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1. Introduction

From an environmental aspect, mobile grazing is superior to sedentary grazing (Na et al., 2018). For instance, reduction of mobility and subsequent concentration of livestock around settlements, has been found to lead to rangeland degradation in Kazakhstan (Kerven, 2003).

In Mongolia, the number of livestock increased by 2.6 times between 1990 and 2021 (NSO Mongolia, 2022). This process directly resulted with overgrazing, followed by environmental degradation (Tuvshintogtokh & Ariungerel, 2013). In recent decades, studies pointed out that around 70 percent of the grassland in Mongolia was degraded (Awaadorj & Badrakh, 2007; Densambuu et al., 2015).

The importance of sustainable ecosystem management is enormous in Mongolia. From an agricultural perspective, pastureland which accounted for 71.6% of Mongolian territory in 2018 acts as the biggest resource of grass, feeding 67 million livestock (Agipar et al., 2019; NSO, 2022). From an ecological perspective, however, pastureland also generates various benefits for society through its ecosystem services. These include: 1) provisioning of herbage for feeding of livestock, 2) regulation of carbon sequestration, water flows, soil fertility and pollination etc., 3) supporting of gene pool protection and lifecycle maintenance, and 4) cultural services of aesthetic, recreation and tourism (Rodríguez-Ortega et al. 2014).

Mobility also brings many benefits to herders, help fattening the sheep (Kerven, 2003), and reducing forage cost (Jun Li et al., 2007). Livestock can take advantage of resources found in different habitat types, allows herders to harvest forage from a large area, which help herders to have and feed more animals than being stationary (Bascom, 1990). Depending on the estimation method, the annual net benefit of mobility per sheep unit was equivalent to 1.13-1.63 in the Mongolian steppe (Gonchigsumlaa & Damdindorj, 2021).

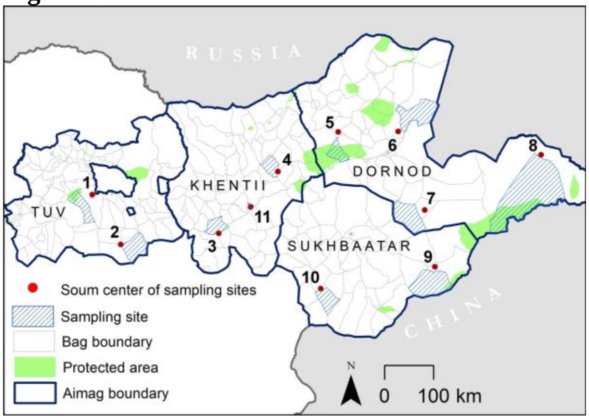
Mobility is reduced since the 1990s in which Mongolia entered to the market economy when the livestock is privatized. The change of economic system and the subsequent loss of support from the government to herders limited mobility as herders with less endowment tend to be more sedentary (Wang et al., (2013). M. Fernandez-Gimenez, (2006) wrote that the reduction of mobility was caused by social and economic factors such as increasing poverty, numbers of herding households, declining terms of trade, lack of social services, and loss of the formal regulatory institution.

Although the shrinking trend of mobility in Mongolia is explained from many different angles, there is a lack of study that employed econometric model to analyze mobility affecting factors.

2. Material and Methods

The study was conducted at the 11 *baghs* (coresites-CS hereafter) of 11 *soums* of 4 provinces, including Tuv (central), Khentii, Dornod and Sukhbaatar (Eastern) in Mongolia from central to eastern as a sampling frame, as predetermined by the MORESTEP project.

Figure 1. Location of the core-sites



(Source: MORE STEP project archive)

The study employed stratified random sampling method which is solely based on probability. We took all names of head of the herder households from predetermined 11 CSs (strata) as a sampling frame. The initial sample size during the 2019 fieldwork represented 22% of the herder population. In the following years, the sample size dropped from 320 in 2019 to 289 in 2020, and to 253 in 2022 (Table 1).

Table 1. Sample size

Strata				Total number of Herder Households (HHs)		Number of herder households participated in the survey		
CS	**Province**	***Soum***	***Bagh***	**HHs**	**Share (%)***	**2019**	**2020**	**2022**
A	B	C	D	E*i*	$F=(\frac{Ei}{\sum Ei})\times 100\%$	H	I	G
1	*Tuv*	*Altanbulag*	*Altan-Ovoo*	204	14.08%	45	38	33
2		*Bayantsagaan*	*Gurvan-Turuu*	99	6.83%	22	20	20
11	*Khentii*	*Kherlen*	*Bayanmunkh*	196	13.53%	43	39	31
4		*Batnorov*	*Ekhenburd*	140	9.66%	31	28	23
3		*Bayanmunkh*	*Kherlen*	97	6.69%	22	22	20
5	*Dornod*	*Tsagaan-Ovoo*	*Guntsengeleg*	81	5.59%	18	15	11
6		*Choibalsan*	*Enger shand*	91	6.28%	20	17	15
7		*Matad*	*Bayankhangai*	65	4.49%	14	12	11
8		*Khalkhgol*	*Tashgai*	93	6.42%	21	20	19
9	*Sukhbaatar*	*Erdenetsagaan*	*Badrakh*	137	9.45%	30	26	23
10		*Bayandelger*	*Duhum*	246	16.98%	54	52	47
Total				**1,449**	**100%**	**320**	**289**	**253**

Source: All names of herder households were obtained from *bagh* leaders

Note: *The proportion to each coresite (CS) is multiplied by the total sample size of 320 to calculate sample size for each CS.

The sample size was reduced due to difficulties in interviewing the same households across different years, including migration, changes in herder status, absence, endemic quarantine, and COVID-19 lockdowns. To generate balanced panel data, households were interviewed repeatedly in 2019, 2020, and 2022. Fieldwork in 2021 was postponed due to COVID-19 lockdowns. Thus, the dataset comprises 759 values obtained from 253 herder households over a period of 3 years

2.1. Model and variables

The dependent variable, lnDIS-Annual mobility distance of a household in km. This includes mobility made between and within seasonal camps, and Otor. Natural logarithm was used to transform the variable

Herder mobility can be measured by the frequency (number of movements made) and distance (km of travel) over year-round. Although both metrics have their own advantages and disadvantages, we found that distance measure (*DIS*) is superior in the model as a dependent or explained variable (Eq 1).

$$lnDIS_{it} = \alpha + \beta_1 lnFM_t + \beta_2 EDU_t + \beta_3 lnHH_t + \beta_4 GEN_t + \beta_5 lnAGE_t + \beta_6 EXP_t + \beta_7 ORG_t + \beta_8 lnDSC_t + \beta_9 lnINC_t + \beta_{10} lnFUEL_t + \beta_{11} lnSHU_t + \beta_{12} SMALLPER_t + \beta_{13} TRUCK_t + \beta_{14} lnHAY_t + \beta_{15} LPA_t + \beta_{16} PLA_t + \beta_{17} AVEG_t + \beta_{18} WAT_t + \beta_{19} DZUD_t + \beta_{20} DRO_t + u_{it}$$

$$i \in 1:224; \qquad t = 1,2,3 \qquad (Eq\ 1)$$

This model is to explain the factors that affect to the distance of travel made for herder mobility or household ***i***, for period ***t*** (***t***=3) per year. The DIS is measured as sum of three types of mobility made within a year as defined by Gonchigsumlaa and Damdindorj (2022), including Seasonal-camp mobility, Within-seasonal-camp mobility and *Otor* mobility.

Here we describe an average household with regard to the herder mobility. The average family moved 4.8 times for 52.6 km on average

Independent variables

Social factors

FM: Household size expressed by the number of family members

EDU: Education level of household head (1=No schooling, 2=Attended Primary school, 3=Attended secondary school, 4=Attended high school, 5=Attended college, 6=Attended university)

HH: The number of households using the same pasture.

GEN-Gender of the household head. (0=Male, 1=Female)

lnAGE-Age of the household head. Ln transformed.

lnEXP-The herding experience of the household head. Estimated by the number of years spent on herding livestock. Ln transformed

ORG- Membership in herder organization (1=Yes, 0=No)

lnDSC-Annual average distance between soum center and the household location in km. Ln transformed

Economic factors

lnINC- Annual total income of herders in USD (Ln transformed)

lnFUEL-Fuel price per liter. Ln transformed

lnSHU-The total number of livestock of the household converted to sheep unit. Ln transformed

SMALLPER- Represents the percentage of small ruminants (sheep and goats) within the herd. A higher proportion of small ruminants can lead to a faster degradation of vegetation output due to their limited grazing space, which may require herders to move to different pasture more frequently.

TRUCK-A dummy variable indicating whether the household own a truck. (0=No, 1=Yes)
lnHAY- Represents the quantity of hay prepared by the herder household, encompassing both the hay harvested and purchased.
LPA-A dummy variable indicating whether the household lost their pasture. (0=No, 1=Yes)

Political factor

PLA-Dummy variable indicating whether the household move in accordance with the local government plan. (0=No, 1=Yes)

Ecological factors

AVEG- Indicates the pasture utilization rate based on the perception of herders. Participants were tasked with assessing the vegetation output of four seasonal pastures both before and after utilization, using a rating scale ranging from 1=Very poor to 5=Excellent. To determine the annual level of pasture utilization, we first calculated the difference between the vegetation rating after utilization and the rating prior to utilization for 4 different seasonal camps and estimated the average value. A negative *"AVEG"* value signifies a degradation in vegetation output, while a positive value indicates an improvement in vegetation output after utilization.

WAT-A categorical variable that represents water output in of the pasture. (1=Bad, 2=Average, 3=Good)
DZUD-A dummy variable indicating whether dzud occurred. (0=Didn't occur, 1=Occurred)
DRO- A dummy variable indicating whether drought occurred. (0=Didn't occur, 1=Occurred)

Table 2. Descriptive statistics of the variables

Variable	Mean	Std.Dev.	Min	Max
DIS	50.046	64.407	1.000	565.000
FM	4.17	1.61	1.00	9.00
EDU	3.13	1.09	-	10.00
GEN	0.07	0.26	-	1.00
AGE	45.36	12.70	21.00	87.00
HH	3.80	2.51	-	40.00
EXP	23.30	13.05	1.00	73.00
ORG	0.32	0.47	-	1.00
lnDSC	4.66	0.68	1.39	6.19
INC (USD)	8,423.15	8,949.6	333.68	133,717.5
FUEL	2,316.54	123.55	2,094.08	2,524.17
SHU	563.59	361.82	37.65	1,818.93
SMALLPER	2.83	8.66	-	120.00
TRUCK	0.91	0.29	-	1.00
HAY	7.61	8.52	-	109.20
LPA	0.05	0.21	-	1.00
AVEG	(0.43)	0.55	(3.00)	2.00
WAT	0.89	0.25	-	1.00
DZUD	0.14	0.35	-	1.00
DRO	0.20	0.40	-	1.00
PLA	0.08	0.27	-	1.00

Note: "To convert the household income, we applied the 2021 average exchange rate of 2,849.29, given that the 3rd year of fieldwork occurred in 2021

3. Results

Statistical tests of robustness

Multicollinearity: VIF test showed average VIF of 1.33 (below 5, not serious)

Autocorrelation: Wooldridge's serial correlation test didn't reject null hypothesis, showing no presence of autocorrelation (Prob > F = 0.0736) showing no autocorrelation

Heteroskedasticity: Modified Wald test found groupwise heteroskedasticity (Prob>chi2 = 0.0000)

Hausman Test: Favored FE over RE estimator (Prob>chi2 = 0.0019)

Alternative: Sargan Hansen overidentification test also favored FE (P-value = 0.0003), addresses heteroskedasticity

Model interpretation

According to the table below, *"lnDSC"*, *"AVEG"*, and *"DRO"* came out **significant across both FE and pooled** estimators. This means:

- "***DSC"*****-** Herders close to soum centers (sub-district) are subject to restricted mobility distance.
- Perceiving a reduction in vegetation cover after using seasonal pastureland ***"AVEG"*** had a positive effect on mobility distance.

- ***"DRO"*** Occurrence of drought motivated herders to move more.

The result of fixed effect estimator indicated that higher number of households grazing in the same area ***"HH"*** is a significant factor for herders to move farther. Interestingly, household heads with more years of herding experience ***"EXP"*** are moving less.

Compared to FE, Pooled estimator identified more significant covariates. This includes:

- Education level of household head ***"EDU"*** negatively affected mobility distance.
- ***"GEN"*** indicated that the average mobility distanced tend to increase for women headed households.
- The age of the household head ***"lnAGE"*** signified thtat old age is a restricting factor for mobility.
- Higher livestock number ***"SHU"*** increased annual mobility distance.
- Adhering to local government plan for mobility ***"PLA"*** increased annual mobility distance.

Figure 2. Model result

		FE robust (xtreg)	Pooled OLS robust
Social	FM	-0.0681*	-0.0520*
	EDU	0.022	**-0.121*** **
	GEN	0.538*	**0.586*** **
	lnAGE	0.695*	**-0.549*** **
	HH	**0.0382** **	0.0185
	lnEXP	**-0.294*** **	-0.0798
	ORG	0.0487	0.13
	lnDSC	**0.707*** **	**0.426*** **
Economic	lnINC	-0.0853	-0.119
	lnFUEL	-0.968	-1.581*
	lnSHU	0.0596	**0.340*** **
	SMALL PER	0.00609	-0.00759
	TRUCK	-0.208*	-0.223*
	lnHAY	0.0302	0.0194
	LPA	0.133	-0.0119
Ecological	AVEG	**-0.204*** **	**-0.371*** **
	WAT	0.0802	0.156
	DZUD	0.0311	0.0147
	DRO	**0.274** **	**0.371*** **
Regulatory	PLA	0.238	**0.546*** **
_cons		6.532	**15.89** **
N		672	672
R-sq: within		0.1414	-
R-sq: between		0.0863	-
R-sq: overall		0.0961	-
R-sq		-	0.218
adj. R-sq		-	0.194

*p<0.10, ** p<0.05, *** p<0.0

Conclusions and Outlook

Both Fixed-Effect and Pooled estimators showed different results. Although statistical tests favoured FE, Pooled OLS model shows more insight in regards to explaining mobility factors. When compared the significant variables across both estimators, herders proximity to sub-districts *"DSC"*, herders' perception of decrease in vegetation cover following pasture utilization "AVEG", and Occurrence of drought "DRO" were the most consistent factors affecting annual mobility distance.

References

Na, Y., Bao, S., Hashimoto, K., McCarthy, C., & Hoshino, B. (2018). The Effects of Grazing Systems on Plant Communities in Steppe Lands—A Case Study from Mongolia's Pastoralists and Inner Mongolian Settlement Areas. *Land*, *7*, 1–10. https://doi.org/10.3390/land7010010

Kerven, C. (2003). *Prospects for Pastoralism in Kazakhstan and Turkmenistan: From State Farms to Private Flocks, Routledge Curzon*.

NSO Mongolia. (2022). *NUMBER OF LIVESTOCK, by type, by region, bag, soum, aimag and the Capital*.

https://www.1212.mn/tables.aspx?tbl_id=DT_NSO_1001_021V1&BAG

Tuvshintogtokh, I., & Ariungerel, D. (2013). *Degradation of Mongolian Grassland Vegetation Under Overgrazing by Livestock and Its Recovery by Protection from Livestock Grazing BT - The Mongolian Ecosystem Network: Environmental Issues Under Climate and Social Changes* (N. Yamamura, N. Fujita, & A. Maekawa, Eds.; pp. 115–130). Springer Japan. https://doi.org/10.1007/978-4-431-54052-6_10

Awaadorj, D., & Badrakh, S. (2007). Vegetation community changes in pastureland. *Geological Issues in Mongolia*.

Densambuu, B., Sainnemekh, S., Bestelmeyer, B., & Budbaatar, U. (2015). *National Report on the Rangeland Health on Mongolia*.

Agipar, B., Bazarsad, C.-O., & Dagys, K. (2019). *Монгол орны бэлчээрийн тулгамдсан асуудал: гарц ба шийдэл*.

Jun Li, W., Ali, S. H., & Zhang, Q. (2007). Property rights and grassland degradation: A study of the Xilingol Pasture, Inner Mongolia, China. *Journal of Environmental Management*. https://doi.org/10.1016/j.jenvman.2006.10.010

Bascom, J. B. (1990). Border pastoralism in eastern Sudan. *Geographical Review*. https://doi.org/10.2307/215850

Wang, J., Brown, D. G., & Agrawal, A. (2013). Climate adaptation, local institutions, and rural livelihoods: A comparative study of herder communities in Mongolia and Inner Mongolia, China. *Global Environmental Change*, *23*(6), 1673–1683. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2013.08.014

Fernandez-Gimenez, M. E., & le Febre, S. (2006). Mobility in pastoral systems: Dynamic flux or downward trend? *International Journal of Sustainable Development and World Ecology*. https://doi.org/10.1080/13504500609469685

Dong, Shikui; Kassam, Karim-Aly S.; Tourrand, Jean François; Boone, Randall B. (2016): Building Resilience of Human-Natural Systems of Pastoralism in the Developing World. Cham: Springer International Publishing.

Rodríguez-Ortega, T.; Oteros-Rozas, E.; Ripoll-Bosch, R.; Tichit, M.; Martín-López, B.; Bernués, A. (2014): Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. In Animal : an international journal of animal bioscience 8 (8), pp. 1361–1372. DOI: 10.1017/S1751731114000421.