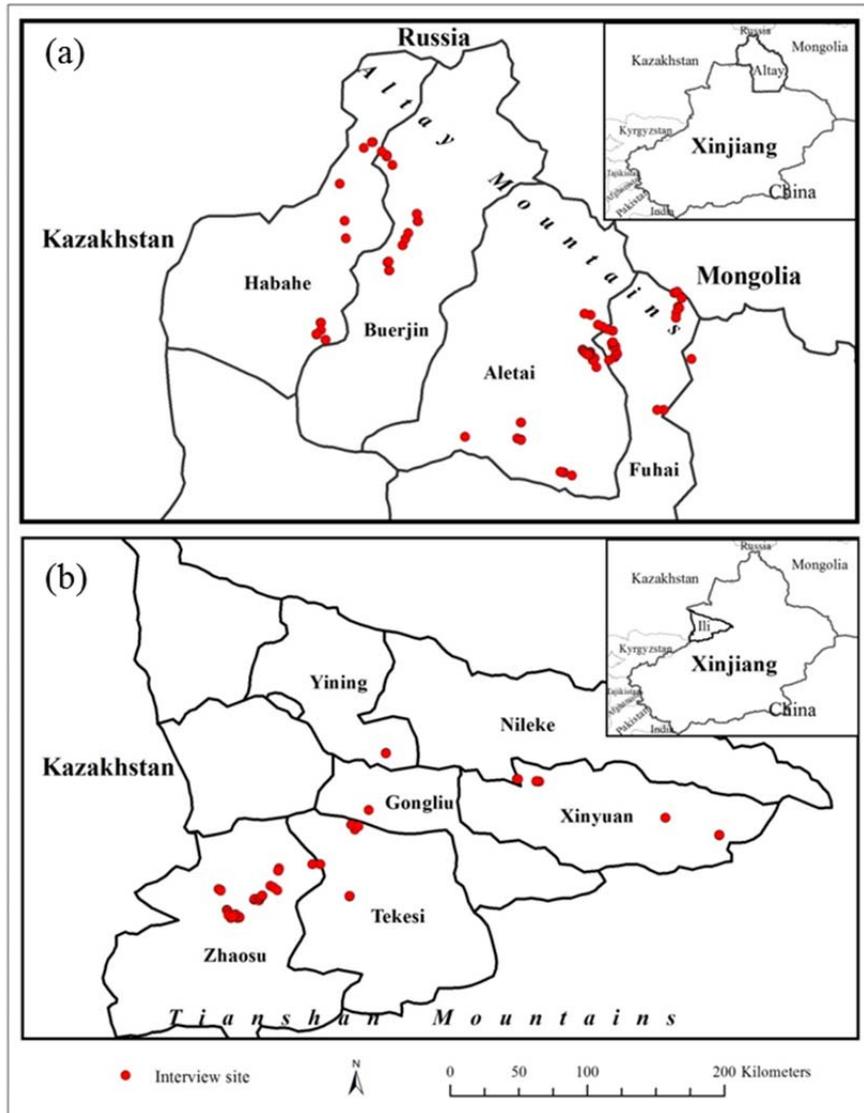


Figure 1 The sites of sampled households in Altay District (a) and Ili Prefecture (b) of Xinjiang, China.

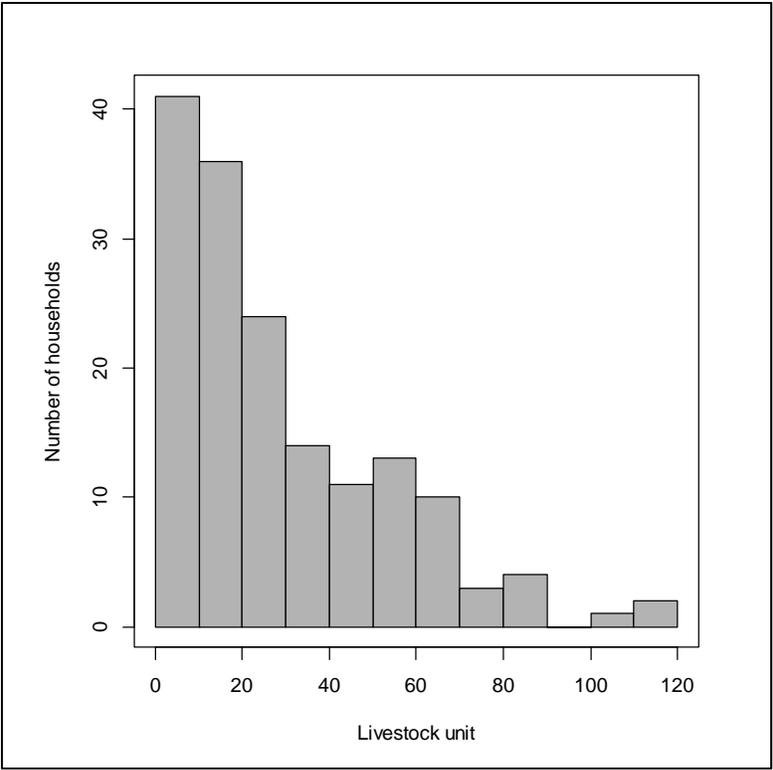


Figure 2 Livestock unit distribution among 159 households

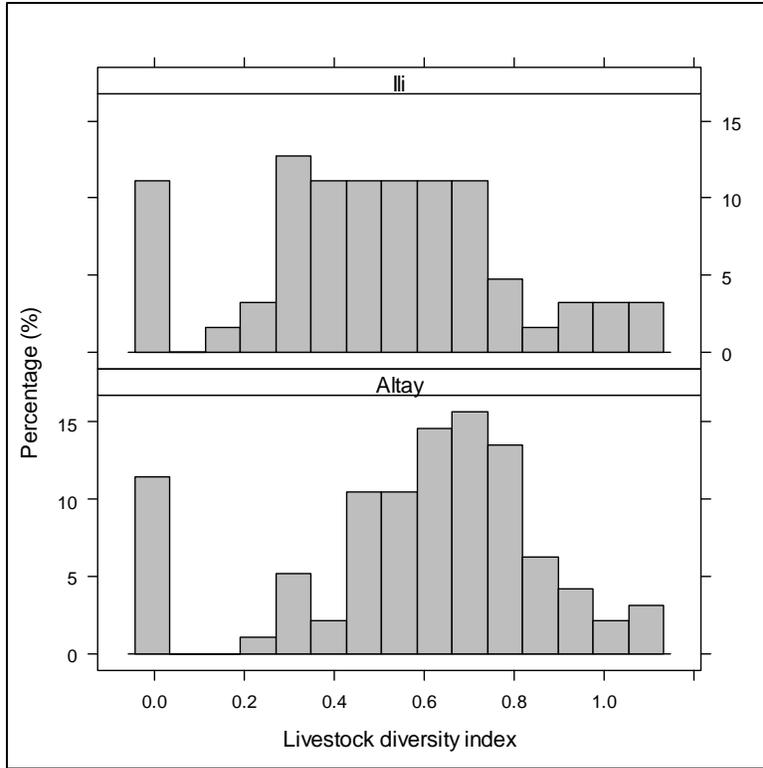


Figure 3 Livestock diversity of individual households in Altay and Ili

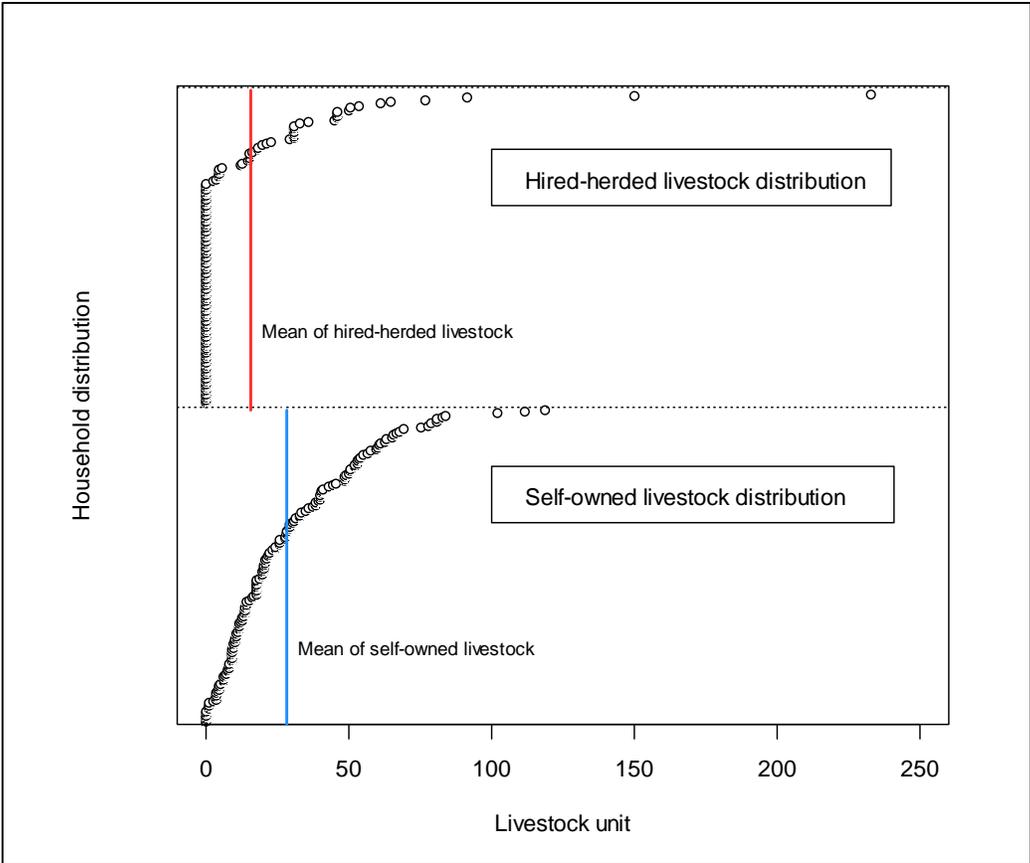


Figure 4 Comparison between the number of self-owned and hired-herded livestock

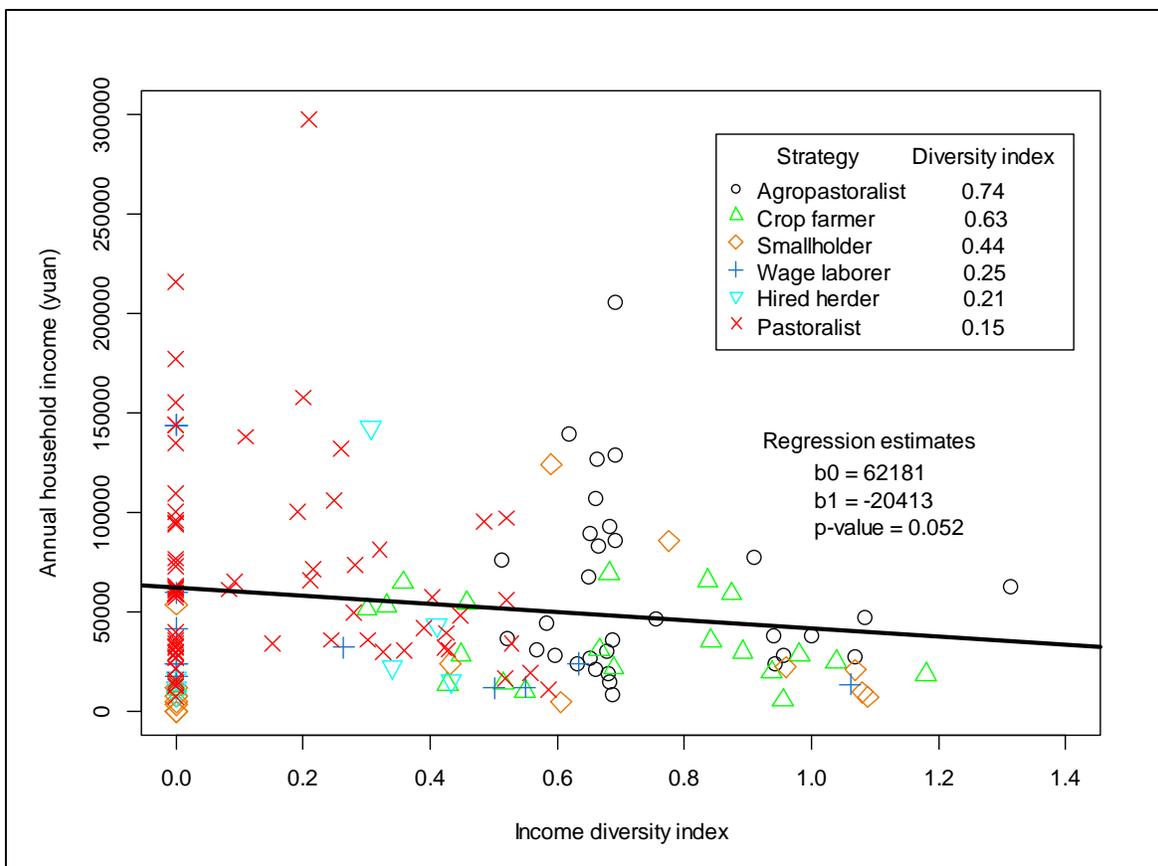


Figure 5 Annual household income and income diversity for six livelihood strategies

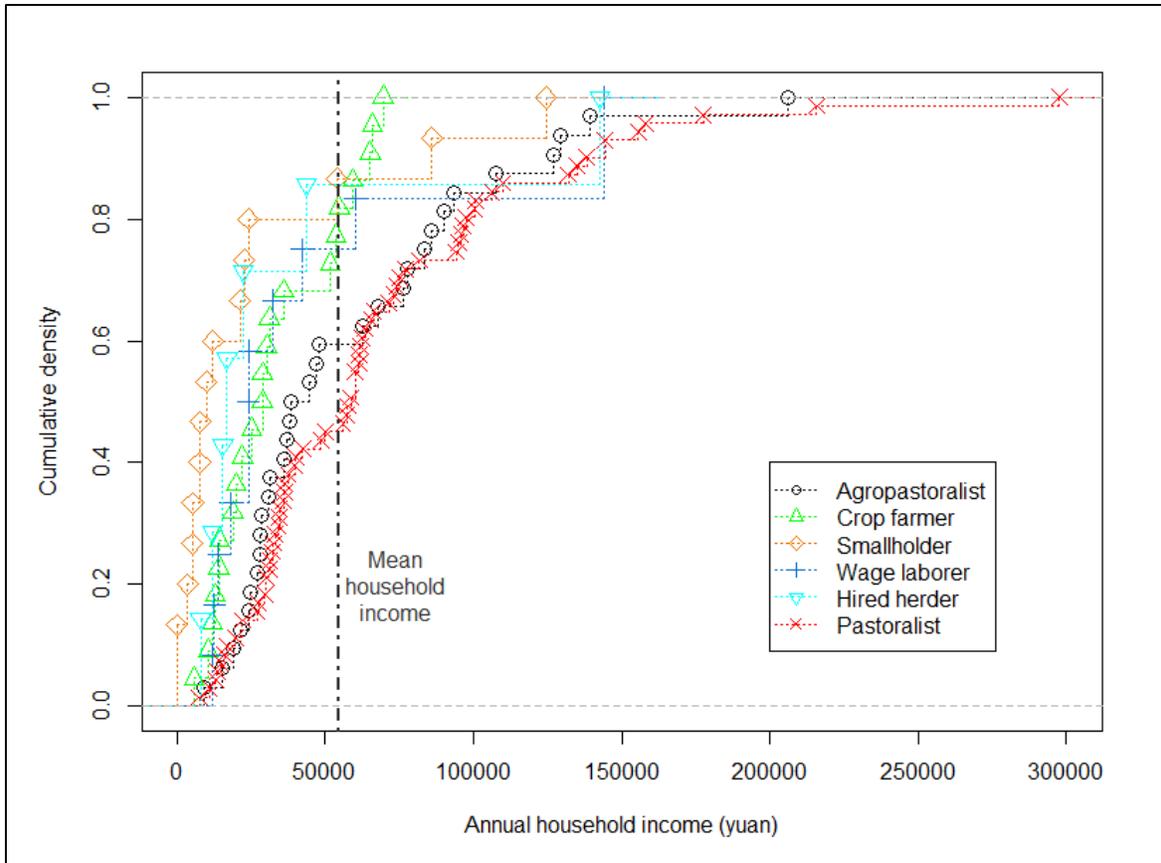


Figure 6 Cumulative density of income distribution for six livelihood strategies

Table 1 Number of livestock owned by sampled households

<b>Livestock</b>	<b>Median</b>	<b>Mean</b>	<b>St.Dev.</b>	<b>Max</b>	<b>Min</b>
<b>Cattle</b>	10	12.08	10.11	60	0
<b>Sheep/Goats</b>	40	69.07	80.73	400	0
<b>Horses</b>	3	4.93	6.65	35	0
<b>Camels</b>	0	0.89	2.15	11	0
<b>Livestock unit</b>	20.40	28.72	24.50	118.80	0

Table 2 Sources of cash income for sampled households

<b>Sources of income</b>	<b>Mean (yuan)</b>	<b>St.Dev</b>	<b>Percentage of involved households</b>	<b>Mean of involved households (yuan)</b>
<b>Livestock</b>	37612.6	45612.2	76.7%	49019.7
<b>Crop</b>	6510.7	14145.3	30.2%	21566.7
<b>Wage</b>	4839.2	18332.0	17.0%	28497.8
<b>Herding fee</b>	2987.5	11537.1	26.4%	11310.0
<b>Subsidy</b>	1867.5	9725.5	12.6%	14847.0
<b>Business</b>	769.8	1757.9	19.5%	3948.4

Table 3 Livelihood strategies estimated via k-means cluster analysis

<b>Livelihood:</b>	<b>Pastoralist</b>	<b>Agropastoralist</b>	<b>Wage laborer</b>	<b>Hired herder</b>	<b>Crop farmer</b>	<b>Mixed smallholder</b>	<b>Whole sample</b>
<b>Income Share (%)</b>							
<b>Livestock</b>	95.1	60.2	0	2.7	10.7	10.7	57.2
<b>Crop</b>	0.6	18	2.7	1.9	70.3	0	13.9
<b>Wage</b>	0.4	9.9	88.2	0	6.1	0	9.7
<b>Herding fee</b>	2.1	7.3	3	93.2	6.6	11	8.7
<b>Subsidy</b>	0.1	1.4	2	0	2.2	43.9	4.9
<b>Small business</b>	1.7	3.2	4.1	2.2	4.2	21.1	4.4
<b>Mean income (Yuan)</b>	68016.1	60125	45943.3	37300	33179.1	25593.3	54587.4
<b>No. of households</b>	71	32	12	7	22	15	159
<b>Percent of households (%)</b>	44.7	20.1	7.5	4.4	13.8	9.4	100

Table 4 Ecological diversity of pastoralist and non-pastoralist households

<b>Variables</b>	<b>Pastoralists</b>	<b>Non-pastoralists</b>	<b>Difference</b>	<b>p-value</b>
<b>Distance (km)</b>	144.81	81.33	63.47	< 0.01
<b>Migration times</b>	20.21	8.14	12.07	< 0.01
<b>Number of pasture types</b>	2.82	2.18	0.64	< 0.01
<b>Summer/Winter elevation difference (m)</b>	2300.69	1276.05	1024.65	< 0.01
<b>Livestock species diversity</b>	0.59	0.51	0.08	0.06

Table 5 Summary of pastoralist and non-pastoralist household characteristics

<b>Variables</b>	<b>Pastoralist household</b>		<b>Non-pastoralist household</b>	
	<b>Mean</b>	<b>Std.Dev</b>	<b>Mean</b>	<b>Std.Dev</b>
<b>Livestock unit owned</b>	42.38	25.08	17.71	17.58
<b>Livestock unit herded for others</b>	4.29	9.82	25.13	73.79
<b>Pasture land ownership (1=yes)</b>	0.94	0.23	0.48	0.50
<b>Hayfield ownership (1=yes)</b>	0.93	0.26	0.65	0.48
<b>Cropfield size (mu)</b>	0.85	3.60	14.02	21.88
<b>Resettlement (1=yes)</b>	0.07	0.26	0.22	0.41

Table 6 Binomial logit regression of livelihood strategy choice  
(pastoralism=1, otherwise=0)

<b>Variables</b>	<b>Estimate</b>	<b>Std.Error</b>
<b>Constant</b>	-2.448***	0.802
<b>Livestock unit</b>	0.071***	0.018
<b>Others' livestock units herded</b>	-0.048**	0.019
<b>Pasture land ownership (1=yes)</b>	1.467*	0.880
<b>Hayfield ownership (1=yes)</b>	0.697	0.866
<b>Cropfield size (mu)</b>	-0.205***	0.051
<b>Resettlement (1=yes)</b>	-2.359***	0.902

\* indicates significance at the 10% level

\*\* indicates significance at the 5% level

\*\*\* indicates significance at the 1% level