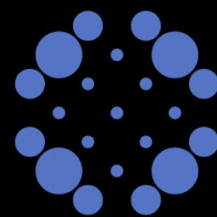


# Livestock and Land Share Contracts in a Hindu Society

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# Livestock and Land Share Contracts in a Hindu Society

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## Abstract

This paper examines factors related to the existence of a livestock rental market in western Nepal and assesses whether this is associated with caste differentiation and land rental market participation. This study brings new empirical evidence of livestock rental market against the established view that such market does not exist due to moral hazard. Theoretical models for asset-rich (high-caste) households, rich in land and livestock, and asset-poor (low-caste) households are presented providing logical explanations for the existence of a livestock rental market and synergies between livestock and land rental market participation. A combination of double hurdle models and bivariate ordered probit models were applied to test the implications of the models. The empirical evidence was found to be consistent with the theoretical models. Land- and livestock-rich (high-caste) households were more likely to rent out land and/or livestock. Land- and livestock-poor and credit constrained (low-caste) households were more likely to rent in livestock and land. Participation in the two markets was positively correlated indicating synergies that may be due to production and transaction cost reducing benefits. The male labor endowment, partly determined by migration, was a major determinant of livestock rental behavior.

**Key words:** livestock rental market; land rental market; share contracts; asset poverty; caste; Nepal

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## 1. Introduction

Livestock remains to be an important asset for farm households in rural areas of developing countries as a provider of multiple services and commodities like traction power, manure, productive asset stock, insurance, meat, milk and wool and is thus a major source of income. Livestock is typically a more liquid asset than land because livestock sales markets are not exposed to the same legal restrictions; in addition, livestock are mobile in contrast to the immobile land resources. This on the other hand has caused land to be favored for collateral purposes while livestock - due to its mobility and fragility - are considered unsuitable for such purposes (Binswanger and Rosenzweig, 1986). Related to this is also the empirical phenomenon that land rental markets tend to be more developed and function better than land sales markets while the opposite is the case for livestock. Binswanger and Rosenzweig (1986) explain the poor development of rental markets for livestock and their services like ploughing services by the considerable moral hazard problem and fragility of animals. Another reason for this poor development could be the short season for such demand in rainfed agriculture while one could expect more of such rental services in irrigated agriculture (Holden et al., 2008). This may also explain why there have been many empirical studies of land rental markets but hardly any studies of livestock rental markets.

Contrary to the statements above we found livestock rental transactions to be quite common in our study area in Nepal and so was the case with land rental transactions. We therefore question why households participate in livestock rental markets and how this relates to the inequality in asset distribution, and the functioning of other input and output markets. In particular we relate livestock renting to the discriminatory caste system (for details see section 2) that is of primary importance for the asset distribution as well as factor market

access (Banerjee and Knight, 1985; Ito, 2009; Aryal, 2011) in Nepal. Traditionally, low-caste males served as ploughmen (called *Hali* in Nepali and the system is called *Haliya*) for high-caste landlords who considered ploughing as inferior work. Under the *Haliya* system, low-caste households used to provide all sorts of manual labor required for farming as well as taking care of livestock (UNRHCO, 2011). Consequently, livestock renting can be associated with such traditional caste differentiation, implying a need to consider caste while analyzing livestock rental contracts. Furthermore, low-caste households tend to have little education and poor access to non-agricultural employment while at the same time they are asset-poor and have no or very little land and livestock endowments. Output sharing contracts dominate in the livestock and land rental markets where low-caste households typically are tenants. Using farm household data from western Nepal we investigate factors explaining or being associated with participation in livestock rental and land rental markets. We are not aware of any earlier studies on this.

For the empirical analysis, we applied double hurdle and bivariate ordered probit models. We tested three major hypotheses. Our first hypothesis that livestock- and land-rich high-caste households with better labor market access are more likely to rent out both land and livestock could not be rejected. The second hypothesis was that land and livestock poor (low-caste) households rent in livestock and land. Our empirical analysis revealed that poverty in land and livestock was significantly positively correlated with renting in these assets and households being credit constrained further enhanced such participation on the demand side of these markets. Therefore, the livestock and land rental markets may serve as a way to overcome the capital and credit constraints of poor households. The third hypothesis, we tested was that livestock renting occurs as complementary contract to a land rental contract. Our empirical analysis showed a strong positive correlation between the participation on the same side of these two markets and hence, the third hypothesis could not be rejected. This



may be explained by land and livestock being essential complementary inputs in the local farming system and joint contracts being a transaction cost reducing device for landlords who face moral hazard problems and search, monitoring and enforcement costs when renting out their resources.

## **2. The caste system in Nepal and its implications**

The caste system, which originates in the Hindu religion, fixes the hierarchy of individuals at birth based on hereditary membership and prevents movement from one category to another.

The major caste classifications are: *Brahmins*, *Chhetries*, *Vaishyas*, and *Sudras* (they are now called Dalits). *Brahmins* have priestly roles and are considered as pure or holy, while *Chhetries* are considered warriors and rulers. *Vaishyas* are regarded as traders while *Sudras* are impure or untouchable and are considered to work as laborers (UNDP, 2008).

Traditionally, the caste classification defines the role of each category and states what they can and cannot do. The most severe implication of this system is the division of labor for each category based on their caste, providing a basis for discriminatory treatment. Among several discriminatory practices, practice of untouchability has severe implications. The practice of untouchability prevents Dalits from participating in religious functions, entering into the shops and houses of other castes, using public wells, and even, attending the same school (Banerjee and Knight, 1985; Aryal, 2011). This practice contributed to social ostracism of Dalits. Though there are differences between each of these groups, the most severe one is between Dalits and non-Dalits. This study therefore classified all households under the study into two broad groups: Low-caste (*Dalits* households only) and High-caste (all other households).

The caste based hierarchy and division of labor exist as long-standing phenomena in Nepal (Gurung, 1997; Hachhethu, 2003; Aryal, 2011). Though caste discrimination had been in practice long before, it was accepted by the state as a legal regulatory mechanism from 1854.

In 1854 Nepal implemented a legal framework that was entirely based on the values of the caste system through the implementation of a first Civil Code. The Civil Code, which was in place and practiced until 1963, accorded differential privileges and obligations to each caste (Hachhethu, 2003; Bennett, 2005; DFID and World Bank, 2006). This resulted in the unequal access to resources and even, unequal treatment from the state institutions.

A new Civic Code in 1963 replaced the Civil Code of 1854. The new Code came with some drastic changes, especially the legal abolition of caste discrimination. However, this did not bring any substantial changes in practice due to the inconsistency between the existing value system and laws (Dahal et al., 2002). Only after 1990, when Nepal adopted a multiparty democracy, the constitution of Nepal explicitly declared that all citizens are equal irrespective of caste. However, the constitutional provision remained ineffective in practice due to lack of supporting laws and low level of social awareness (Bhattachan et al., 2002). In reality the remaining laws and the existing bureaucratic structures facilitated to continue caste discrimination in the name of maintaining tradition.

In 2007, Nepal became a secular republic nation and the Interim Constitution of Nepal 2007 assured legal abolition of caste discrimination. With this, several legal and political changes are made to end caste discrimination, but the overall social transformation necessary to bring this in effect may take long time.

The central issues in this paper are the implications of caste discrimination for factor market participation directly and through its effects on asset distribution. Caste discrimination against Dalits has various implications related to market participation, access to and ownership of resources, and level of human capital (Banerjee and Knight, 1985; Ito, 2009; Aryal, 2011). Traditionally, Dalits were not allowed to own land (George, 1987) and to receive education: they were only allowed to do menial jobs (Banerjee and Knight, 1985). A crucial implication of this is the less access to land by Dalits in Nepal because land transfer is

predominantly inter-generational among family members despite the existence of a land market (Wily et al., 2008). Moreover, accessing land through the land sales market is out of reach for the poor due to credit market imperfections. Similarly, when compared to others, Dalits lie far behind in wellbeing indicators such as literacy, income, life expectancy and representation in politics (UNDP, 2008). Due to poverty and illiteracy, Dalits are highly dependent on high-caste households for their survival. In the study area, we observed that even the clusters of Dalits live separately from other caste groups. *Haliya* system that links Dalits as a farm worker in high-caste households still existed. Despite legal abolition of caste discrimination, Dalits still suffer from the negative impacts of the past discrimination, especially in their participation in better paying jobs. Though the caste based division of labor is diluted over time, the historical pattern of employment to a large extent influences their choice of occupation. The past experiences may create lower expectations among Dalits making them to accept low-paid lower status jobs (Banerjee and Knight, 1985). In addition, studies in India, where similar caste discrimination is in practice, show that Dalits face significant transactions costs in participating in regular off-farm employment (Madheswaran and Attewell, 2007; Ito, 2009). A study in Nepal (Hatlebakk et al., 2010) showed an association between caste and migration, and thus, Dalits were less likely to migrate. He also found a positive effect of the social network on the likelihood of getting jobs in the migration destination.

### **3. Background on livestock rental markets**

Contractual arrangements in agriculture have remained an area of interest for several researches. Land tenancy contract and labor employment contract have remained the key areas of focus (Otsuka et al., 1992). There are therefore few literatures related to livestock rental markets as compared to land rental markets. The usual absence of livestock rental markets has been explained by the fragility of animals, moral hazard related to management

of rental animals, the short season for use of animals as traction power in rain-fed agriculture, and the well-functioning sales markets for animals (Binswanger and Rosenzweig, 1986; Holden et al., 2008). This also gives reason to ask why the livestock rental market exists in some cases, like in our study area.

Livestock plays important roles in many types of farming systems where land and livestock are inter-related components. In such farming systems where land rental markets are common it is possible that major attributes of the land rental market also affect the possible existence of a livestock rental market. Furthermore, these markets might represent a response to other factor market imperfections in rural areas, such as imperfect or missing credit and insurance markets where the non-existence or access to these markets may be affected by unequal resource distribution. Land tenancy contracts and the contract production of livestock have many common characteristics (Knoeber and Thurman, 1995; Knoeber, 2000). Knoeber (2000) studied land and livestock contracting in agriculture using the principal-agent perspective. He examined contracts in broiler production and claims that risk sharing and incentives largely explain such contracts. However, his study concentrated on agriculture in developed countries like USA.

Among the few studies in developing countries, Aspen (1993) found both livestock share contract and land rental contract in Ethiopia. Tadesse and Holden (2010) in their study in Ethiopia examined the determinants of livestock rental contract choices and their impact on poverty. Their study showed that livestock rental contracts contributed to overcome capital constraints in an area with high production risk and imperfect markets, despite the likelihood of moral hazard. Furthermore, they found a positive welfare effect of the livestock rental contracts in the case of livestock tenants.

In developing countries, formal risk coping strategies are often costly (Morduch, 1995) and thus, farm households need to rely on informal risk sharing strategies (McPeak, 2006).



Studies of risk and insurance in Indian villages using ICRISAT data showed that livestock production is typically the least risky enterprise while compared to earnings from wage and income from crops produced (Townsend, 2000). Another study using the same data showed that bullocks are sold when households face adverse weather shocks in order to smooth consumption (Rosenzweig and Wolpin, 2000). Rosenzweig and Wolpin (2000) also found that under a situation when agriculture suffers from covariate risk, livestock served as a buffer stocks because livestock are movable form of capital as compared to land. Though livestock is an important source of liquidity, using it as buffer stock is costly because households may need to sell livestock at low prices when they face shocks under covariate risk (Holden and Shiferaw, 2004).

Several studies claim that when there are production risks but no insurance markets, sharecropping contracts occur due to the need to share risk (Akerberg and Botticini, 2002; Otsuka, 2007). However, empirical evidence does not always support the risk sharing hypothesis as a prime motivation for sharecropping (Allen and Lueck, 1999). Poor households may also use sharecropping to overcome capital constraints and balance their asset portfolios, and to enhance cooperation with relatives or neighbors (Bogale and Korf, 2007).

In Nepal, short-term sharecropping, known as *Adhiya* in Nepali, is the most common land rental arrangement (Acharya and Ekelund, 1998). The term *Adhiya* is understood as 50-50 sharing of the produce. However, this differs depending on the supply of inputs by landlords and tenants. In general, the tenant provides labor and all other inputs, while the landlord provides the land. In practice, not all inputs are shared equally between landlord and tenant. Mostly, inputs such as cost of chemical fertilizers, irrigation, and improved seeds are shared (Acharya and Ekelund, 1998). The arrangements may differ depending on the level of dependency and the relationship of the tenant to the landlord. In *Gausala* village in Nepal,

Acharya and Ekelund (1998) found that none of the landlords shared the costs of the inputs in the case of pure tenants, indicating that contract terms might improve with economic status of the tenants. Their study also showed that 86 percent of total borrowers among the pure share tenants have borrowed from their landlords. Under such cases, landlords possess power to force the tenants to apply more inputs and may not share all inputs equally.

In Nepal, Aryal and Holden (2010) found significant transaction costs in the land rental market, particularly in the demand side of the market. This indicates that many potential tenants find themselves rationed out or have only rationed access to land through the land rental market. They also found that low-caste households have higher land productivity compared to high-caste households. Despite this, some high-caste landlords rented out their land to other high-caste tenants that were less productive. This might be due to the tenure insecurity caused by the land-to-the-tiller policy in Nepal. In general their conclusion was in line with the claim made by Otsuka (2007) that inefficiency of sharetenancy might not be due to the inherent difficulty of contractual arrangement of sharetenancy but more due to policy distortions. This may be the reason for the dominance of short-term informal sharecropping contract in the study area, which is similar to what Acharya and Ekelund (1998) observed.

The origin of a livestock rental market in Nepal may come from the traditional *Haliya* system for ploughing and permanent bonded agricultural labor. A study by CSRC (2007) showed that almost 300,000 Dalit households work as *Haliya* in Nepal. Of the total *Haliya* workers, 97 percent belong to Dalits (UNRHCO, 2011). Since ploughing land using oxen was assumed to be below the dignity of high-caste households, they relied mostly on low-caste male for this (Adhikari, 1992). He further noticed that in the case of high-caste landlord and low-caste tenant, there may also be an interlinked contract where the tenant works as a ploughman and agricultural laborer on the land of the landlord. In south Asia, most of the permanent agricultural laborers belong to low-caste and their employers to high-caste (Otsuka et al.,

1992). In addition, *Hali* and his family members were often required to assist their respective patrons in other activities related to farming and also taking care of livestock (UNRHCO, 2011).

By tradition, Dalits were assigned manual jobs and this has also lowered their general expectations regarding the access to jobs (Banerjee and Knight, 1985). However, the strict norms created interdependence and synergies between these caste groups, and trust which reduced the moral hazard problems associated with rental contracts. Furthermore, households within villages are closely connected. As a result, there is a possibility to reduce transaction costs related to livestock rental transactions. The low-caste households also depend on access to land and to livestock in order to subsist and supply the services demanded by high-caste households. In addition, most of the livestock tenants belonging to low-caste households are found to have worked as agricultural labor, livestock attendants or *Hali* to the landlord. This has increased their level of trust and helps reduce monitoring costs for landlord. Our data revealed that land and livestock contracts are mostly integrated. Of the sample households that rented in livestock, almost 60 percent have also rented in land. Under such a contract, the landlord can monitor the use of livestock as well as the land in the same visit. In many cases, not only landlords but their close relatives can undertake these monitoring activities. If the tenant resides by the close relatives of the landlord, the landlord can get information about the use and care of the livestock that he/she rented out. Therefore, socio-economic factors, especially caste differentiation in access to resources and markets may explain the continued existence of the livestock rental market.

There are two types of livestock rental contracts in our study area: i) the livestock lord owns or covers the initial payment for purchasing livestock and ii) the livestock lord and tenant share the costs of initial purchase. In the first case, the livestock tenant has to cover most of the other costs including labor, shed for the animal, feed, water, and also medicine. Sharing

of output depends on the type of livestock contracted. In case of cows and buffaloes, the livestock tenant has to share 30-50 percent of the revenue obtained from selling milk and milk products, usually *Ghee* (a kind of butter) or give certain amount of cash to the livestock lord at each lactation. In this case, the tenant has no right to the offspring or the revenue obtained from selling the animal. In the case of oxen, tenants are required to provide traction services to the livestock lord and thus, most of the households renting in oxen belong to low-caste households. However, in case of medical expenses, the tenant can share some of the costs with the livestock lord if the information is given on time. In case of unexpected death of the animal, the tenant has to provide evidence to livestock lord or any person assigned by him. In the second type of contract, both the livestock lord and tenant share the initial purchase costs as well as benefits. This contract is often found in case of small ruminants, especially goats. As goats are the popular source of meat in the society, it has high selling value throughout the year, mainly during festivals. However, contract choice is not the major focus in this article due to limited sample size for some contract types.

## 4. Model and empirical strategy

### 4.1 Theoretical framework

A farm household has initial endowments of land  $\bar{A}$  and livestock  $\bar{N}$ . Assume that both of these are associated with caste of the household,  $C$ .  $A_j$  and  $N_j$  are land and livestock resources transacted in the land and livestock rental markets. Consider that the labor endowment of the household  $L$  depends on the migration  $M$ , which in turn depends on the caste as high-caste households have more migrated members - partly because they have better access to regular off-farm employment due to better family networks and higher level of education. This results in a reduction in male labor endowment of high-caste households with migrated members. The production function,  $q$  is then given by

$$1) q = q(N, A; L(M(C))) ; \text{ where } \frac{\partial q}{\partial N}, \frac{\partial q}{\partial A}, \frac{\partial q}{\partial L}, \frac{\partial^2 q}{\partial N \partial A}, \frac{\partial^2 q}{\partial N \partial L}, \frac{\partial^2 q}{\partial A \partial L} > 0; \frac{\partial^2 q}{\partial N^2}, \frac{\partial^2 q}{\partial A^2}, \frac{\partial^2 q}{\partial L^2} < 0$$

$$N = \bar{N} + N_j \text{ and } A = \bar{A} + A_j$$

where  $N$  and  $A$  refer to operational holding of livestock and land resources respectively. The production function assumptions state that livestock, land and labor are complementary factors of production (have positive cross-derivatives) and this is plausible in our context.

Note that both caste and migration are categorical variables.

In our study area both land and livestock rental contracts are predominantly share contracts where the owner gets a share of the output from crop and livestock production. However, a household can decide whether to participate or not as a lord in the rental markets for land and livestock while potential tenants may be rationed in their access to land and livestock through the rental market. This is due to the presence of moral hazard, monitoring and supervision costs and the dominance of share contracts (Bell and Sussangkarn, 1988; Dutta et al., 1989; Singh, 1989). Therefore, we will present two general models: one for a household that is wealthy in land and livestock (high-caste household) and who is likely to rent out part of these endowments, and one for a household that is poor in land and livestock endowments (low-caste household) and that may access these through the rental markets.

### **General model for asset rich household**

Households with surplus land and livestock, which they cannot manage themselves and that they do not want to sell, will rent out these. Their option may be to rent out the land and livestock separately or jointly. We assume that land and livestock are complementary inputs in crop and livestock production. There are transaction costs related to establishing, monitoring and enforcing rental contracts, however, a joint contract may increase returns and reduce transaction costs in relation to establishment, monitoring and enforcement of such a contract. This requires identification of a tenant partner that is trustworthy and in need of both land and livestock. If a productive potential tenant is trustworthy but capital and credit-

constrained and with limited land and livestock endowments it may be optimal to rent both land and livestock to him. This is formalized below.

Assume that the production function on rented out land looks like this:

$$q_A^{ro}(A^{ro}, N^{ro}; l_A^t, A^t, N^t), \text{ with } \frac{\partial q_A^{ro}}{\partial A^{ro}} > 0, \frac{\partial q_A^{ro}}{\partial N^{ro}} \geq 0, \frac{\partial^2 q_A^{ro}}{\partial A^{ro} \partial N^{ro}} \geq 0, \text{ with potential synergies}$$

involved in joint contracts and similarly in livestock contracts. Superscript  $t$  refers to tenant.

Assume that transaction costs related to land and livestock renting are non-decreasing (concave) functions of the amount of land and livestock that are rented out whereas a joint contract reduces total transaction costs. This means:

$$l_N^{ro} = l_N^{ro}(A^{ro}, N^{ro}); l_A^{ro} = l_A^{ro}(A^{ro}, N^{ro}) \text{ and } \frac{\partial l_N^{ro}}{\partial N^{ro}} \geq 0; \frac{\partial l_A^{ro}}{\partial A^{ro}} \geq 0; \frac{\partial^2 (l_N^{ro} + l_A^{ro})}{\partial A^{ro} \partial N^{ro}} < 0; \frac{\partial l_N^{ro}}{\partial A^{ro}} < 0; \frac{\partial l_A^{ro}}{\partial N^{ro}} < 0$$

Where  $l_N^{ro}$  and  $l_A^{ro}$  are transaction costs (in form of family labor) related to renting out of livestock and land. In all cases, superscripts  $ro$ ,  $ri$  and  $o$  refer to rent out, rent in and own components of the corresponding variable while the subscripts  $N$  and  $A$  refer to livestock and land, respectively.

Therefore, the general income maximization problem of the asset rich household is:

$$2) \text{ Max } Y = \left\{ \begin{array}{l} \left[ P_A q_A(l_A^o, \bar{A} - A^{ro}, \bar{N} - N^{ro}) + (1 - \alpha) P_A q_A^{ro}(A^{ro}, N^{ro}; l_A^t, N^t, A^t) - w l_A^{ro}(A^{ro}, N^{ro}) \right] + \\ \left[ P_N q_N(l_N^o, \bar{N} - N^{ro}, \bar{A} - A^{ro}) + (1 - \beta) P_N q_N^{ro}(N^{ro}, A^{ro}; l_N^t, N^t, A^t) - w l_N^{ro}(N^{ro}, A^{ro}) \right] \\ - w(l_A^o + l_N^o) \end{array} \right\}$$

Where  $A^{ro} \geq 0, N^{ro} \geq 0, l_A^{ro} \geq 0$  and  $l_A^o$ .  $\alpha$  is the output share of the tenant in the land rental market and  $\beta$  is the output share of the tenant in the livestock rental market.  $P$  is the price of output and  $w$  refers to wage of labor.



The first order conditions with respect to land and livestock rented out for a household that rents out both land and livestock are:

$$2.1) -P_A \frac{\partial q_A}{\partial N^o} - P_N \frac{\partial q_N}{\partial N^o} + (1-\alpha) P_A \frac{\partial q_A^{ro}}{\partial N^{ro}} + (1-\beta) P_N \frac{\partial q_N^{ro}}{\partial N^{ro}} - w \left( \frac{\partial l_A^{ro}}{\partial N^{ro}} + \frac{\partial l_N^{ro}}{\partial N^{ro}} \right) \leq 0; \perp N^{ro} \geq 0$$

$$2.2) -P_A \frac{\partial q_A}{\partial A^o} - P_N \frac{\partial q_N}{\partial A^o} + (1-\alpha) P_A \frac{\partial q_A^{ro}}{\partial A^{ro}} q_A^{ro} + (1-\beta) P_N \frac{\partial q_N^{ro}}{\partial A^{ro}} - w \left( \frac{\partial l_A^{ro}}{\partial A^{ro}} + \frac{\partial l_N^{ro}}{\partial A^{ro}} \right) \leq 0; \perp A^{ro} \geq 0$$

These conditions demonstrate that in the case of interior solutions more land and livestock are rented out the lower the marginal returns are to these under own management, the higher the marginal productivities are under rental management, the higher the shares of the output that the lord gets, and the lower the marginal transactions costs related to the rental contracts are.

The cross derivatives,  $\frac{\partial q_A^{ro}}{\partial N^{ro}}$  and  $\frac{\partial q_N^{ro}}{\partial A^{ro}}$  are positive if the land and livestock are rented out

to the same tenant and the tenant is poor in land and livestock, otherwise they are zero. This favors renting both the land and livestock to the same tenant. The cross derivatives for the

transaction costs,  $\frac{\partial l_A^{ro}}{\partial N^{ro}}$  and  $\frac{\partial l_N^{ro}}{\partial A^{ro}}$  are negative if the contracts are linked to the same tenant,

otherwise they are zero. This also favors joint contracts to reduce transaction costs.

### **General model for asset poor household**

The tenants are offered incentive contracts based on sharing of output. To further enhance

their incentives their contracts may be renewed upon good performance while bad

performance can have long-term rationing out effects. This serves to prevent shirking and

reduce or eliminate Marshallian disincentive effects due to output sharing. Assuming that the

contract renewal in the second period depends on the performance in the first period, the

income maximization problem for the asset poor household can be expressed as follows.

$$3) \text{ Max } EU(Y) = \left\{ \begin{array}{l} EU_1 \left[ P_{A1} q_{A1} (l_{A1}^o, \bar{A}^o, \bar{N}^o) + \alpha P_{A1} q_{A1}^r (l_{A1}^r, \bar{A}^r, \bar{N}^r) + P_{N1} q_{N1} (l_{N1}^o, \bar{A}^o, \bar{N}^o) + \right. \\ \left. \beta P_{N1} q_{N1} (l_{N1}^r, \bar{N}^r, \bar{A}^r) - wL \right] \\ \rho \left\{ \eta_A (q_{A1}^r) EU_2 [\bar{A}^r] - \eta_N (q_{N1}^r) EU_2 [\bar{N}^r] \right\} \end{array} \right\}$$

where  $L = l_{A1}^o + l_{A1}^r + l_{N1}^o + l_{N1}^r$ ,  $\bar{A}^r \geq 0$ ,  $\bar{N}^r \geq 0$ ,  $l_{A1}^r \geq 0$ ,  $l_{N1}^r \geq 0$

Subscripts 1 and 2 refer to period one and two respectively.  $\rho$  refers to the discount factor

given by  $\rho = \frac{1}{1 + \delta}$ , where  $\delta$  is the discount rate.  $\eta$  is the probability of contract renewal for

land and/or livestock contracts in period two and depends on the amount of output produced in period one, creating incentives for tenants to be more efficient to counteract the

disincentive effect of output sharing. Therefore,  $\eta = \eta(q_{A1}^r, q_{N1}^r)$ ;  $\frac{\partial \eta}{\partial q_{A1}^r} > 0$ ,  $\frac{\partial \eta}{\partial q_{N1}^r} > 0$

This is demonstrated by inspecting the Kuhn-Tucker first order conditions for tenants that rent in land or livestock or both:

$$3.1) \frac{\partial q_{A1}^o}{\partial l_{A1}^o} - w = 0$$

$$3.2) \frac{\partial q_{N1}^o}{\partial l_{N1}^o} - w = 0$$

$$3.3) \frac{\partial EU_1}{\partial Y} \left( \frac{\partial q_{A1}^r}{\partial l_{A1}^r} - w \right) + \rho \left\{ \frac{\partial \eta_{A2}}{\partial q_{A1}^r} \frac{\partial q_{A1}^r}{\partial l_{A1}^r} EU_2 [\bar{A}^r] \right\} \leq 0 \perp l_{A1}^r \geq 0$$

$$3.4) \frac{\partial EU_1}{\partial Y} \left( \frac{\partial q_{N1}^r}{\partial l_{N1}^r} - w \right) + \rho \left\{ \frac{\partial \eta_{N2}}{\partial q_{N1}^r} \frac{\partial q_{N1}^r}{\partial l_{N1}^r} EU_2 [\bar{A}^r] \right\} \leq 0 \perp l_{N1}^r \geq 0$$

Equations 3.3) and 3.4) demonstrate that by working harder to increase their output from rented land and livestock the tenants increase the probability of contract renewal. Tenants with sufficient labor to do this will prefer to do so. For this to be an efficient incentive device for landlords it is important that tenants have sufficient labor endowment and are rationed in their access to land and labor. Kassie and Holden (2007) have demonstrated the relevance of threat of eviction as an incentive device in land rental contracts.

Based on these analyses, the following hypotheses are derived:

H1. Livestock- and land-rich high-caste households with better labor market access are more likely to rent out both land and livestock.

H1a. Labor-poor households are more likely to rent out their livestock (+rent out more) and less likely to rent in (+rent in less) than labor-rich households.

H1b. Migration is positively correlated with renting out livestock (+rent out more), while it is negatively correlated with renting in livestock (+rent in less).

H2. Land- and livestock-poor (low-caste) households rent in livestock (and land).

H2a. Credit constrained low-caste households are more likely to rent in livestock (because they cannot afford to buy).

H2b. Labor-rich low-caste households are more likely to rent in livestock.

H3. Livestock renting occurs as a complementary contract to a land rental contract.

## 4.2 Methods

Double hurdle models were chosen to identify the factors that influence the probability and level of livestock rental market participation by farm households. First, we tested censored Tobit models vs. the double hurdle (Cragg) models for our data. The censored Tobit model assumes that the same mechanism determines both the zeros and the positives and the amount of the variable in question given that the variable is positive (Wooldridge, 2002; Cameron and Trivedi, 2009). Therefore, in the censored Tobit model, a variable which increases (decreases) the probability of participation in the livestock rental market also increases (decreases) the amount of livestock rented in or out. The double hurdle model allows more flexibility assuming that the decision to participate and the amount of participation may be influenced by different variables. In the Cragg model, the first part corresponds to households' choice of whether to participate or not in the livestock rental market (Probit

model) and the second part corresponds to the extent of participation in the market given that it has decided to participate (Truncated regression model).

For comparison, we applied the likelihood ratio test because the Cragg model nests the censored Tobit model (Fin and Schmidt, 1984; Greene, 2003). The test led us to reject the censored Tobit model in favor of the Cragg model on both sides of the market. Empirical analysis also showed substantial differences between variables affecting likelihood to participate and the level of participation, on each side of the market, indicating the relevance of the double hurdle model. We then tested the Cragg model versus the Wooldridge model by using a Young test as these two models are non-nested to each other (Young, 1989). The Young test is given by:

$$V = n^{-\frac{1}{2}} LR_n(\hat{\theta}_n, \hat{\gamma}_n) / \hat{\omega}_n \xrightarrow{D} N(0, 1)$$

where n refers to number of observations,  $LR_n(\hat{\theta}_n, \hat{\gamma}_n) \equiv L_n^f(\hat{\theta}_n) - L_n^g(\hat{\gamma}_n)$ , is the likelihood ratio statistic for the model  $F_\theta$  (for Cragg model) against the model  $G_\gamma$  (for Wooldridge

model) and  $\hat{\omega}_n^2 \equiv \frac{1}{n} \sum_{i=1}^n \left[ \log \frac{f(Y_i | Z_i; \hat{\theta}_n)}{g(Y_i | Z_i; \hat{\gamma}_n)} \right]^2 - \left[ \frac{1}{n} \sum_{i=1}^n \log \frac{f(Y_i | Z_i; \hat{\theta}_n)}{g(Y_i | Z_i; \hat{\gamma}_n)} \right]^2$ . For model selection,

we choose a critical value c from the standard normal distribution for a specified significance level such as 2.58 (for 1 percent) and 1.96 (for 5 percent). If  $V > c$ , we reject the null hypothesis that the models are equivalent in favor of  $F_\theta$  being better than  $G_\gamma$ . If  $V < (-c)$ , we reject the null hypothesis in favor of  $G_\gamma$  being better than  $F_\theta$ . If  $|V| \leq c$ , then we cannot discriminate between the two competing models given the data (Young, 1989).

In our analysis, the Young test favored the Cragg model against the Wooldridge model in the demand side of the livestock rental market whereas it did not discriminate between these two models in the supply side of the market. Therefore, we present the results from the Cragg

model only. The log-likelihood for the Cragg model is:

$$\ln L = \sum_0 \ln [1 - \Phi(\mathbf{z}\boldsymbol{\gamma})] + \sum_+ \left\{ \ln \Phi(\mathbf{z}\boldsymbol{\gamma}) + \ln \phi \left[ \frac{1}{\sigma} \left( \frac{y - \mathbf{x}\boldsymbol{\beta}}{\sigma} \right) \right] - \ln \Phi \left( \frac{\mathbf{x}\boldsymbol{\beta}}{\sigma} \right) \right\}$$

In addition to these models, we also tested for possible selection bias using control function approach. For this method, we need a variable that determine participation but do not affect the degree of participation. We used the variable ‘number of adult males’ in our case because this variable was found to affect participation decision in the rental market but not in the degree of participation in the Cragg model. We did not find any significant selection bias.

A bivariate ordered probit model was applied to test whether there was any association between livestock and land rental market participation. Both dependent variables - net livestock leased-in (*nlsli*) and net land leased-in (*nli*) - were ordinal and have three alternatives. In each rental market, a household can either rent-out or remain autarkic or rent-in. Bivariate ordered probit models can be derived from the latent variable model (Sajaia, 2008). Assume that two latent variables  $y_1^*$  and  $y_2^*$  are given by:

$$\begin{aligned} y_{1i}^* &= \mathbf{x}'_{1i} \boldsymbol{\beta}_1 + \varepsilon_{1i} \\ y_{2i}^* &= \mathbf{x}'_{2i} \boldsymbol{\beta}_2 + \gamma y_{1i}^* + \varepsilon_{2i} \end{aligned}$$

where  $\boldsymbol{\beta}_1$  and  $\boldsymbol{\beta}_2$  are vectors of unknown parameters,  $\gamma$  is an unknown scalar,  $\varepsilon_1$  and  $\varepsilon_2$  are the error terms. The explanatory variables in the model satisfy the conditions of exogeneity such that  $E(\mathbf{x}_{1i} \varepsilon_{1i}) = 0$  and  $E(\mathbf{x}_{2i} \varepsilon_{2i}) = 0$ .

We observe two categorical variables  $y_1$  and  $y_2$  such that:

$$y_{1i} = \begin{cases} 1 & \text{if } y_{1i}^* \leq c_{11} \\ 2 & \text{if } c_{11} < y_{1i}^* \leq c_{12} \\ \vdots & \vdots \\ J & \text{if } c_{1J-1} < y_{1i}^* \end{cases} \quad y_{2i} = \begin{cases} 1 & \text{if } y_{2i}^* \leq c_{21} \\ 2 & \text{if } c_{21} < y_{2i}^* \leq c_{22} \\ \vdots & \vdots \\ K & \text{if } c_{1K-1} < y_{2i}^* \end{cases}$$

The unknown cutoffs satisfy the condition that  $c_{11} < c_{12} < \dots < c_{1J-1}$  and  $c_{21} < c_{22} < \dots < c_{2K-1}$ .

Under the assumption that observations are independent, the log likelihood for the entire sample in the case of bivariate ordered probit is given by:

$$\ln \ell = \sum_{i=1}^N \sum_{j=1}^J \sum_{k=1}^K I(y_{1i} = j, y_{2i} = k) \ln \Pr(y_{1i} = j, y_{2i} = k)$$

Given that  $\varepsilon_{1i}$  and  $\varepsilon_{2i}$  are distributed normally, the system of equations are estimated by full-information maximum likelihood (Sajaia, 2008).

In estimating the econometric models stated above, we included migration as if it were an exogenous variable. However, most of the economic models treat migration as an endogenous variable. Therefore, we looked for the possibility to overcome this problem of endogeneity associated with it by instrumenting for migration. However, we were not able to find any good instrument for it due to data limitations. We considered using caste as an instrument but caste also has other direct or indirect effects that made it unsuitable as an instrument and could not be left out in the second stage of the regressions. The caste variable was of primary interest in our analysis through its effects on labor market participation and asset distribution and therefore also participation in other factor markets such as the livestock and land rental markets. The same issue is of concern for the credit constraint variable which was assumed to be important for poor low-caste households. In the absence of suitable instruments we resorted to running the models with and without the credit constraint dummy variable.

## 5. Study area and data

Data for this study were collected in the western hills of Nepal in 2003. A total of 500 households were surveyed from three villages: Lahachok, Rivan and Lwang-Ghalel. This paper utilizes data from 489 households as 11 households were dropped due to some inconsistencies. The settlements in the study area are 15-45 km from the main city. Due to the



poor road networks, the area is not accessible by road during the rainy season, but a rough road links the central plain area, called Khoramukh, during the dry season. As many settlements are on the hills, people have to walk 2 to 6 hours to reach the village market center at Khoramukh. Human labor is the common mode of transporting agricultural products to the market. Hills and mountains higher than 1200 m are the major topographical feature of this region (Thapa and Weber, 1995).

Agriculture is the main economic activity in the study area. Integration of crop and livestock is a main characteristic of the farming system as livestock is essential not only for traction power but also for sustainable crop production through the use of manure. This is one of the possible reasons why the land and livestock rental market decisions are inter-related. Almost all of the households in the study area own livestock (ACAP, 1999). Buffaloes, cows and oxen are the major large livestock, while goats and sheep are the main small ruminants. In addition, unlike other types of livestock, oxen and cows are not sold for the purpose of meat consumption in Hindu society and therefore, markets for cows and oxen are limited outside the rural areas where agriculture is not the major activity. Resource poor farmers - who cannot invest in cattle and buffalo - usually prefer sheep and goat husbandry.

Table 1 presents the major household characteristics by caste. Differences between high-caste and low-caste households are highly significant in the case of income and major assets such as land, livestock and other household assets. Likewise, at least one member has migrated for 43 percent of the high caste households whereas this is the case for 28 percent of the low-caste households. Furthermore, 41 percent of the high-caste households have a member with regular job against only 9 percent of the low-caste households.

Nearly 13 percent of the total sample households rented in livestock while 11 percent rented out. Cows, oxen and buffaloes are the major livestock used for rental transactions. Out of the total households that rented out livestock, 76 percent reported that they have rented out oxen

to low-caste households and this is also associated with labor contracts for ploughing. Some high-caste households also have shared ownership holding of oxen because they need a pair of oxen to plough the land. Non-participation in the livestock rental market is higher than that of the land rental market, which possibly implies that there are larger transaction costs in the livestock rental market as compared to the land rental market (Binswanger and Rosenzweig, 1986). Ranking of all sample households on the basis of net land leased-in and net livestock leased-in separately also depicts this (see Figure 1).

Table 2 summarizes livestock and land rental market participation of the sample households by caste. According to Table 2, 31 percent of the households that rented in land have also rented in livestock. Likewise, 36 percent of the households that rented out land have also rented out livestock. None of the households that have rented out land were found to rent in livestock and similarly, none of the households that have rented in land were found to rent out livestock. Interestingly, households that rent out both land and livestock are mostly high-caste households whereas households that rent in both land and livestock are mostly low-caste households, favoring our first hypothesis. Out of 30 households that rent out both land and livestock, 28 belong to high-caste households.

Table 3 presents the major characteristics of the farm households participating in the land and livestock rental markets. The percentage of female-headed households is significantly higher among the households renting out livestock (land), whereas households renting in livestock (land) are mostly male-headed. Of total households that rented in livestock, only 19 percent have at least one adult member migrated against 89 percent for those households that rented out. Similar difference is observed between the households that are renting in and renting out land. Of the total households that rented in livestock, 66 percent were low-caste households, while only 7 percent of them have rented out livestock. Differences with regard to male headship, caste, and migration are highly significant between the households that participated

on each side of these markets. Likewise, differences in own land holding, operational land holding, and family labor endowment were also significant across both markets. Average ownership land holding of the households that rent out livestock was 0.96 ha against 0.25 ha for those that rent in. Similarly, the differences in ownership livestock holdings were also significant: households renting out livestock owned 3.3 TLU (Tropical Livestock Units) against 1.5 TLU for those that rented in. The family labor endowment (measured in Standard Labor Units) and the labor endowment per unit own land holding were significantly higher among the households that rented in land and similarly for livestock, indicating that land and livestock have moved to farmers with larger family labor endowment. Of the total households that rented in both livestock and land 63.4 percent have rented in from the same household. In the case of land, the Gini coefficient for ownership holding was 0.46 while it was 0.37 for the operational holding. Similarly, for livestock, the Gini coefficient for ownership holding was 0.40 while it was 0.38 for operational holding. The rental markets for land and livestock therefore contributed to a more egalitarian distribution of these resources across households.

## **6. Results and discussions**

### **6.1 Participation in the livestock rental market**

Table 4 presents the results of the double hurdle models for both sides of the livestock rental market. Hypothesis 1 claims that livestock and land-rich high-caste households with better market access are more likely to rent out both land and livestock. To test this hypothesis empirically, we put forth two sub-hypotheses. Results show that hypothesis H1a, which states that labor-poor households are more likely to rent out livestock (+rent out more) and less likely to rent in (+rent in less), cannot be rejected because households with more male labor endowment were found to be less (more) likely to rent out (in). Similarly, households with more female labor endowment rented out less. Land ownership holding was positively associated with the likelihood of renting out livestock, but it was found to affect negatively

the amount rented out. This indicates complementarities between land and livestock inputs in rural farming (less labor-intensive feeding regimes may be feasible when there is more land). Based on the results hypothesis H1b – migration is positively correlated with renting out livestock (+rent our more) and negatively correlated with renting in (+rent in less) – cannot be rejected because migration dummy was highly significant in both sides of the land rental market. Migration was found to have positive effect on the likelihood to rent out livestock and the amount rented out, while there was negative association between migration and likelihood to rent in livestock as well as amount rented in. The caste dummy was not found to have a significant additional effect on the probability to rent out livestock, implying that inequality in asset endowments and market access (which are closely associated with caste in our case) rather than more direct and separate caste effects determine the participation in the supply side of the livestock rental market.

Given that low-caste households are often discriminated against in the regular outside job market, they rely more on the agricultural sector. Furthermore, high-caste households consider ploughing land by using oxen as an inferior job and such caste-related labor restrictions might have favored low-caste households in renting livestock and land. This might indicate why caste membership remains highly significant even after controlling for possible factors that represent inequalities in resource endowments and market access between these two groups such as land, livestock, family labor endowments, and migration, and credit constraint. However, the inclusion of the migration dummy in the empirical analysis does not fully control for labor market access. The caste dummy may also capture other omitted variables correlated with caste.

Hypothesis H2 stated that land- and livestock-poor (low-caste) households rent in livestock (and land). Our empirical analysis in Table 4 does not allow us to reject this hypothesis because low-caste households were significantly more likely to rent in livestock and rented in

more as compared to high-caste households. Likewise, credit constrained households were found to have significantly higher likelihood of renting in livestock, implying that hypothesis H2a that credit constrained low-caste households are more likely to rent in livestock, cannot be rejected. Hypothesis H2b cannot be rejected partially because the male labor endowment was significantly positively correlated with the likelihood to rent in livestock. Finally, low-caste households were significantly more likely to rent in livestock and rented in significantly more livestock than high-caste households after controlling for differences in asset endowments. These results might also have association with the practice of *Haliya* (bonded labor) system as nearly 74 percent of the low-caste households have worked as permanently attached *Haliya* labor. Such manual labor with livestock may still be perceived as inferior by high-caste households. This can be one of the possible reasons why low-caste households have higher probability to rent in livestock. In addition, less access to credit, poverty and liquidity constraints created incentives to rent in livestock which is a lumpy asset where renting can reduce up-front costs of accessing livestock.

## **6.2 Association between livestock and land rental market participation**

Table 5 provides the results of the analysis of the association between livestock and land rental market participation. In the absence of good instruments for access to credit, we estimated the models with and without the credit constraint dummy variable.

Hypothesis H3 that livestock renting occurs as a complementary contract to a land rental contract was tested by assessing the correlation between land and livestock rental market participation decisions after controlling for differences in endowments and caste. The variable *Athrho* in Table 5 shows that there was a highly significant positive correlation between the errors in the two ordered probit models and this high level of significance did not change when we control for access to credit. Therefore, hypothesis H3 cannot be rejected.

This implies that a household that is renting in land is also more likely to rent in livestock and

vice versa whereas a household that rents out land is also more likely to rent out livestock and vice versa. Hence the rental decisions are positively inter-related. This is consistent with the theory of production complementarities and transaction cost reducing effects of joint contracts. A Wald test of independence of equations in Table 5 also supported that these decisions are interrelated as the test cannot accept the null hypothesis that the decisions are independent.

Results show that low-caste households were significantly more likely to rent in livestock compared to high-caste households after controlling for other differences in endowments but this was not the case in the land renting. One of the possible reasons for no significant effect of caste on renting out of land could be the tenure insecurity caused by the land-to-the-tiller policy that may cause some high-caste households to prefer to rent out their land to other high-caste households even though these are less productive producers (Aryal and Holden, 2010). Male labor endowment, young household head, less migration, and asset poverty (land and livestock) were found to be the important variables positively related to the decisions to rent in and negatively related to renting out livestock and land. The inclusion of the credit constraint dummy variable did not affect the results much but shows that credit constrained households were more likely to be on the renting in side and less likely to be on the renting out sides of the rental markets for livestock and land.

## **7. Conclusions**

While rental markets are the only form of market for labor (due to the prohibition of slavery) and a very common form of market for land, they are uncommon for livestock due to the fragility and mobility of livestock. We therefore examined the rationale for the existence of a livestock rental market in western Nepal with a focus on caste differentiation prevailing there. Results of the analysis have several important policy implications. Firstly, as low-caste households are more likely to participate in the demand side of the livestock rental market



even after controlling for asset inequalities and market access; this indicates the existence of caste differentiation in market participation. The major policy implication in this case is that rural policies should not only address the asset and market access inequalities but also the social systems that create caste inequalities. Secondly, the positive association between land rental and livestock rental market participation decisions of households indicated that there are complementarities between these factors of production in hill agriculture and thus, policies targeted to enhance land productivity should also include livestock management as a crucial issue. Thirdly, as most of the households that rented in land and livestock did that from the same landlord, this indicates that these sorts of interlinked contracts may emerge as a transaction costs reducing strategy for the households renting out. Fourthly, the credit-constrained tenant households used the livestock and land rental markets as capital-saving devices to access more of these resources. For these households, the livestock and land rental markets serve as a substitute for the credit market, and this allows them to better exploit from crop-livestock synergies in hill agriculture. Therefore, promoting credit facilities for the rural poor is an important policy option to enhance the poor's access to productive resources because many of them are still rationed in their access to these resources.

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**Table 1 Major household characteristic by caste**

Household Characteristics variables	High-caste	Low-caste	All sample	Test
Male head dummy (%)	20	65	30	82.72***
Literate head (%)	35	19	31	10.40***
Age of household head (in year)	49	49	49	0.09
Ownership holding (in hectare)	0.64	0.17	0.54	9.02***
Operational holding (in hectare)	0.62	0.34	0.56	5.93***
Owned livestock (in TLU)	3.54	1.52	3.09	8.15***
Operated livestock (in TLU)	3.32	2.41	3.12	3.49***
Standard labor unit	3.81	3.98	3.85	0.85
Standard consumer unit	4.93	5.2	4.99	1.09
Farm income (in Rs.)	32035	15312	28376	6.44***
Remittance income (in Rs.)	20127	3449	16478	4.42***
Total income (in Rs.)	72360	30929	63295	8.15***
Value of asset (in Rs.)	38581	15360	33500	8.22***
Agricultural wage labor (unskilled) (%)	12.3	69.8	24.9	7.16***
Non-agricultural wage employment (unskilled) (%)	34.2	25.6	32.3	3.78***
Regular salary jobs (at least one member) (%)	41.3	9.2	26.6	5.71***
At least one member earning pension (%)	26.7	5.6	22.1	3.96***
At least one adult member migrated (%)	43	28	31	2.57***
Credit constrained (%)	38.7	74.5	47	43.58***
Number of sample households	382	107	489	

## Notes:

1. Test shows the difference between high-caste and low-caste households; t-test is used for continuous variables and chi-square test for categorical variables.
2. Regular salary jobs include the jobs both in and outside the country.
3. Livestock is measured as Tropical Livestock Unit (TLU)

**Table 2 Livestock and land rental market participation of the sample households by caste**

Land	Livestock										Total		
	Rent in				Owner operated				Rent out				
	High-caste		Low-caste		High-caste		Low-caste		High-caste	Low-caste			
	No.	%	No.	%	No.	%	No.	%	No.	%			
Rent in	11	9	26	22	53	45	27	23	0	0	0	0	117
Owner operated	10	3	15	5	208	72	31	11	24	8	2	0.7	290
Rent out	0	0	0	0	48	59	4	5	28	34	2	2	82
<b>Total</b>	<b>21</b>	<b>34</b>	<b>41</b>	<b>66</b>	<b>305</b>	<b>83</b>	<b>62</b>	<b>17</b>	<b>52</b>	<b>93</b>	<b>4</b>	<b>7</b>	<b>489</b>



**Table 3 Characteristics of households participating in land and livestock rental markets**

Variables	Land			Livestock		
	Rent in	Rent out	test	Rent in	Rent out	test
Male Head (%)	39.4	25.6	4.1**	43.6	28.6	2.9*
Literate (%)	26.5	35.4	1.8	22.6	33.9	1.9
Low-caste (%)	45.3	7.3	33.3***	66.2	7.1	43.4***
At least 1 adult member migrated (%)	26.5	71.9	40.2***	19.4	89.3	57.7***
Age of household head (years)	49	51	1.1	48	50	0.99
Owned land (ha)	0.21	1.04	16.8***	0.25	0.96	8.1***
Family labor endowment	5	3.6	5.1***	4.2	3.5	2.1**
Family labor endowment/Owned land	24.8	3.6	10.6***	18.2	4.3	7.2***
Operated land (ha)	0.6	0.59	0.13	0.48	0.73	2.9**
Family labor endowment /Operated land	10.2	8.4	2.14**	11.9	6.8	2.6***
Family labor endowment /Own livestock	4.6	1.4	3.14***	5.6	1.2	3.1***
Family labor endowment /Operated livestock	3.1	3.3	0.36	1.3	8.9	4.4***
Own livestock (in TLU)	2.4	3.8	4.4***	1.5	3.3	8.8***
Own livestock/Owned land	11.4	3.9	5.3***	5.4	3.9	2.5***
Own livestock/Operated land	4.9	9.2	4.1***	3.9	6.2	3.1***
Operated livestock (in TLU)	3.1	3.1	0.96	3.4	1.2	10.7***
Operated livestock/Owned land	15.6	3.3	7.7***	15.4	1.4	9.1***
Operated livestock/Operated land	6.9	7.9	0.94	11.1	2.2	7.5***
Number of observations	117	82		62	56	

Note: Test for significance of difference between those renting in and renting out land and livestock (t-test for continuous variables and chi-square test for categorical variables). Family labor endowment is measured as Standard labor units (SLU). Livestock is measured in Tropical Livestock Unit (TLU).

Significance levels: \*: 10% level, \*\*: 5% level, \*\*\*:1% level

**Table 4 Analysis of livestock rental market participation**

	Renting in (Yes=1)		Renting out (Yes=1)	
	Probit	Truncreg	Probit	Truncreg
Caste dummy: low(1)	1.045*** (0.252)	0.863** (0.391)	-0.381 (0.370)	-0.857* (0.488)
Value of Asset (In Rs.)	0.007 (0.004)	0.002 (0.007)	-0.010** (0.004)	0.012** (0.006)
Owned livestock (in TLU)	-0.227*** (0.071)	-0.374** (0.156)	-0.046 (0.047)	0.511*** (0.092)
Owned land holding (ha)	0.357 (0.292)	0.445 (0.545)	1.000*** (0.192)	-0.483** (0.190)
Age of hh head (years)	-0.006 (0.009)	0.021* (0.011)	0.011 (0.009)	-0.005 (0.011)
Sex head dummy: male(1)	-0.154 (0.233)	-0.209 (0.255)	0.003 (0.229)	-0.066 (0.286)
Number of adult males	0.189** (0.083)	0.109 (0.108)	-0.212** (0.100)	-0.056 (0.114)
Number of adult females	-0.154 (0.104)	-0.126 (0.139)	-0.032 (0.104)	-0.315** (0.147)
Migration dummy: 1 (yes)	-0.406* (0.222)	-0.652** (0.300)	1.731*** (0.252)	1.048*** (0.366)
Credit constrained: Yes(1)	1.235*** (0.271)	0.411 (0.590)		
Constant	-1.842*** (0.554)	0.602 (1.073)	-2.410*** (0.518)	0.478 (0.649)
Sigma Constant		0.844*** (0.076)		0.756*** (0.071)
Wald Chi-square	114.36	57.13	105.321	57.010
Number of observations	433	62	427	56
<b>Test</b>		<b>Renting in</b>	<b>Renting out</b>	
LR test (Cragg vs. Tobit model)		LR chi2=22.3 Prob>chi2= 0.0014 Cragg is preferred to Tobit	LR chi2=55.53 Prob>chi2=0.000 Cragg is preferred to Tobit	
Young test (Wooldridge vs. Tobit model)		V =3.13; c=2.58	V =3.03; c=2.58	

Young test (Cragg vs. Wooldridge model)	V >c →Wooldridge is Preferred to Tobit  V =2.68; c=2.58  V >c →Cragg is Preferred to Wooldridge	V >c →Wooldridge is Preferred to Tobit  V =1.94; c=2.58  V >c →not discriminate between two models
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Significance levels: \*: 10% level, \*\*: 5% level, \*\*\*:1% level

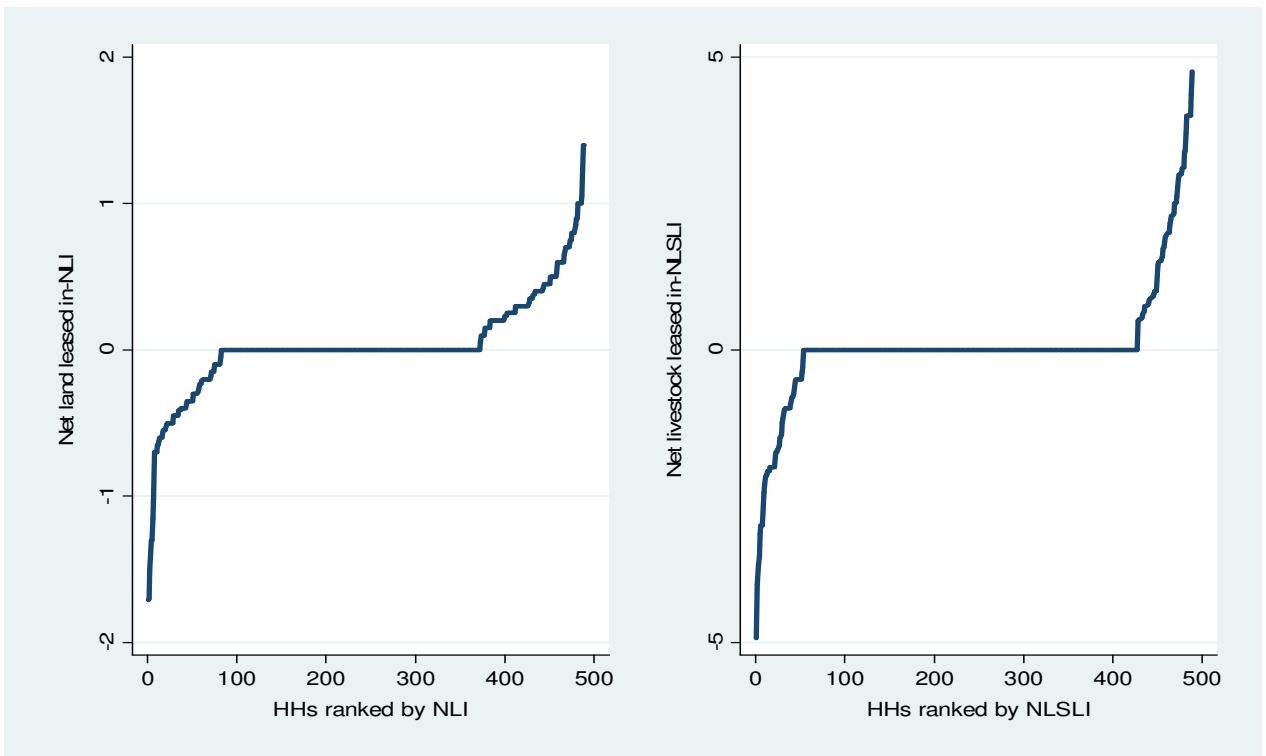
**Table 5 Analysis of association between land and livestock rental markets participation**

Market participation <sup>1</sup>	Bivariate ordered probit models			
	Without credit constraint		With credit constraint	
	Livestock	Land	Livestock	Land
Caste dummy: low(1)	0.908*** (0.207)	0.267 (0.200)	0.910*** (0.207)	0.252 (0.198)
Value of Assets (In Rs.)	0.005** (0.002)	0.003 (0.003)	0.008*** (0.003)	0.004 (0.003)
Owned livestock (In TLU)	-0.052** (0.021)	-0.045* (0.026)	-0.029 (0.023)	-0.034 (0.026)
Owned land holding (ha)	-0.719*** (0.128)	-1.367*** (0.302)	-0.449*** (0.146)	-1.233*** (0.307)
Age of household head (years)	-0.008 (0.006)	-0.011** (0.005)	-0.009 (0.006)	-0.012** (0.005)
Sex head dummy: male(1)	-0.040 (0.154)	0.234 (0.143)	-0.047 (0.158)	0.233 (0.144)
Number of adult male	0.169*** (0.055)	0.403*** (0.057)	0.177*** (0.056)	0.406*** (0.057)
Number of adult female	-0.060 (0.061)	-0.017 (0.062)	-0.060 (0.064)	-0.015 (0.063)
Migration dummy: 1 (yes)	-1.070*** (0.157)	-0.809*** (0.125)	-0.985*** (0.160)	-0.736*** (0.129)
Credit constrained: 1 (yes)			0.996*** (0.192)	0.406** (0.158)
Constant ( <i>Athrho</i> ) <sup>2</sup>		0.373*** (0.077)		0.338*** (0.081)
Wald Chi-square		145.24***		136.25***
Wald test of independence of equations		23.68***		17.53***
Number of observations		489		489

Significance levels: \*: 10% level, \*\*: 5% level, \*\*\*:1% level

1. Dependent variable: Rent out=1; non-participation=2, and rent in=3

2.  $Athrho = \frac{1}{2} \ln \left( \frac{1+\rho}{1-\rho} \right)$  where,  $\rho = corr(u_1, u_2)$ ;  $u_1 \xrightarrow{D} N(0, \sigma)$  and  $u_2 \xrightarrow{D} N(0, 1)$ .



**Figure1 Households ranked by Net land leased in and Net livestock leased in**