



Socio-economic and ecological factors influencing herder household mobility in Mongolian Steppe

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Abstract

Mongolia's heavy dependence on pastureland makes sustainable pasture use crucial. Historically, nomadic Mongolians maintained ecosystems by frequently moving livestock, a practice essential for pasture sustainability. Despite its importance, research on the factors affecting herder household mobility (HHM) is limited, especially using econometric modelling to identify and estimate these factors. This study examines socio-economic and ecological factors influencing HHM in four Mongolian provinces using pooled data econometric models.

The research addresses two main questions: 1) What social, economic, and ecological factors influence HHM decisions? 2) What policy implications arise from these factors? The study was conducted in 11 sub-districts across four provinces, using stratified random sampling based on probability. Data were collected from the same 253 households over three years in 2019, 2020 and 2022, resulting in a total of 759 observations.

The ecological factors such as the number of households sharing the same pasture (24.9%), water output in the pasture (26.7%) and drought (41.6%) promote greater mobility. Economic factors include livestock wealth, which contributes to a 45.2% increase in mobility distance. Finally, the social factors that increase mobility distance include the female household head (76.1%), the distance to the district center (57.2%), and adherence to local government plans (62.1%).

Conversely, ecological factors such as better vegetation conditions (30.2%) correlate with shorter HHM distances. Among the economic factors, increased fuel prices (54.8%) and owning a truck by a herder (18.2%) reduce mobility distance. Social factors that reduce mobility distance include larger family sizes (17.3%) and older household heads (38.2%).

The study's insights offer crucial implications for policy-making aimed at enhancing sustainable HHM in Mongolia. Understanding these factors can help devise strategies to support herder communities while maintaining pastureland sustainability, ensuring both ecological balance and the well-being of herder households.

Introduction

Pastureland provides essential ecosystem services, including livestock forage, carbon sequestration, and water flow regulation (Rodríguez-Ortega et al., 2014). However, climate change and land-use changes have negatively impacted Mongolia's rangelands, leading to reduced pastoral mobility and increased environmental degradation (Fernández-Giménez et al., 2018). In 2018, pastureland covered 71.6% of Mongolia, feeding 64.7 million livestock (Agipar et al., 2019; NSO, 2024). The rapid growth of livestock, which has more than doubled since 1990, has resulted in overgrazing, with 57% of rangelands degraded as of 2016 (Densambu, B et al., 2018).

Sustainable pastureland management, essential for balancing ecosystem health and herder livelihoods, relies on mobility strategies such as seasonal and *Otor* movement (long distance movement) (Gonchigsunlaa & Damdindorj, 2021). Yet, since the transition to a market economy in the 1990s, mobility has declined due to privatization and weakened institutional support (Fernandez-Gimenez & Le Febre, 2006). Reduced herder household mobility (HHM) exacerbates rangeland degradation, undermining livelihoods and livestock productivity (Kerven, 2003; Humphrey & Sneath, 1999) of herder households (HHs).

This study uses econometric models to investigate socio-economic and ecological factors influencing herder household mobility in Mongolia, aiming to inform policies that enhance mobility and promote sustainable rangeland use.

Methods

The study was conducted in 11 sub-districts (core sites) across four provinces: *Tuv*, *Khentii*, *Dornod*, and *Sukhbaatar*. Using stratified random sampling, 320 HHs were selected in 2019, representing 22% of the herder population. The sample size decreased to 289 in 2020 and 253 in 2022 due to household migration, status changes, absences, endemic quarantine, and COVID-19 lockdowns. To generate balanced panel data, the same HHs were surveyed yielding 759 observations from 253 HHs over three years.

The annual total distance of HHM, measured by km (**lnDIS**⁴) was selected as the dependent variable, which we want to explain using independent variables (total distance moved for three types of HHM: between and within seasonal camp mobility and *otor* mobility (Gonchigsumlaa & Damdindorj, 2021)). We divided the independent variables into ecological, economic and social factors. **Ecological factors** include vegetation condition (**AVEG2**), rated from 1 (Very poor) to 5 (Excellent), to capture vegetation changes before and after pasture use (Fernández-Giménez et al., 2018); water availability (**WAT**), categorized as 1 (Bad), 2 (Average), or 3 (Good) (Lkhagvadorj et al., 2013); and two dummy variables for Dzud (harsh winter) (**DZUD**) and drought occurrence (**DRO**), indicating whether these disasters occurred in the previous year (Fernández-Giménez et al., 2018). **Economic Factors** include annual income of the HH, by Mongolian Tugrik (MNT) (**lnINC**); livestock number of the household, by sheep unit (**lnSHU**); number of households using the same pasture, to express the pasture competition (**lnHH**); dummy variable indicating whether the household owns a truck (**TRUCK**) (Lkhagvadorj et al., 2013); fuel price per liter (**lnFUEL**) (Gonchigsumlaa & Damdindorj, 2021); and dummy variable indicating whether the HH lost their pasture (**LPA**). Social factors include family size (**lnFM**); gender of the HH head, (0=Male, 1=Female) (**GEN**); age of the household head (**lnAGE**); HH head's number of years spent on herding livestock, as for experience (**lnEXP**); annual average distance between district center and the HH location in km (**lnDSC**); dummy variable whether the household move in accordance with the local government plans (**PLA**); and dummy variable whether the household is a member of a herder organization (**ORG**).

We run four types of econometric models for analysis including Pooled OLS, Pooled OLS with clustered robust standard error, Fixed effect model (FE), and Random effect (RE) model.

Results

Descriptive statistics

For seasonal-camp mobility, a household moved an average distance of 35.4 ± 37.05 km, with a minimum distance of 0 km and a maximum distance of 292 km. As for within-seasonal-camp mobility, a household moved an average distance of 4.5 ± 12.9 km, with a minimum distance of 0 km and a maximum distance of 196 km. Also, for *otor*, a household moved an average distance of 12.8 ± 41.8 km, with a minimum distance of 0 km and a maximum distance of 460 km. Overall, an average HH moved 4.8 times for 52.6 ± 65.1 km on average, with a minimum distance of 1 km and a maximum distance of 565 km.

Robustness of Test Results

The dataset comprises panel data for 253 households over three years (T=3, N=253). Seven of the 17 explanatory variables are dummies, which could lead to multicollinearity. However, the Variance Inflation Factor (VIF) test showed low multicollinearity, with an average VIF of 1.31 (well below the threshold of 5) (James et al., 2013). Wooldridge's test for serial correlation did not detect first-order autocorrelation (Prob > F = 0.1135). Fixed Effect (FE) and Random Effect (RE) models are widely used for panel data analysis. FE models account for within-entity variation, controlling for time-invariant characteristics (Torres-Reyna, 2007), making them suitable for our dataset. In contrast, RE models assume no correlation between entity-specific effects and predictors. The Hausman test, which compares FE and RE, rejected the null hypothesis (Prob > chi2 = 0.0017), favoring FE (Hausman, 1978). To address heteroskedasticity concerns affecting Hausman test, the robust Sargan-Hansen test was also applied (Mark E Schaffer & Steven Stillman, 2006), confirming FE as appropriate (P-value = 0.0003). The restricted F-test compared

⁴ [In the abbreviations of the variables, if there is a "ln" then it means that the variable is natural log transformed.](#)

FE and Pooled OLS, favoring the latter (Prob > F = 0.0000) as a more optimal model. Similarly, the Breusch-Pagan test (Prob > chi2 = 0.0000) supported RE over Pooled OLS (Vijayamohanan Pillai N., 2016). Finally, the Chow test (Prob > F = 0.0000) confirmed Pooled OLS as the best fit for the data. Based on these results, the robust Pooled OLS model was selected for analysis.

Model results

In the table below, we compared the results of four different estimators including Pooled OLS, Pooled OLS with clustered robust standard error, Fixed effect model (FE), and Random effect (RE) model.

Table 1. Results of the models: Factors affecting the distance of herder household mobility

Variables	Pooled OLS	Pooled OLS robust	FE robust (xtreg)	RE robust (xtreg)
AVEG2	-0.359***	-0.359***	-0.184***	-0.255***
lnHH	0.201***	0.201***	0.198***	0.208***
WAT	0.237*	0.237*	0.0766	0.160
DZUD	0.0147	0.0147	0.0248	0.0212
DRO	0.348***	0.348***	0.268***	0.294***
lnINC	-0.0168	-0.0168	-0.00512	-0.0109
lnSHU	0.275***	0.275***	-0.000853	0.205***
TRUCK	-0.201*	-0.201*	-0.157*	-0.166*
lnFUEL	-1.583***	-1.583***	-0.863	-1.123
LPA	0.0378	0.0378	0.0564	0.0275
lnFM	-0.211***	-0.211***	-0.202*	-0.164*
GEN	0.566***	0.566***	0.461*	0.517***
lnAGE	-0.657***	-0.657***	0.444	-0.402**
lnEXP	0.0008	0.0008	-0.276***	-0.0883
lnDSC	0.373***	0.373***	0.688***	0.458***
PLA	0.483***	0.483***	0.253**	0.356***
ORG	0.129*	0.129*	0.0481	0.0811
Constant	14.62***	14.62***	5.980	10.34*
Observations	759	759	759	759
R-sq: within	N.A	N.A	0.1294	0.1053
R-sq: between	N.A	N.A	0.1116	0.2463
R-sq: overall	N.A	N.A	0.1132	0.1985
R-sq	0.2087	0.2087	N.A	N.A

* p<0.15, ** p<0.10, *** p<0.05

Source: Results of Stata software, OLS analysis of data from 759 herder households

As shown in the table, the difference between default and cluster-robust standard errors for the Pooled OLS model was minimal, likely due to the short panel data. A notable exception was the variable “ORG,” which was not significant at the 15% level under robust errors. The model’s coefficient of determination (R² = 0.2087) indicates that 20.87% of the variation in mobility distance is explained by the included factors. The relatively low R² value in the pooled OLS model indicates that while the included variables explain a portion of the variation in household mobility, other unobserved factors likely play a significant role. Variables such as the education level of the household head, the annual income, access to diversified or improved livelihood opportunities etc. Despite this modest R², most variables were statistically significant, with 12 showing meaningful effects at 85-95% confidence levels.

Ecological Factors: Vegetation condition after pasture use (AVEG2) negatively influenced mobility distance (-0.359***), while factors like increased household competition for pasture (lnHH), water availability (WAT), and drought occurrence (DRO) had positive effects, with mobility distance increasing by 24.9%, 26.7%, and 41.6%, respectively.

Economic Factors: Wealth (lnSHU) positively affected mobility distance (0.275***), while owning a truck (TRUCK) (-0.201*) and rising fuel prices (lnFUEL) (-1.583*) reduced it.

Social Factors: Family size (lnFM) (-0.211***) and the age of the household head (lnAGE) (-0.657***) reduced mobility distance, while female household head (GEN) (0.566***), distance from the district center (lnDSC) (0.373***), and adherence to local government plans (PLA) (0.483***) positively influenced mobility.

Discussion

Research on herders' mobility often focuses on ecological factors, with less attention given to socio-economic drivers. Mobility is a crucial strategy for utilizing unevenly distributed forage and sustaining livestock. Herders understand long-term pasture dynamics but struggle with short-term changes, risking ecosystem health if traditional knowledge is lost (Oyundelger et al., 2024, *unpublished manuscript*).

Short-distance mobility is often constrained by limited grazing areas within administrative units, exacerbating pasture degradation. However, reciprocal grazing agreements can mitigate this (Fernandez-Gimenez & Le Febre, 2006). Mobility strategies, such as fall *Otor*, are effective in reducing the impacts of climate shocks like Dzud (Baival & Fernández-Giménez, 2012).

Economic constraints, including high fuel costs and limited labor, also influence mobility. Wealthier households with larger herds tend to migrate farther (Fernández-Giménez, 2001), while those lacking resources are less mobile (Baker & Hoffman, 2006). Policy interventions like the proposed Pastureland Law and improved pasture use planning can enhance sustainable mobility and resilience (Fernández-Giménez et al., 2018).

Strategic shock management, supported by modern tools such as savings and insurance, could further strengthen herders' resilience. Policymakers should focus on integrating these strategies while fostering collective action through Pasture User Groups (Kasymov et al., 2023).

Based on the research result two policy implications were derived. Firstly, the successful implementation of pasture use planning is critical for fostering pastoral mobility and mitigating overgrazing. Local administrations must take an active role in regulating pasture use and determining the timing of seasonal movements. While ecological factors and traditional practices influence mobility, local administrative organizations should establish clear schedules for seasonal movement in collaboration with herders. This ensures that winter and spring pastures are well-maintained and protected post-migration. Coordination with Pasture User Groups and herders' communities is essential to enforce these schedules and promote sustainable pasture management practices. Secondly, developing supportive infrastructure such as water points, livestock corridors, and seasonal shelters is essential to enable herders to move efficiently between pastures. Policies should incentivize adherence to established mobility plans and provide resources for maintaining infrastructure. Integrating these measures with broader sustainable rangeland management policies will help reduce competition for resources, improve pasture conditions, and ensure the long-term viability of pastoral livelihoods.

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