2026 RESILIENCE LEARNING MONTH
Knowledge Sharing and Learning Events
23 April–7 May 2026

Climatic Extremes and Pastoral Vulnerability:

The Impact of Dzud on Household Livestock in Mongolia

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Introduction

- **Agriculture:** a key sector in Mongolia, accounting for one third of employment and over 10% of GDP. Livestock and animal husbandry is responsible for 80% of agricultural production.
- **Dzud:** severe winter disasters where **snow**, **ice**, and **cold** block livestock access to forage and water, causing mass animal deaths and major social and economic impacts.
- **Affected DMCs**: Mongolia, China's Inner Mongolia Autonomous Region and parts of Central Asia (particularly Kazakhstan and the Kyrgyz Republic)
  - **White (Tsagaan) dzud:** deep, suffocating snow that covers pastures
  - **Black (Khar) dzud:** occurs after a dry summer, leaving little snow or water
  - **Ice/Iron (Tomor) dzud:** covers grazing areas with an icy crust
  - **Combined dzud:** brings a mix of these brutal conditions, creating an almost insurmountable barrier for herding families
  - Different types of dzud pose distinct and differentiated risks

Context

- **Strategic prioritization and momentum:** Mongolia is hosting COP17 of the United Nations Convention to Combat Desertification (UNCCD) on 17-28 August 2026, during the International Year of Rangelands and Pastoralists (54% of world's land surface).
- **Recent experience:** Mongolia suffered an 'Iron Dzud' in 2024, which killed eight million livestock - 12.5% of the total, caused losses of $1.5-1.9 billion, and affected 180,000 herder households.
- **Food systems resilience and transformation:** the ADB identified agrifood systems transformation as a core strategic priority in 2025, in delivering $40 billion food security commitment in Asia Pacific during 2022-2030, while food insecurity has spiked by almost 100 million people across emerging Asia since 2020.
- **Climate change:** threatens to increase the frequency and severity of dzud. The interplay between summer drought and winter dzud is eroding livelihoods and food security. Land degradation amplifies these issues, and affects 65% of rangelands.

Literature review

- **Aggregated insights:** the search string of "dzud" or "zud" AND "Mongolia" yields 144 results in *ScienceDirect.*
- **Drivers and dynamics of vulnerability:** over-grazing and land degradation (Li et al, 2025; Nyamjav et al, 2025), climate change (Chadraabal et al, 2020; Begzsuren et al, 2004; Nara and Battulga, 2019), resource inequality and competition (Joly et al, 2018; Fernandez-Giminez et al, 2012).
- **Socioeconomic impacts of dzud:** rise in livestock mortality (Chadraabal et al, 2020), increased rural-urban migration (Xu et al 2021), higher insurance demand (Mogge and Kraehnert, 2025), persistent socioeconomic deprivation (Groppo and Kraehnert, 2016), food insecurity (Dagys et al, 2023).
- **Responses and solutions for adaptation and resilience:** early warning systems and disaster risk management (Chadraabal et al, 2020; Sternberg and Batbuyan, 2013; Nara and Battulga, 2019), community-based resource management (Fernandez-Giminez, 2015), nomadic migration, on-farm techniques, storage and cover (Huang et al, 2025; Kashida et al, 2025), rules and governance (Allington et al, 2024; Nyamjav et al 2025; Fernandez-Giminez et al, 2012).

Contribution

- **Policy-grounded measure of dzud:** weather-based using Mongolian government's formal classification (not livestock-based like most studies)

- **Differentiated dzud:** our research analyzes the differentiated impacts of various types of dzud, including white, black, and iron (many studies homogenize the impacts of dzud, e.g. Thaiiri et al 2008)

- **Scope, frequency, and coverage:** our analysis brings together national quarterly household survey and high-resolution climate data over more than a decade (none of the 144 articles use national household survey data - 23 use household surveys, but these tend to be small scale (75-250 observations).

- **Household characteristics:** our empirical model integrates a range of household features to uncover patterns of vulnerability and resilience mediated by gender, age, education, and employment (most literature focuses on livestock lost only).

Overview of results

- The occurrence of dzud affects household decision on both (i) whether to own small livestock and (ii) number of livestock owned.

  - The experience of **any dzud** significantly reduces the **probability** of owning livestock and lowers the **number** of livestock owned.
  - **Ice dzud** reduces the **probability** of owning livestock.
  - **White dzud** significantly affects the **number** of small livestock owned.
  - The impacts of the dzud also vary depending on the **socioeconomic and demographic** features of households

Data: Dzud data

Monthly Dzud calculation in Google Earth Engine using high-resolution climate reanalysis data from ERA5, based on Mongolia's 2015 Government Resolution No. 286, titled Procedure for Assessing Drought and Dzud Conditions

3.3.1. White dzud

- Snow **density** in any region is **≥ 0.25 g/cm³**
- 10-day or monthly average temperature is **≥ 3.0°C colder** than the long-term average or exceeds the standard deviation
- Average **snow depth** exceeds:
  - **25 cm** in high mountain and forest-steppe zones
  - **22 cm** in steppe zones
  - **12 cm** in desert-steppe zones

3.3.2. Approaching white dzud

- Snow **density** is between **0.20–0.24 g/cm³**
- Average snow depth exceeds:
  - **16 cm** in high mountain and forest-steppe zones
  - **11 cm** in steppe zones
  - **5 cm** in desert-steppe zones

3.3.3. Black dzud

Occurs in areas that **had drought or moderate drought in summer**, followed by:

- No snowfall in winter
- 10-day or monthly average temperature is **≥ 3.0°C colder** than normal
- Livestock suffer from lack of water and forage

3.3.4. Approaching black dzud

Occurs in drought-prone areas with:

- **Low snowfall**
- Temperature is **≥ 2.0°C colder** than normal
- Livestock suffer from limited forage and water

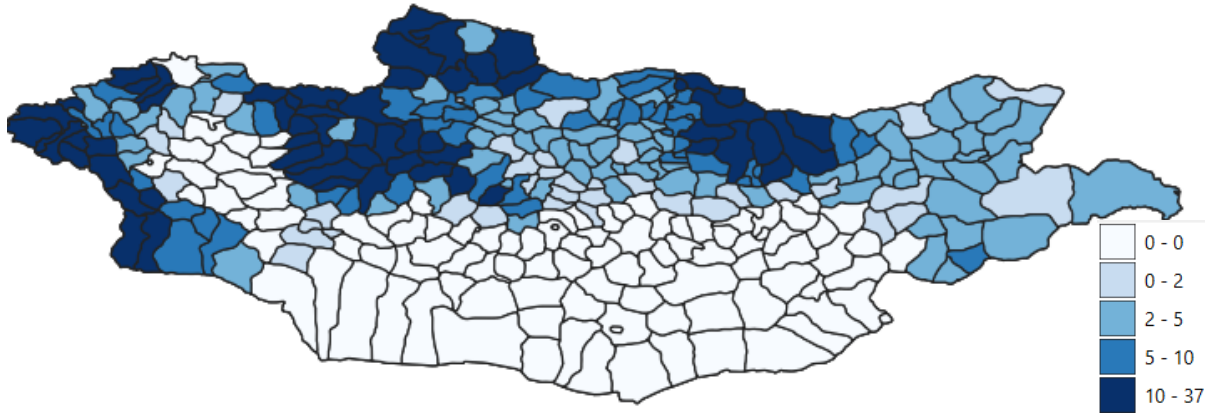
3.3.5. Iron or Ice dzud

- A thaw-freeze cycle creates **ice crusts** on top of or within the snowpack, preventing livestock from grazing
- Or when snow **density ≥ 0.35 g/cm³**

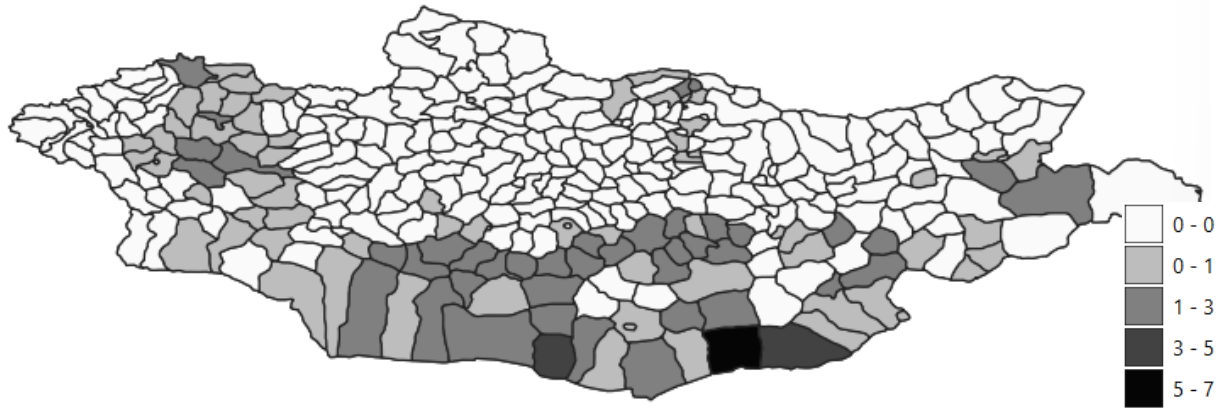
Data: Dzud data

Dataset	Variables	Provider	Link
ERA5-Land Monthly Aggregated - ECMWF Climate Reanalysis	2m temperature, snow density, snow_depth	ECMWF via GEE	https://developers.google.com/earth-engine/datasets/catalog/ECMWF_ERA5_LAND_MONTHLY_AGGR
ERA5-Land Daily Aggregated - ECMWF Climate Reanalysis	2m temperature, snow density	ECMWF via GEE	https://developers.google.com/earth-engine/datasets/catalog/ECMWF_ERA5_LAND_DAILY_AGGR
Mongolia administrative boundary data	Soum-level boundaries	Database of Global Administrative Areas (GADM)	https://gadm.org/download_country.html
Mongolia ecological zones shapefile	Ecological zones with government-assigned classifications	Mongolia Environmental Information Center GeoPortal (WGS84-converted)	https://eic.mn/geodata/

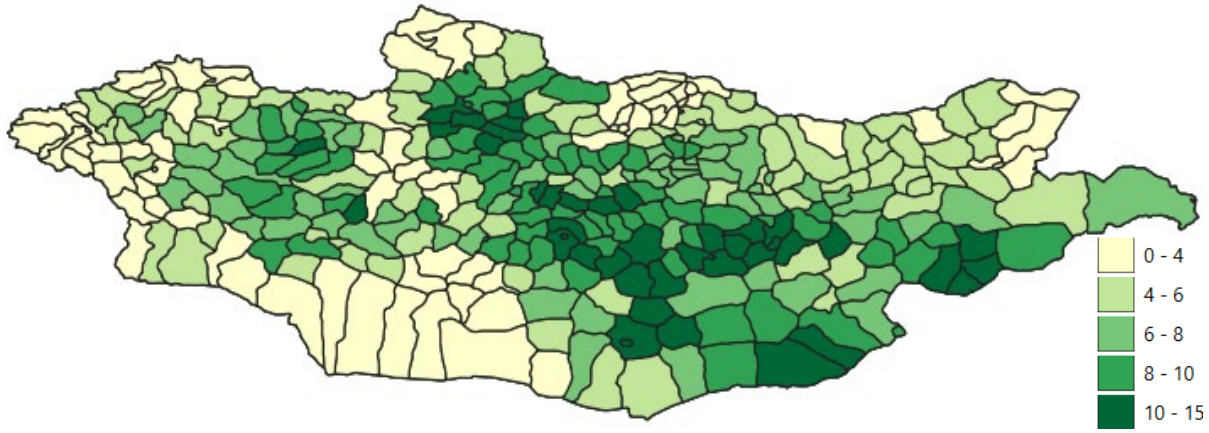
Data: Dzud data



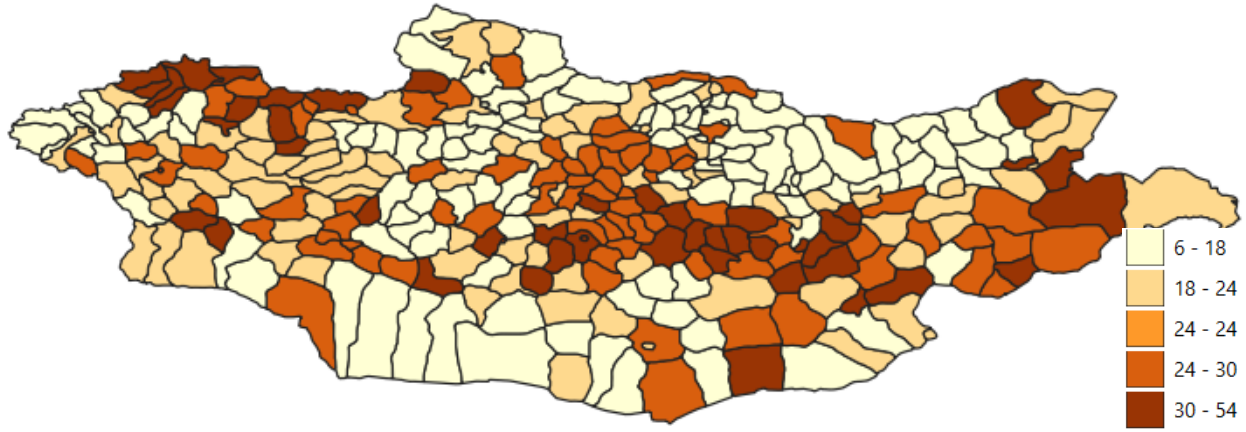
White dzud occurrences in study years



Black dzud occurrences in study years

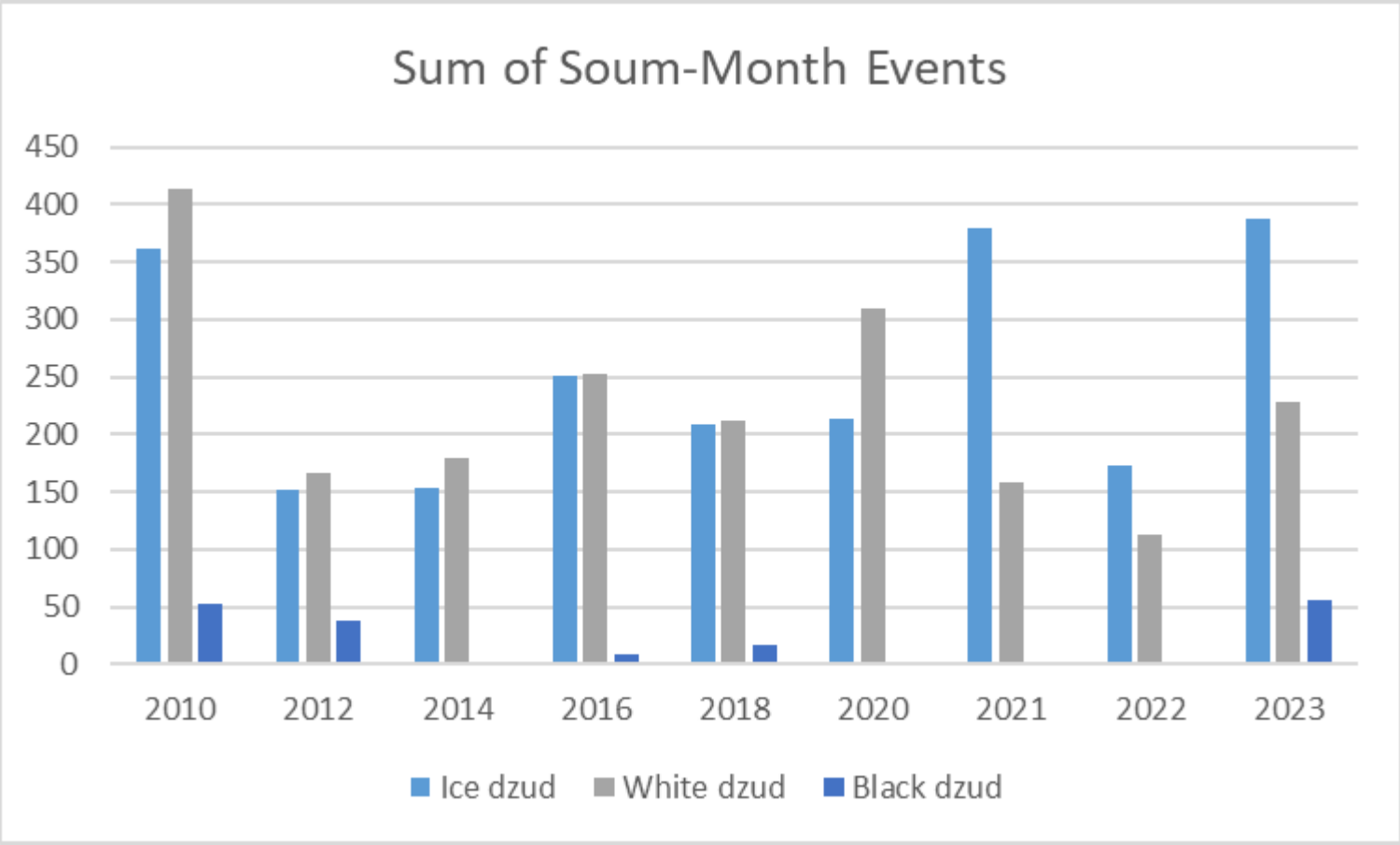


Ice dzud occurrences in study years



Summer drought occurrences in study years

Data: Dzud data



Top recorded dzud events

2009–2010: Often cited as one of the deadliest, killing 8.5 to 10.3 million livestock (approximately 20% of the total population) and affecting 28% of the population.

2023–2024: Labeled as one of the most severe in 50 years, starting with early snowfall in November 2023. By March 2024, over 8 million livestock died, affecting 90% of the country and causing extreme economic hardship for herders.

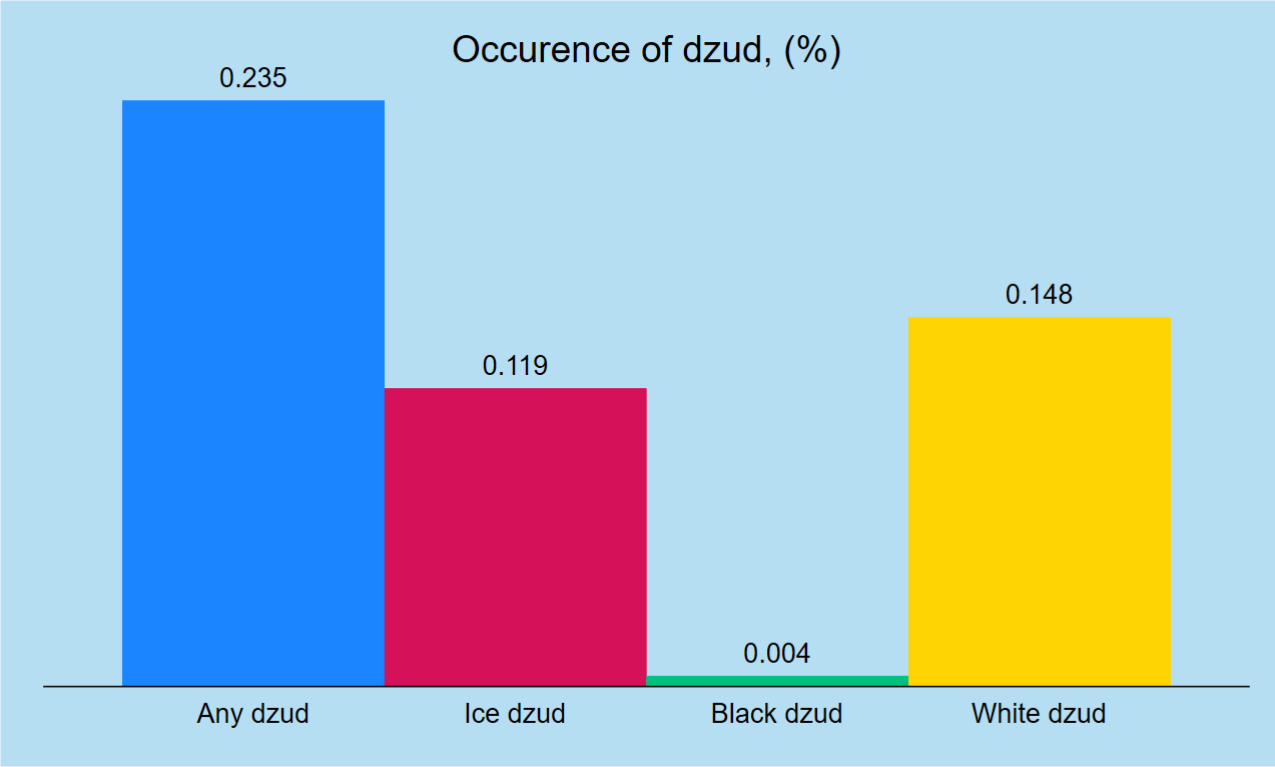
Data: Livestock data

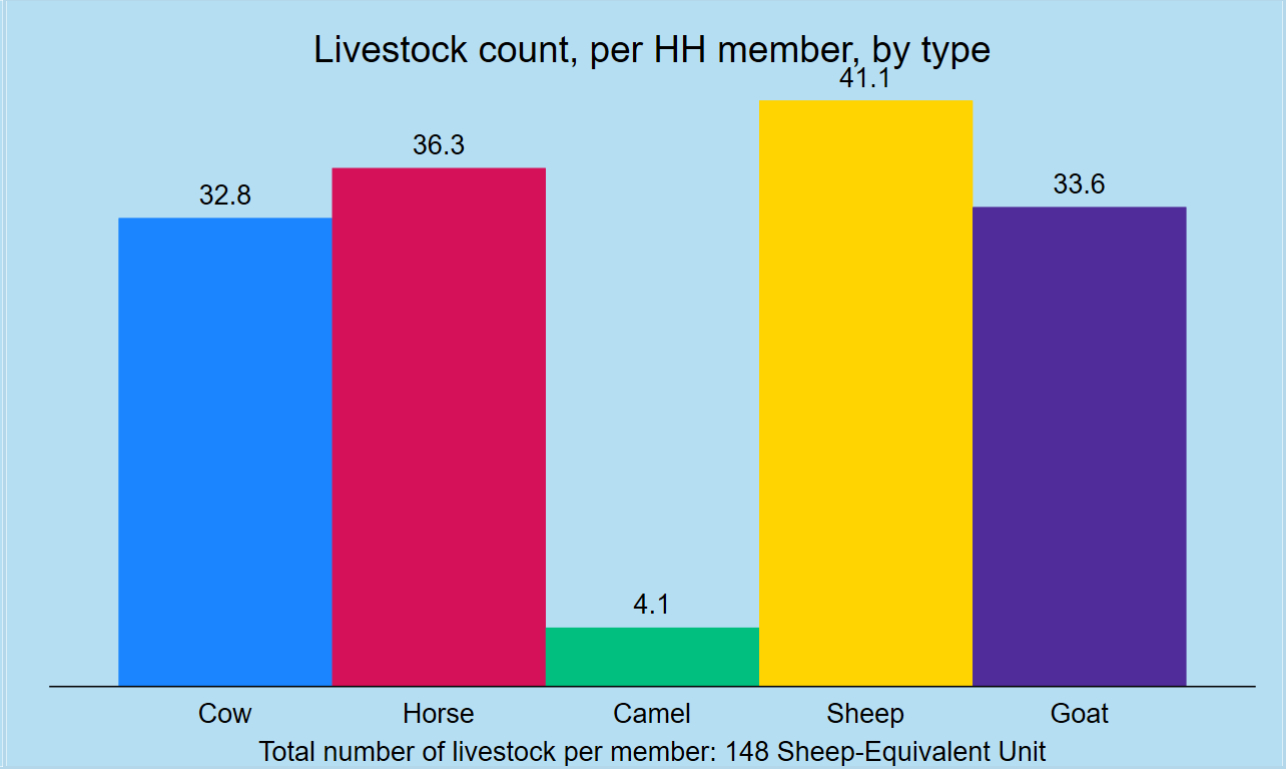
- The Household Socioeconomic Survey (HSES) is a nationally representative, quarterly survey conducted by the National Statistics Office of Mongolia.
- The survey encompasses entirety of Mongolia (Capital city, 21 aimags, 330 soums).
- The rural households' data is used.
- The number of observations: 12,897 households.
- Dependent variable: 5 types of livestock (cow, horse, camel, sheep, goat), in addition to the total number of livestock
- Household and individual characteristics: age, education, marital status, employment type, household size, number of children

Descriptive statistics

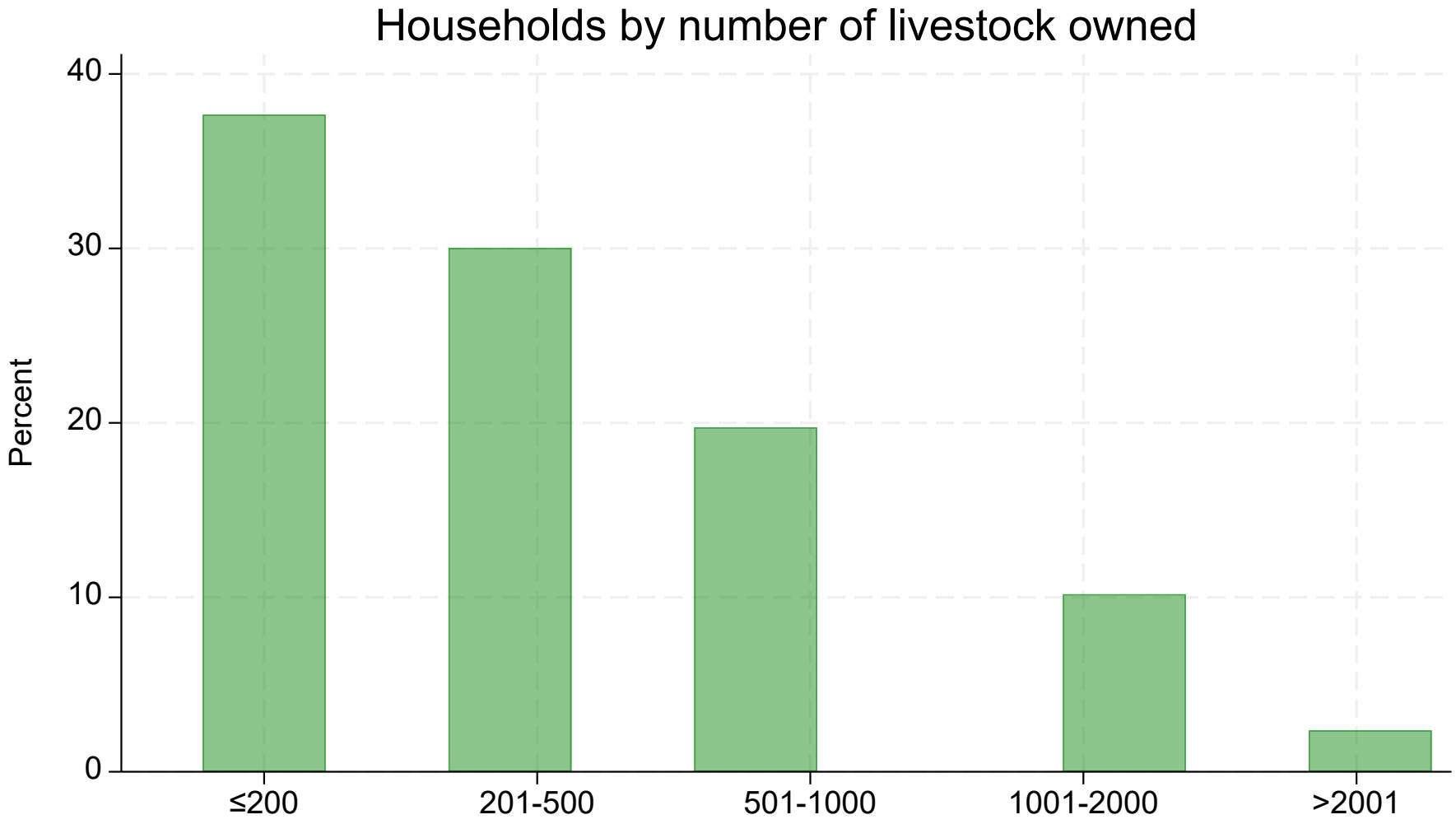
Variables	Mean	Standard deviation
Livestock	148.0	228.9
Small	74.67	102.0
- Sheep	41.07	68.36
- Goat	33.6	46.25
Big	73.29	161.8
- Horse	36.33	107.6
- Cattle	32.83	68.16
- Camel	4.13	30.95
Any dzud	0.235	0.424
- ice dzud	0.119	0.324
- black dzud	0.0042	0.065
- white dzud	0.148	0.355
Gender	0.865	0.342
Age	45.09	13.9
Marital status	0.783	0.412
Employment status	0.518	0.5
Years of education	8.501	4.216
Household size	3.716	1.78
Children less than 6 years old	0.566	0.812
Children less than 16 years old	1.317	1.351

Descriptive statistics



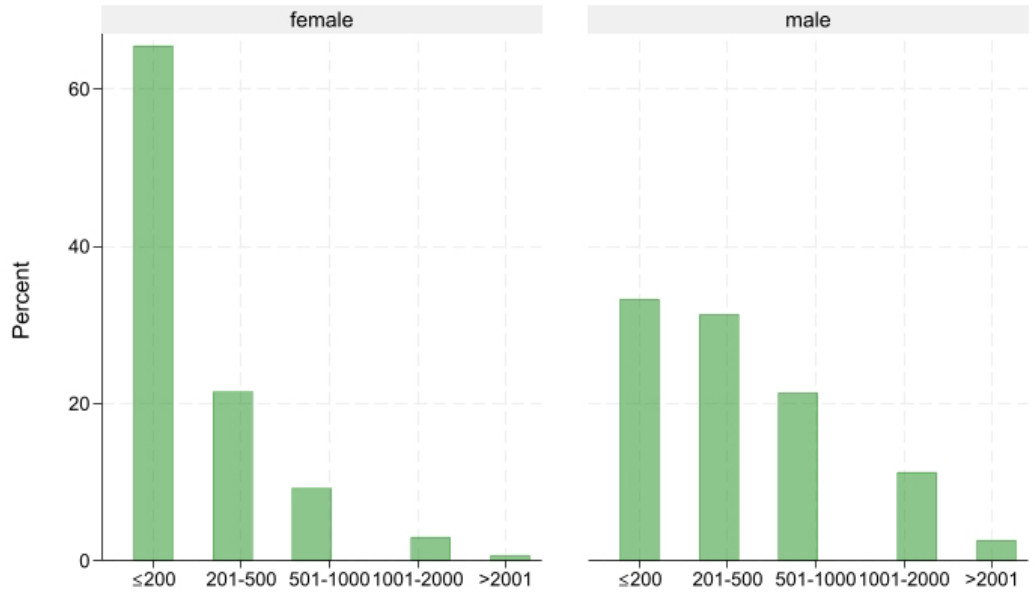


1/3 own up to 200 heard size, most households (67%) have heard size up to 500 livestock

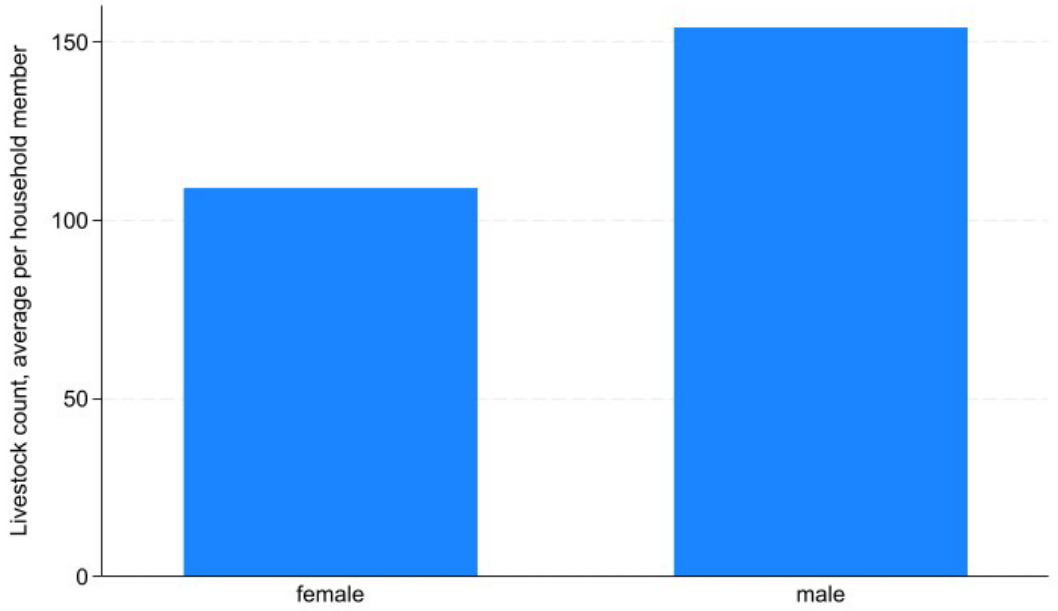


Female-headed households own smaller size herds (on average)

Herd size

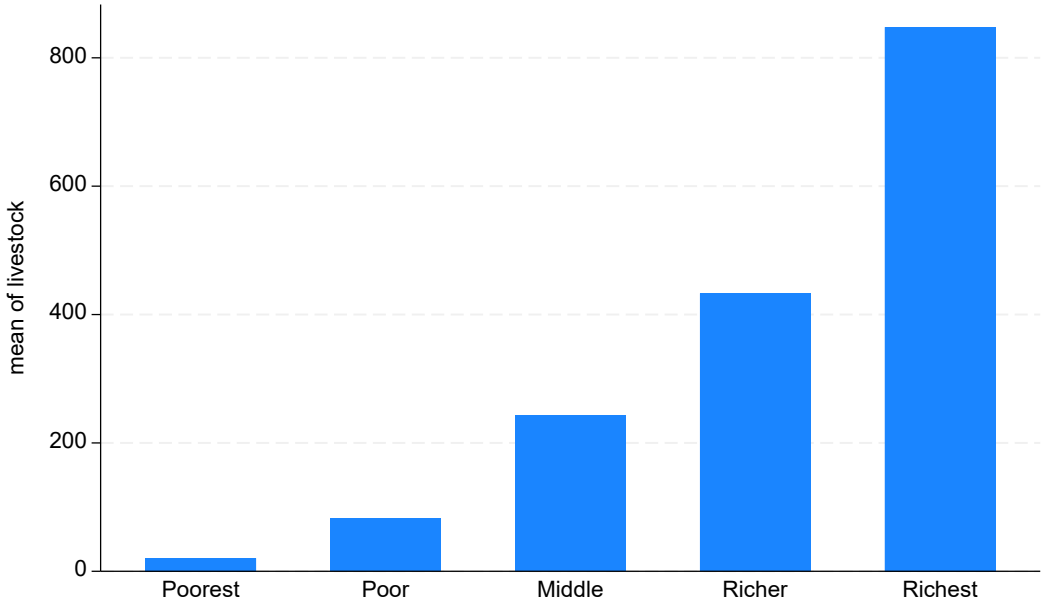


Herd size per household member

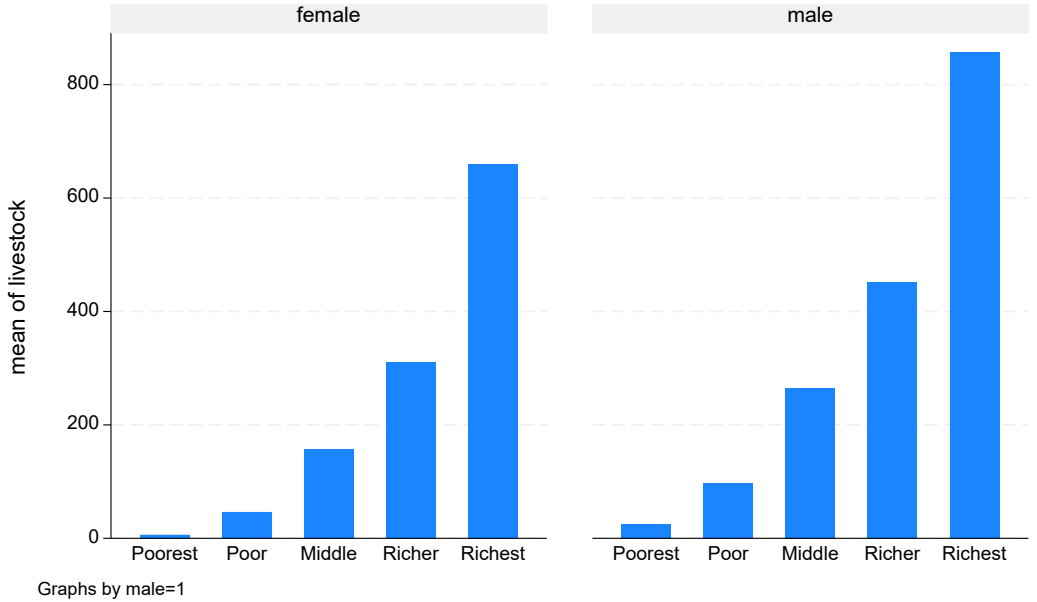


Income and heard size

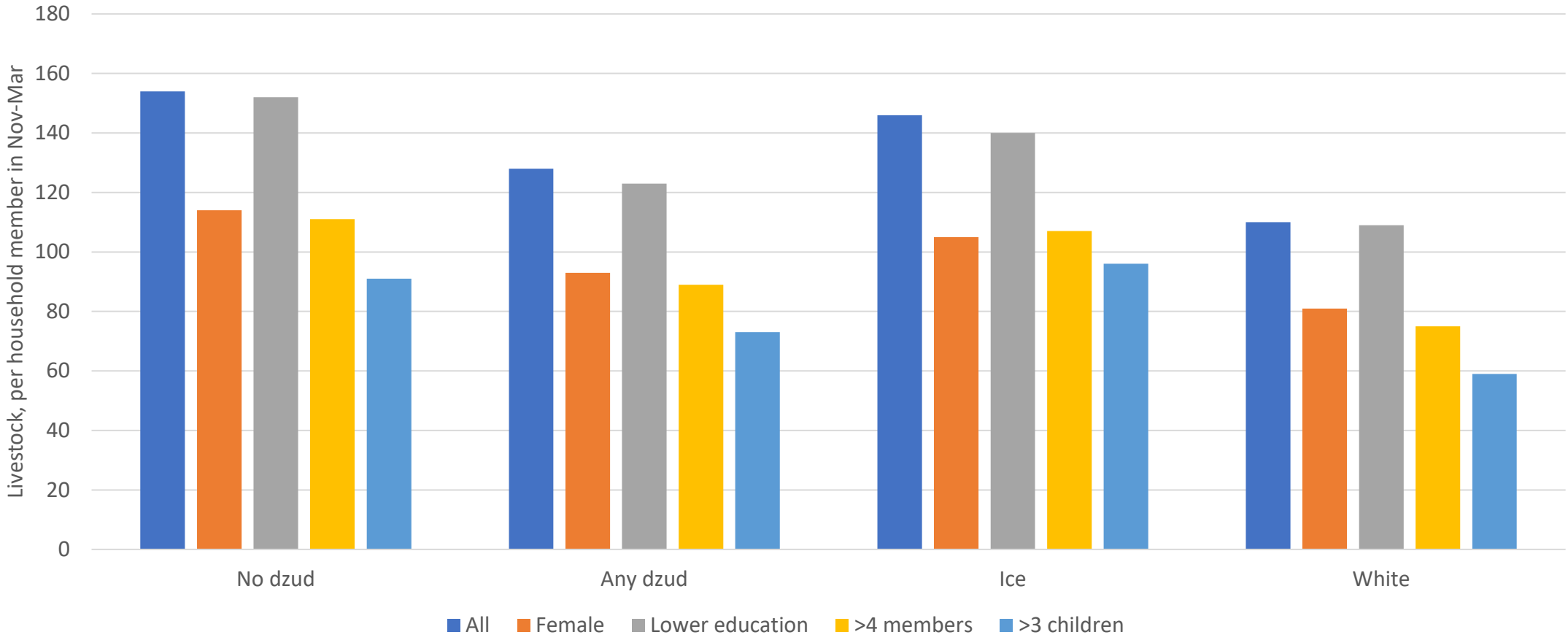
Lower income households own smaller size herds



Female own smaller herd size even in the same income group



After dzud livestock is lower especially in female-headed, large household and more children



Existing policies in Mongolia

Policy	Objective	Key Mechanism	Limitations
Dzud Early Warning & Risk Monitoring System (NAMEM)	Anticipate dzud risk and enable early preparedness	Seasonal forecasts, dzud risk maps, pasture conditions	Forecasts do not alwasys translate into timely actions; limited capacity at soum and herd level to act
Government Dzud Emergency Response (SEC, NEMA, MoFALI)	Reduce livestock mortality and protect basic livelihoods during dzud	Coordinated humanitarian assistance (cash, fodder, veterinary supplies, fuel, food)	Reliance on funding, mostly reactive; arrives after losses occur
Index-Based Livestock Insurance	Transfer catastrophic dzud risk away from herder households	Index-based mortality payouts	Limited coverage and uptake; poorest and most remote herders less likely enrolled; does not prevent animal deaths
Social Protection & Cash Assistance during Dzud	Protect vulnerable households' consumption and wellbeing	Emergency cash and welfare assistance	Primarily relief-oriented; weak linkage to long-term livelihood recovery and resilience building
Pasture Management & Herding Adaptation Policies	Reduce structural vulnerability to dzud	Sustainable pasture use, herd size management, and restoration of traditional mobile grazing	Long-term, hard to enforce, effectiveness constrained by overgrazing, institutional coordination, and climate change trends

Policy implications

- Since Dzud is becoming more frequent, investments in dzud resilience could be more economically viable.
- Adapt solutions for each dzud type (working on this)
- Examples:
  - Increase emergency fodder and hay (to prevent starvation)
  - livestock shelters

Empirical strategy

- Double hurdle model is estimated as below:

$$Y^*_{1iastm} = \alpha_0 + \alpha_1 Z_{astm} + \partial X_{iastm} + Aimag_a + Year_t + Month_m + u_{1iastm} \quad (1)$$

$$Y^*_{2iastm} = \delta_0 + \delta_1 Z_{astm} + \rho X_{idtm} + Aimag_d + Year_t + Month_m + u_{2iastm} \quad (2)$$

where Y^*_{1iastm} represents the decision to own livestock,

Y^*_{2idtmw} is the number of livestock owned,

Z_{astm} is occurrence of dzud,

X_{idtm} is individual characteristics.

Preliminary analysis using a double-hurdle (Craggit) model

- **Any dzud** significantly reduce both probability of livestock ownership and herd size in Mongolia.
- **Ice dzud** lowers the probability of owning livestock ->households exit livestock ownership entirely
- **White dzud** reduces herd size ->a reduction in herd size among livestock-owning households

- Youth (<36 years old): Dzud reduces the probability of livestock ownership -> Urbanization

- Vulnerable groups include:
  - small herd-size
  - female-headed households
  - low income

Thank you.