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

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Abstract

Diversification is routinely promoted to improve poor rural peoples' livelihoods. Using semi-structured interview data collected from 159 households in Xinjiang, China, this study identifies six distinct livelihood strategies by cluster analysis: pastoralists, agropastoralists, crop farmers, wage laborers, hired herders, and mixed smallholders. Patterns of livelihood diversification and their relationship with household incomes indicate that pastoralism, although preferred, is unattainable for 55% of households given their meager asset endowments and government policy pressures toward sedentarization. The results strongly suggest that livelihood diversification does not improve welfare for pastoral households in Xinjiang. Rather, maintaining extensive herding seems the key to poverty reduction.

Acknowledgements

1. INTRODUCTION

The development studies literature of the past generation has heavily emphasized the benefits of diverse livelihoods for rural populations (Bird & Shepherd, 2003; Ellis & Bahiigwa, 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). Chambers and Conway (1991) first defined rural livelihoods as "the capabilities, assets (stores, resources, claims and access) and activities required for a means of living." (Chambers & Conway, 1991:6) The notion of livelihoods centers on the household asset endowment and their allocation of assets to income generating activities (Barrett et al., 2005). The aim of livelihood analysis is to capture the multiple interactions between peoples' resources and strategies given their socio-ecological contexts (Ansoms & McKay, 2010).

Rural livelihoods diversification is generally accepted as desirable and a key focus of poverty reduction strategies in developing countries (Ellis, 1998, 2000a; Abdulai & CroleRees, 2001; Block & Webb, 2001; Smith et al., 2001; Carswell, 2002; Niehof, 2004; Bezu et al., 2012). A representative statement by a leading scholar in the field holds 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 typically requires diversifying assets and the activities to which those assets are deployed (Barrett et al. 2001). Analysis of the portfolios of income sources can thereby shed light on households' choices and outcomes given their motivations and constraints.

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 not automatic. Yet diversification is now commonly assumed by government and donor policymakers to be desirable for the rural poor. As we show in this paper, diversification is not always effective. In some settings, physical geography strongly favors a particular income-generating activity and specialization 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 pasture lands are one such location. The multiple socio-ecological challenges of life in these places has long favored pastoral livelihoods centered on the extensive grazing of livestock (Dong et al., 2011). Researchers working in different pastoral areas around the world routinely conclude 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; Behnke, 1993; Fratkin and Roth 2005; McPeak et al., 2011). That message often gets lost, however, as it has been on the Central Asian steppe of western China, where government officials exhibit little awareness of lessons from other places.

This study investigates livelihood diversification among pastoral households in the Altay and Tianshan Mountains of Xinjiang, China. Beyond offering important new insights on a seriously 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 contextualize 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. Our evidence clearly shows that livelihood diversification does not translate 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 grazing of livestock 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 contextualized 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 shown. Fourth, the impact of livelihood diversification on

household welfare and the barriers to adopt the preferred strategy are further explored using stochastic dominance analysis and binomial regression. The paper concludes with discussing policy implications.

2.   LIVELIHOOD DIVERSIFICATION CONTEXTUALIZED

While livelihood diversification theory generally works in sedentarized rural societies based on crop cultivation, some of its fundamental assumptions may not hold firmly in the pastoral society of northern Xinjiang. 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 combine crop cultivation with 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 grazing and their culture has refined the art of animal husbandry to reinforce their ecological endowments. These ecological 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.

The literature on the rural non-farm economy, like the literature 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 when presented the opportunity (Barrett et al., 2001; Block & Webb, 2001; Barrett et al. 2005). 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 minimization 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 sedentarization, which merely magnifies the perils of pastoralism. Species diversification instead, mixing browsers and grazers that are complementary in their use of rangeland resources, appears a more effective risk minimization strategy in this setting.

Pastoral households in northern Xinjiang diversify assets, incomes, and activities mostly due to "push factors" – because they are compelled to by adverse circumstances – rather than "pull factors" that attract them to an improved standard of living. As the government of China has initiated a series of ecological restoration, sedentarization, and development projects throughout its pastoral areas over the past decade (Xinhua, 2007), pastoralists have had to adapt their livelihoods in response. These polices emphasize sedentarization and livelihood diversification, justified by the argument that current resource use patterns have seriously damaged pastures and are ecologically unsustainable. The Twelfth Five Year Plan of China explicitly expressed the intention to "civilize" the pastoralists of Xinjiang by settling them and transforming their livelihoods (National Development and Reform Commissions, 2011).

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 marginalization. Yet these policies 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 range management practices (Solomon et al., 2007). Given these challenges, pastoralists in Xinjiang have responded by accepting sedentarization, diversifying their

income sources, and, where feasible, even emigrating to other countries (Cerny, 2010; Fernandez-Gimenez & Le Febre, 2006).

3.   STUDY AREAS, DATA COLLECTION AND ANALYTICAL METHODS

(a) Study area

The Xinjiang Uyghur Autonomous Region (XUAR) is located in northwestern China, spanning over 1.6 million square kilometers in the center of the Eurasian landmass. Situated in the middle of the ancient Silk Road, Xinjiang has 5,600 kilometers' border with eight countries from northeast to southwest: Mongolia, Russia, Kazakhstan, Kyrgyzstan, Tajikistan, Afghanistan, Pakistan, and India. Moving from the south of Xinjiang to the north, which approximates to latitudinally moving from Los Angeles to Seattle, one crosses a physical landscape that ranges from the second highest point (K2, 8,611 meters) to the second lowest point (Aiding Lake, -154 meters) on the Earth (Starr, 2004). As the most remote region from oceans in the world, the water vapor 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).

Fieldwork was conducted in the Altay Mountains of Altay District and the Tianshan Mountains of Ili Prefecture in northern Xinjiang, where pastoralism is traditionally the dominant livelihood strategy. Infrastructure such as roads, schools, and health facilities are relatively weak in these two regions. However, climate, landscape, population density, and the ratio of Kazak ethnic population differ between them (Table 1). In general, the environmental conditions in Altay are harsher, with less annual precipitation, lower average temperature, larger proportion of Gobi desert, and a magnitude lower population density. Compared to Altay, Ili is a more developed region with more Han immigrants. As a result, only 20.7% of the population in Ili are Kazak, while in Altay they account for more than 50%.

Table 1   here

(b) 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 socio-cultural contexts of livelihood diversification.

Selection of households was made on the basis of representativeness of different rural livelihoods along the pastoral migration routes, 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 deserts, 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 standardized survey questions regarding demographic background, household assets, cash-generating activities, and income from each source. In addition, we asked open-ended questions regarding 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 summarized 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).

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.

(c) 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 characterized by maximum 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 use cluster analysis for livelihoods classification, we conducted the analysis based on the share of income[1] 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[2]. 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 a 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 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 are associated with the adoption of distinct livelihood strategies, with the objective of identifying the correlates of access to the most remunerative strategies.

4. LIVELIHOOD PORTFOLIOS

(a) 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 maximize the utilization of pastures while minimizing 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.

(i) Land

There are three types of lands owned[3] 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% of households claim ownership over pasture lands. Due to various reasons such as

mining, tourism development, pasture fencing, and sedentarization, pastoralists gradually lose 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 free of snow in winter. Some of these lands are used for free range, while others serve as sources for fodder harvest. About 77% of households in our sample own hayfields. Since the utilization 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.

As an increasing number of pastoralists are adopting a sedentary lifestyle, they start to cultivate staples and vegetables in cropfields. About 32% of households own crop fields in our sample. Compared to pastures and hayfields, cropfields can be easily quantified in terms of sizes. Among these households who own cropfields, the average size is 27 mu[4] (about 1.8 hectares).

(ii) Livestock

The major livestock raised by pastoralists are cattle, sheep, and goats, with a small number of horses and camels (Table 2). 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 2　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% of them have less than 15 livestock units[5], while less than 15% 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 minimize risk exposure, since a mixture of large and small ruminants, grazers and browsers can optimize the utilization of

available resources (Nori, 2007). In this paper, we use the Shannon-Weiner Diversity Index[6] 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 0, indicating no diversification whatsoever. Seven of them do not possess any livestock, while 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% 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% households in our sample are engaged in hired herding, the number of livestock they take care of 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 tend 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 income. Many of these hired-herded livestock owned by crop farmers, sedentarized pastoralists, and even Han Chinese settled in towns.

(b) 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 fees, government subsidy, and small business (Table 3). 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[7] 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[8]. Other sources of income (wage, subsidy, and small business) were directly reported by respondents.

Table 3 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 own consumption.

The details of each cash income source are presented in Table 3. The most important source is livestock. Average income from this sector is about 38,000 yuan. About 77% of households depend on livestock sale to sustain their livelihoods. For those engaged in this sector, the average is more than 49,000 yuan.

The second most important income source is from crop cultivation, in which 30.2% 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 labor and capital investment. For those households involved in crop production, cash income from crop is less than half of that from livestock.

About 17% of households are engaged in wage labor. The average income from this sector is 4,839 yuan, but for those who are involved in this sector, their average income is about 28,500. There are two types of wage income. The first type involves employment in the government or other public organizations. Respondents belonging to this group have relatively stable income. The second type is

more common, which is 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 income from a hired 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 warm seasons, 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% of the sample. Some households receive subsidy from the poverty reduction program financed by both central and local 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 implementation of ecological restoration and tourism development projects.

About 20% 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 to run a small grocery store in the yurts, as access to grocery items is very limited on the remote pasture lands.

(c) Livelihood strategies

Based on the Simple Structure Index and common sense checks, 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 4.

Table 4　here

Pastoralists are both the highest earners and the largest group among the six clusters, representing almost 45% of the entire sample. More than 95% 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 68,000 yuan annually, roughly 2.5 times as much as the poorest cluster and 36% 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% of the whole sample. Livestock revenue, the most important income source for this cluster, constitutes over 60% of their cash income. This is followed by crop revenue, which accounts for almost 20% of the total.

The distinguishing feature of the **wage laborer** group, representing 7.5% of the sample, is their dominant reliance on wages as a source of income: almost 90% 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 laborers are the third wealthiest group, their income is still about 15% less than the sample average.

Households in the **hired herder** cluster derive 93.2% 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% of the entire sample, all other clusters have some (far less specialized) 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 37,300 yuan, which is 30% less than the sample average.

Crop farmers represent 13.8% of the entire sample. On average, they receive more than 70% 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% of crop farmers' income is from livestock sales, which is much less than the agropastoralists who derive more than 60% from this source. Another key distinction between crop farmers and agropastoralists is average household income level. Crop farmers only earn 55% of what agropastoralists do on average, and about 40% 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% of the sample average. They heavily rely on government subsidies to maintain their livelihoods.

This cluster also relies relatively heavily on earnings from small business. About 20% of their cash income comes from selling milk products and grocery items, while none of the other clusters derive more than 5% from this source. The remaining 20% of their income comes either from livestock sales or herding fees. Mixed smallholders are not engaged in crop cultivation or wage labor at all.

5. LIVELIHOOD DIVERSIFICATION ANALYSIS

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 mean household income. But those who are without sufficient herd are in trouble. Although those who found jobs, the wage laborers, are next best off, their group average income is 16% less than the sample mean and 33% less than the pastoralists. The clear implication is that maintaining viable herding is the key to poverty reduction in the pastoral areas in Altay and Ili. In order to quantitatively investigate the impact of livelihood diversification on welfare, we explored the relationship between income diversity and annual household income and then explored the factors that are associated with the adoption of livelihood strategy.

(a) 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 ($p=0.052$) negative association between households' income diversity and their annual income, where wealthier households tended to have less diversified income streams. Insofar as population growth and government polices 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, more diversified households' annual cash income is much less than those who are largely able to maintain livestock herding.

Figure 5   here

The relationship between household income and its diversification classified by livelihood strategies 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 fields, allowing them to diversify their income sources around their fixed bases. 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. Wage laborers and hired herders are much more focused on their dominant sources of income, with diversity indexes around 0.2. Pastoralists, the wealthiest group, have the lowest income diversity index at 0.15.

(b) Livelihood strategy superiority

The distinct groups identified by cluster analysis enable us to order the different livelihood strategies adopted by the pastoral households in Altay and Ili by stochastic income distributions. Mean cash income varies dramatically across strategies, ranging from 25,593 yuan per household per year for mixed smallholders to 68,016 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[9]. The cash income distribution of pastoralists and agropastoralists appear to first-order stochastically dominate the other four strategies. Wage laborers' income distribution first-order stochastically dominates that of smallholders and hired herders. In addition, second-order dominance can be inferred for pastoralists over agropastoralists. 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 labor 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 sedentarization and encouragement of diversified livelihood activities.

Figure 6   here

(c) 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% 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 laborer, farmer, hired herder and mixed smallholder to form a non-pastoralism group to compare against the pastoralism group[10]. Key household level variables of these two groups are summarized in Table 5, including livestock units owned by the household, livestock unit herded for others, household pasture land 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.

Table 6   here

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% 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 (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.

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% 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 will 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 labor intensive and fixed in space and time, especially in places suffering from poor facilities and unfavorable 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% of sample households had been relocated into the

newly built resettlement villages, while almost another 20% households had agreed to move into resettlement villages and purchased a house with government subsidy. Among those relocated households, almost 80% had given up livestock herding. With limited nearby lands, which are usually of poor quality, reduced livestock holdings and herd migration are inevitable outcomes from sedentarization through resettlement.

The ongoing transition in livelihoods in Altay District and Ili Prefecture from heavy dependence on mobile livestock herding to relying on sedentarized livelihood strategies is an explicit aim of the central government's Twelfth Five Year Plan. These policies aim at sedentarizing pastoralists and transforming them into modernized ranchers who produce large quantities of dairy and meat using an industrialized approach. However, only the first half of this plan – sedentarization – is being actively pursued, while the second half – intensifying and modernizing livestock production – is left behind without corresponding investment and planning. During the implementation of these sedentarization policies, new houses ranging from 60 to 90 square meters with a three mu (about 2000 m^2) yard are sold at a subsidized rate, with pastoralists paying 50% of the cost. In addition, a 50 mu (about 3.33 hectare) hayfield is given as a bonus for purchasing a house in the resettlement villages. However, almost all respondents complained that the hayfields are far from being enough to sustain a viable herd of livestock, and these lands often suffer from high aridity and alkalinity. Although the local government did not revoke sedentarized pastoralists' traditional claims to grazing lands, being much further away from their traditional overwintering bases almost forces them to give up their hayfields there.

6. CONCLUSIONS AND POLICY IMPLICATIONS

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 laborers, hired herders, and mixed smallholders. The results show that although pastoralism is the most remunerative and the stochastically

dominant livelihood strategy, only 45% 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 at once 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 labor and sedentarization. Finally, the non-pastoralist households suffer more from the negative impacts of relocation in the government's newly built resettlement villages.

Our findings in northern Xinjiang underscore two key points. First, policy interventions for the development of pastoral areas must be based on contextualized analysis. 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. Efforts to sedentarize pastoralists and transform their livelihoods away from extensive livestock herding in northern Xinjiang, including through providing discounted homes in resettlement villages, have turned out to be futile and counterproductive for households in the area.

Based on our findings, obvious policy recommendations include interventions to ensure continued access to pastures and hayfields so that more households can continue to engage in mobile livestock herding. Policy makers must recognize the barriers to the adoption of the more remunerative livelihood strategy, pastoralism, based on the ecological and cultural comparative advantage of the Kazak pastoralists. The implementation of the ecological restoration and pastoral resettlement programs are

working against the economic interests of these peoples. Future pastoral policies should promote policies that enable poorer households to regain access to pastures and hayfields in order to rectify the damage done by recent measures and to help correct the imbalance of opportunities that exists in northern Xinjiang. Households routinely expressed to us 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.

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Endnotes

1. 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.

2. 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 omit those results.

3. 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.

4. 1 mu = 666.67 square meters.

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

6. 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 ith type of livestock in the r-string of interest (i=1,2,…,r).

7. In 2010, the price was about 1,100 yuan for a lamb, 2,500 yuan for a calf, and 5,000 yuan for a horse. The average income from a mu of crop field is about 800 yuan.

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

9. 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).

10. We lack adequate degrees of freedom to estimate a multivariate probit.

Table 1   Descriptive information of study sites (XUAR Chorography Committee, 2011)

Variables	Altay District	Ili Prefecture
Annual rainfall (millimeter)	180.8	257.5
Temperature high (°C)	28.2	30.2
Temperature low (°C)	-23.2	-16.5
Elevation high (meter)	3930	5952
Elevation low (meter)	365	530
Population density (per square kilometer)	4.8	43.0
Percent of Kazak population (%)	51.4	20.7

Table 2　Number of livestock owned by interviewed households

Livestock	In Kazak	In Chinese	Median	Mean	St.Dev.	Max	Min
Cattle	*Sier*	*Niu*	10	12.08	10.11	60	0
Sheep/Goats	*Koyi*	*Yang*	40	69.07	80.73	400	0
Horses	*Utt*	*Ma*	3	4.93	6.65	35	0
Camels	*Tuye*	*Luotuo*	0	0.89	2.15	11	0
Livestock unit			20.40	28.72	24.50	118.80	0

Table 3 Sources of cash income for sampled households

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

Table 4 Livelihood strategies estimated via k-means cluster analysis

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

Table 5   Summary of pastoralist and non-pastoralist household characteristics

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

Table 6　Binomial logit regression of livelihood strategy choice

(pastoralism=1, otherwise=0)

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

* indicates significance at the 10% level

** indicates significance at the 5% level

*** indicates significance at the 1% level
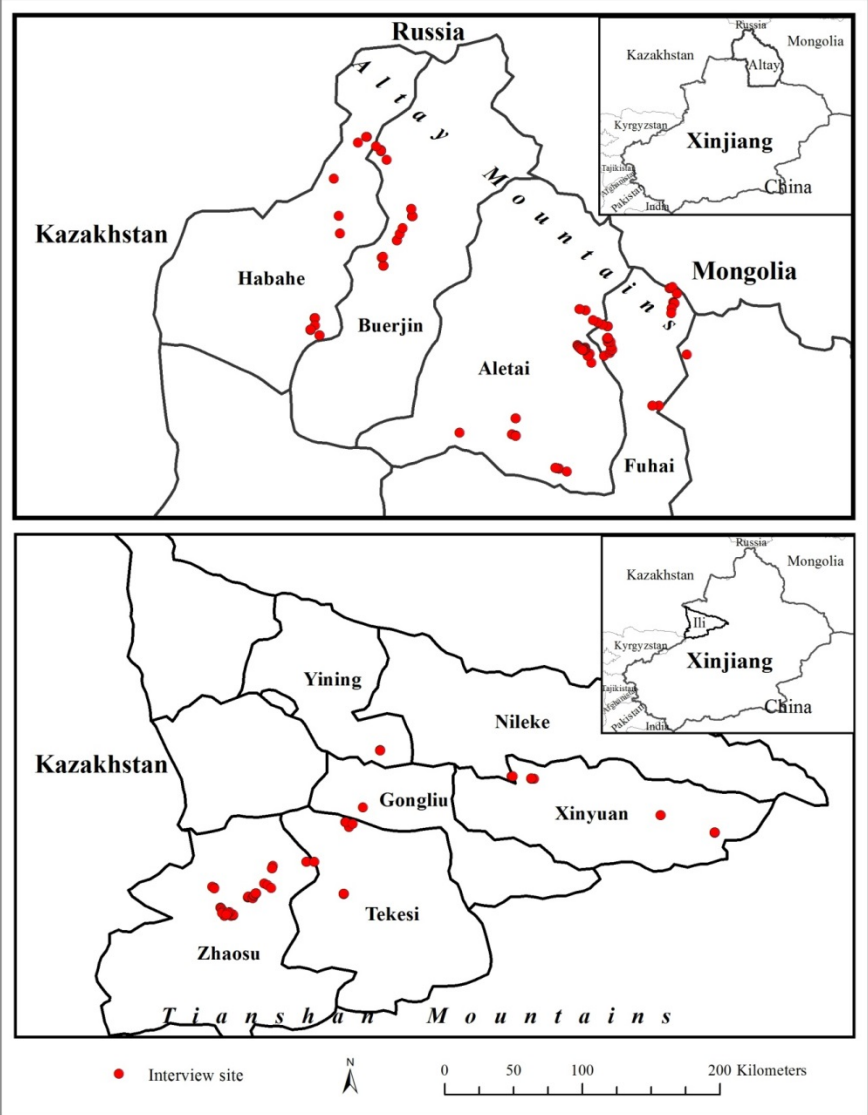
Figure 1   Interview sites in Altay District and Ili Prefecture of Xinjiang, China
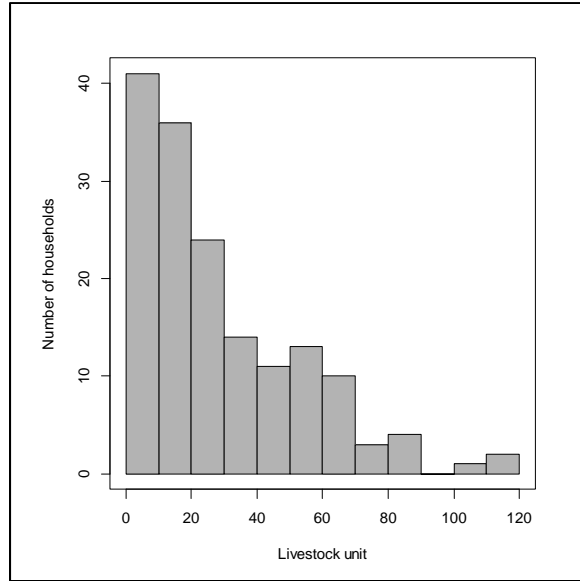
Figure 2   Livestock unit distribution among 159 households
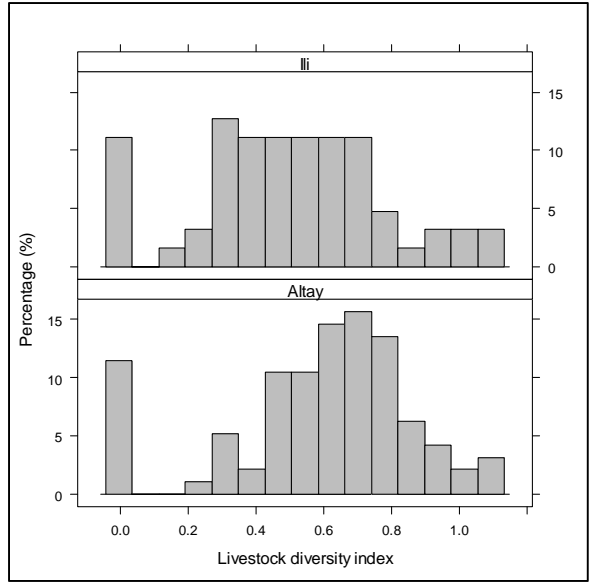
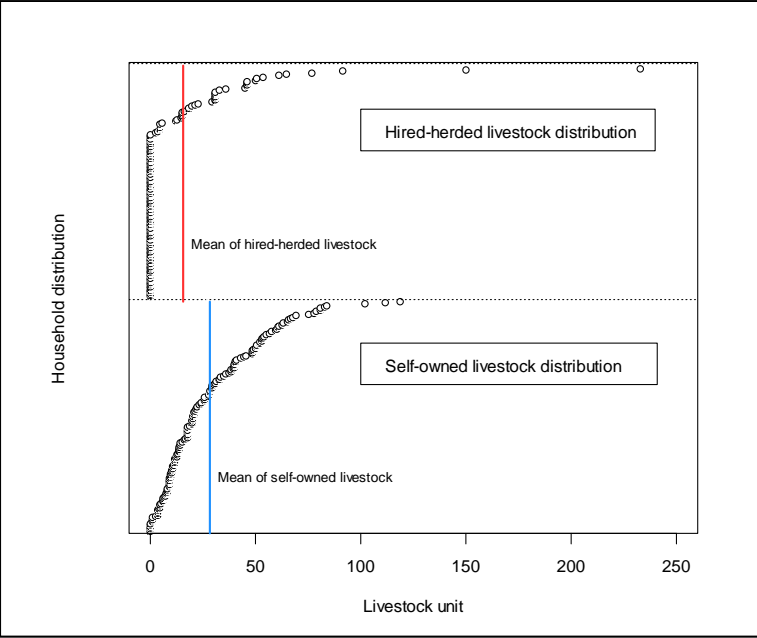Figure 3　Livestock diversity of individual households in Altay and Ili

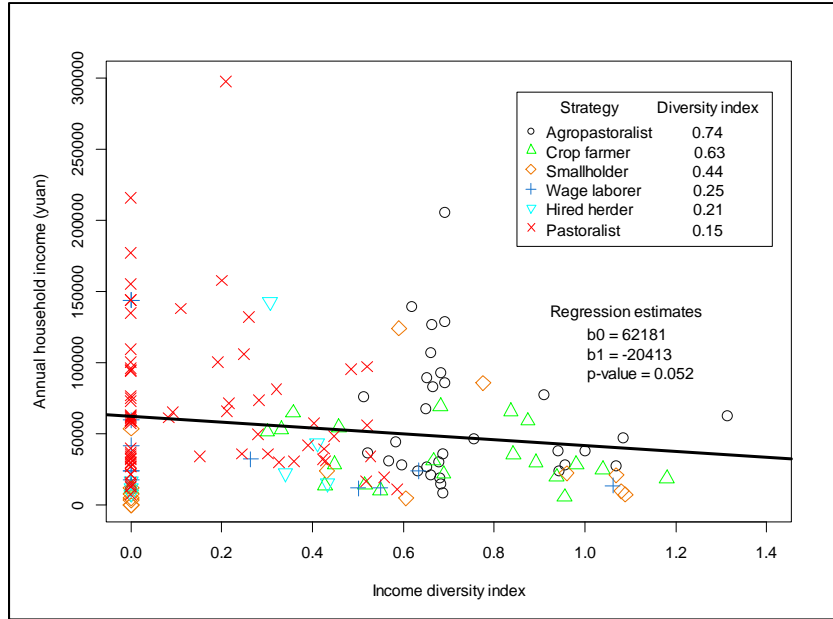Figure 4   Comparison between the number of self-owned and hired-herded livestock

Figure 5   Annual household income and income diversity for six livelihood strategies
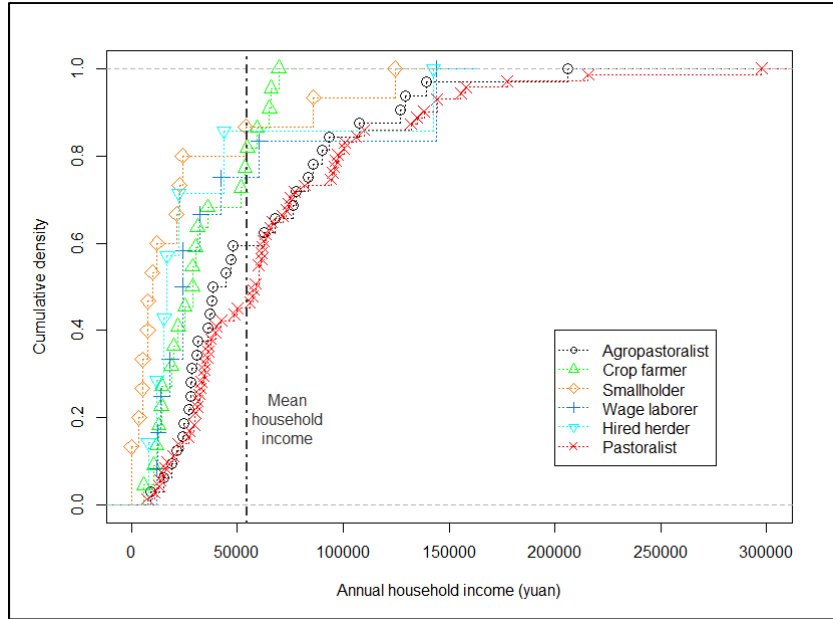
Figure 6　Cumulative density of income distribution for six livelihood strategies