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Sitting in the same boat: Subjective well-being and social comparison after an extreme weather event

Svenja Fluhrer[a,b], Kati Kraehnert[a*]

[a]Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, P.O. Box 60 12 03, D-14412 Potsdam, Germany

[b]Faculty of Life Sciences, Department of Agricultural Economics, Humboldt-Universität zu Berlin, Invalidenstaße 42, D-10115 Berlin, Germany

** Corresponding author. Email address: kraehnert@pik-potsdam.de*

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Abstract

How does subjective well-being depend on the fate of others when a covariate shock strikes? We address this question by providing novel evidence on the impact of shock-induced damages experienced by individuals and their reference group on life satisfaction. We do so by examining the case of pastoralists in Mongolia, who faced a once-in-50-years winter disaster. Our identification strategy exploits the quasi-experimental nature of the extreme event. The empirical analysis builds on a detailed household panel survey, complemented with aggregated climate data and historic livestock census data. Results show that exposure to the extreme event significantly and strongly reduces subjective well-being even 4-5 years after the event occurred. The negative shock impact is amplified by observing peers doing economically worse. Similarly, exposure to the extreme event increases the perceived inequality among households with assets at risk. We argue that the event increased sectoral disparities between pastoralists and those households not engaged in agriculture.

Keywords: subjective well-being, extreme weather event, social comparison, pastoralism, self-reported shock

JEL: I30, D63, O15, Q54

1. Introduction

How does subjective well-being depend on the fate of others when a covariate shock strikes? It is documented that observing peers doing better can either positively or negatively affect an individual's well-being (e.g., Brown et al., 2015; Clark et al., 2008). Yet, the opposite case – the effect of observing peers facing economic damages as a result of a severe shock – is not explicitly addressed by research. With climate change, this question is becoming more relevant, as not only are extreme weather events predicted to increase in frequency and intensity but also the economic damages associated with them (Hoegh-Guldberg et al., 2018; Seneviratne et al., 2012). This paper tests empirically the impact of shock-induced damages experienced by individuals and their reference group on the subjective well-being of individuals. We do so by examining the case of pastoralists in Mongolia who faced a once-in-50-years winter disaster that caused the death of more than 10 million livestock. Our identification strategy exploits the quasi-experimental nature of the extreme event.

Our analysis builds on a small, but growing, field of research that quantifies losses in subjective well-being caused by exposure to extreme weather events. For instance, Ahmadiani and Ferreira (2021) match county-level data on the occurrence of tropical cyclones, severe storms, and flooding with repeated cross-sectional health surveys to investigate the effect of extreme weather events on life satisfaction in the US. Results show that living in a disaster-affected county significantly reduces life satisfaction up to 18 months after the disaster. Matching meteorological data at the postcode level with pooled cross-sectional survey data, Carroll et al. (2009) show that exposure to a severe drought in spring lowers life satisfaction in the short run in rural regions of Australia. Focusing on Bulgaria, Sekulova and Van den Bergh (2016) document that exposure to a flood reduces an individual's life satisfaction for up to six years after its occurrence. Von Möllendorff and Hirschfeld (2016) match district-level data on floods and storms with household panel data from Germany that span 11 years. Using an individual fixed effects approach, they find a negative impact of extreme weather events on life satisfaction 6-18 months after the event. One of the rare studies using data from a developing country, Fernandez et al. (2019) estimate the costs of floods by documenting the negative impact of tangible flood damages on life satisfaction among households in the Philippines.

However, important questions remain. First, the channels through which extreme events reduce life satisfaction are not pinpointed. For instance, does the negative effect go through the channel of asset or income losses among exposed households? Or is it the potentially traumatic experience of living through extreme weather conditions, even without suffering damages, that lowers life satisfaction? With a few notable exceptions (Fernandez et al., 2019; Sekulova and Van den Bergh, 2016), most existing studies proxy shock intensity with secondary data, aggregated at a higher administrative or geographical level, which does not allow for distinguishing between these channels. Hence, most existing research is constrained to estimate the average impact of extreme events on subjective well-being across all individuals residing in a given geographic unit. Such an approach ignores the potential heterogeneity in the physical impact of a disaster across individuals living in the same community (Cohen, 2002). Second, the role of economic damages experienced by others on individuals' own subjective well-being is not yet investigated. This question is particularly relevant in light of the covariate nature of extreme weather events, which may have consequences for inequality dynamics and mutual support systems within communities.

This paper advances the state of the art by providing novel evidence on the role of unequal losses caused by an extreme weather event on life satisfaction, applying a social comparison theory framework. Our analysis draws on a household panel survey we collected in Mongolia between 2012 and 2015, shortly after the country was hit by an extreme winter that featured extremely low temperatures and excessive snowfall. Strong spatial variation in the intensity of the shock led to highly unequal livestock losses across pastoralist households. The exceptionally detailed survey data provide information on self-reported losses at the household level as well as specific locational information regarding the place of residence for each respective household just prior to the shock, which we complement with weather data and data from the historic annual Mongolia Livestock Census. We use cross-sectional analyses to quantify the impact of the extreme weather event on individuals' life satisfaction in the aftermath of the event. Specifically, we investigate whether the relative damages experienced by peers matter for subjective well-being recorded 2-3, 3-4, and 4-5 years after the event. Lastly, we explore the effects of the extreme event on households' perceived economic well-being in comparison to the whole population in a given district, an alternative social comparison outcome that broadens the reference group to include non-herders.

Results show that exposure to the extremely severe winter significantly and strongly reduces subjective well-being even 4-5 years after the event occurred. Importantly, the negative shock impact is amplified by observing peers doing economically worse. We find that average losses experienced by pastoralists in the reference group significantly reduce own subjective well-being while holding individuals' own shock-induced losses constant. Similarly, exposure to extreme weather conditions increases the perceived inequality among households with assets at risk. We argue that extreme weather events increase sectoral disparities between pastoralists and households not engaged in agriculture. To the best of our knowledge, our paper is the first to document a negative effect of peers facing economic damages on individuals' subjective well-being, while pinpointing how this effect develops over time.

The paper is organized as follows. The next section provides a conceptual framework. Section 3 introduces the Mongolian context and describes features of the extreme weather event, followed by an introduction of the data in section 4. Section 5 outlines the estimation strategy. Results and robustness checks are reported in section 6. Section 7 concludes.

2. Conceptual framework

Social comparison is a longstanding focus in economics. First developed by Duesenberry (1949) with the so-called relative income hypothesis and later empirically tested by Easterlin (1974, 1995), social comparison is recognized as an important underlying factor shaping an individual's well-being. According to the relative income hypothesis, an individual's subjective well-being is influenced by both absolute and relative incomes. In other words, the proxy U for utility, such as happiness or life satisfaction,[1] is not only determined by an individual's own income c, but also by the average income of the reference group r (Brown et al., 2015; Falk and Knell, 2004):

$$U = U(c, r) \quad (1)$$

In theoretical work, the relationship between the income of others and an individual's own well-being is assumed to be inverse (Easterlin, 1995). A common explanation is the so-called envy effect, proposing that an increase in the average income of the reference group negatively affects an individual's well-being because it is associated with feelings of envy and an increase in the individual's aspiration level (Bárcena-Martín et al., 2017).

Yet, empirical research also documents a positive correlation between the average income of the reference group and an individual's well-being in some contexts (e.g., Amendola et al., 2019; Kingdon and Knight, 2007). A popular explanation for this finding is the tunnel or signal effect. Accordingly, an individual's utility increases because the individual derives information about their own future prospects when observing others progressing, which outweigh feelings of jealousy (Hirschman and Rothschild, 1973; Senik, 2004). For instance, Clark et al. (2009) find that, in Denmark, individuals' job satisfaction is not only positively correlated with their own wage, but also positively correlated with the average wage of all other workers within the same company or institution. Clark et al. argue that this is the case because individuals expect to be themselves awarded with a pay rise.

[1] Life satisfaction, often used interchangeably with subjective well-being, is widely employed in the economics literature as proxy for individual utility and welfare (Frey and Stutzer, 2002).

Research conducted in the context of developing countries suggests an alternative explanation for the positive link between own well-being and the income of the reference group.[2] It is documented that individuals lacking access to formal risk management often share risks within their community (Besley, 1995; De Weerdt and Dercon, 2006; Kochar, 1995). Especially in communities that largely depend on rain-fed agriculture, households smooth consumption and cope with shocks by using informal credits and reciprocity-based networks (Ligon et al., 2002; Mazzucato, 2009). Investigating the effect of comparison income in divided South Africa, Kingdon and Knight (2007) identify informal risk sharing as a possible explanation for the positive relationship between life satisfaction and average income in the community.

We are not aware of any study that explicitly focuses on the effects of observing others facing economic damages on an individual's own well-being. Closest to our research question is a branch of studies looking at the impact of living in low versus high unemployment areas. For instance, using seven waves of the British Household Panel Survey, Clark (2003) finds a negative effect of unemployment on the subjective well-being of employed individuals when considering regional unemployment rates and the unemployment status of household members or the individual's partner. Meanwhile, unemployment among various reference groups is positively associated with the subjective well-being of unemployed men. Similar results are found for unemployment rates at the neighborhood level for Australia (Shields et al., 2009) and South Africa (Powdthavee, 2007). Buffel et al. (2015) investigate the impact of the 2008 economic crisis on depression rates in Europe. They find a positive relationship between national unemployment rates and depression for employed individuals, while the effect size is smaller for unemployed individuals. While national-level

[2] Two further explanations for the positive relationship between life satisfaction and the average income in the reference group are suggested: altruism (Kingdon and Knight, 2007) and the externalities of social capital; the latter can occur in form of better institutions or improved educational and cultural opportunities in the community sponsored by the better-off (Clark et al., 2009; Helliwell, 2001).

unemployment rates may decrease the stigmatization of unemployed individuals (Clark, 2003), increased job insecurity and worsened job prospects decreases the well-being of employed individuals and those looking for a job (Clark et al., 2010; Helliwell and Huang, 2014).

A widely discussed issue in social comparison research is the choice of the reference group. Brown et al. (2015) show that the relative income effect is sensitive to the definition of the reference group. Physical distance and shared attributes are assumed to be reasonable criteria for individuals to decide about relevant reference groups (Goethals and Klein, 2000; Kingdon and Knight, 2007). Yet, there is no uniform approach in the literature. The definition of the reference group in empirical research ranges from all citizens in a given country (Easterlin, 1995), individuals from the same region or neighborhood (Luttmer, 2005), to individuals "close to one's own ability or opinion" (Festinger, 1954, p. 121).

3. Pastoralism and weather risks in Mongolia

The focus of our analysis is on unequal losses among pastoralist households in Mongolia. Animal husbandry is an important sector within the Mongolian economy. In 2012, when the data collection of the household panel survey analyzed here started, 35% of the labor force was engaged in pastoralism and 19% of the population solely depended on herding for their livelihood (National Statistical Office of Mongolia, 2013). In rural areas, livestock is the most important productive asset as it not only provides income through the sale of cashmere, other wools, meat, and dairy products, but also serves the subsistence needs of households (Xu et al., 2019). For pastoralists, livestock is simultaneously an investment and a savings good that determines the household's future income and consumption potential (Oniki and Dagys, 2017).

Mongolian herders live in a risky environment. Unusually harsh winters, known as dzud in Mongolian, cause sudden and mass livestock mortality, thus threatening the livelihood of pastoralist households. Extreme winters are the result of a complex interplay of several unfavorable climatic conditions that may include excessive snowfall, cold air outbreaks, and drought in the preceding summer (Batima, 2006; Nandintsetseg et al., 2007; Sternberg, 2018). While five major extreme winters have struck Mongolia since 1990, our focus in the following is on the 2009/10 winter, which is considered the "most severe winter in nearly five decades" (FAO, 2010, p. 1). More than 10.3 million head of livestock died during the 2009/10 winter across Mongolia, about 23.9% of the national herd (United Nations Mongolia Country Team, 2010). Livestock mortality rates among sample households in western Mongolia (see section 4) were even higher, with households losing 45% of their herd, on average.[3]

Just prior to the 2009/10 winter, below-average precipitation in the 2009 summer caused poor pasture conditions. Consequently, animals could not build up enough fat reserves (Shinoda and Nandintsetseg, 2015). In October 2009, early and heavy snowfalls prevented animals from reaching the grass (Iijima and Hori, 2018). In December 2009 and January 2010, already weakened animals froze to death when record-low temperatures, dropping below -40 °C in 19 of the 21 provinces, occurred (Sternberg, 2010). Finally, in May 2010, when the snow melted, flash floods caused further livestock deaths (Shinoda and Nandintsetseg, 2015).

Given the seriousness of the situation, the Mongolian Government declared a national disaster in January 2010 and appealed to the international community for humanitarian aid (European Commission, 2010). From March 2010 onwards, the Mongolian Government, provincial governments, national NGOs, and international NGOs provided affected households with emergency aid in form of hay and fodder, food assistance, and other support. Finally, the removal of millions of animal carcasses scattered across the open rangeland, posing a risk to the health of humans and surviving livestock, had to be organized. Relief organizations and international agencies reported a high level of psychological stress and trauma among affected pastoralists (United Nations Mongolia

[3] Note that there are no reports of increased human mortality due to the extreme winter event.

Country Team, 2010; International Federation of Red Cross and Red Crescent Societies and Mongolian Red Cross Society, 2010).

4. Data

Our empirical analysis uses data from the Coping with Shocks in Mongolia Household Panel Survey, implemented by the authors (Kraehnert et al., 2021) in collaboration with the National Statistical Office of Mongolia (NSO). The survey, carried out between 2012 and 2015, comprises three annual panel waves and was collected in the three neighboring provinces of Uvs, Zavkhan, and Govi-Altai in western Mongolia (Fig. A1 in the Appendix). The sample was drawn using a stratified three-stage design, based on the 2010 Population and Housing Census.[4] The survey is representative of the urban and the rural populations in each of the three provinces. Sample households are located in 49 out of the 61 districts and in 108 out of the 289 sub-districts in the survey provinces.

The baseline model uses data from the first panel wave, with household interviews taking place continuously between June 2012 and May 2013, 2-3 years after the 2009/10 extreme winter occurred. In each month, survey interviews took place across the whole survey area, making the data roughly representative across seasons. For each household, the interviews for waves 2 and 3 were conducted exactly 12 and 24 months after the wave 1 interview, respectively. The sample comprises 1,768 households, among which 1,061 owned livestock in 2009, before the shock. The sample analyzed here consists of 1,631 individuals ranging between 17 and 83 years of age.[5]

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[4] In the first sampling step, each of the three provinces was subdivided into three mutually exclusive strata of province centers, district centers, and rural areas, resulting in nine strata in total. In the second step, Primary Sampling Units (PSU) were randomly selected from each stratum, resulting in a total of 221 PSU. In the third step, eight households were randomly selected from each PSU.

[5] We exclude from the sample 22 individuals whose household only formed after the extreme event and 115 individuals with missing values in covariates.

The survey records information on the demographics of each household member, household income, assets, consumption expenditures, subjective well-being, as well as characteristics of the district, among other things. Life satisfaction – the first dependent variable – was recorded with a single-item question on an 11-point Likert scale as follows: "All things considered, how satisfied are you with your life these days?," with 0 indicating completely dissatisfied and 10 indicating completely satisfied. The same question was asked for various sub-domains of life satisfaction, including satisfaction with respondents' personal income, their household's economic situation, the dwelling, family life, and respondents' own health. The life satisfaction module was asked of the household head or, if the head was not present, to another adult member. Among the sample of individuals analyzed here, 61% are the head, 34% the spouse of the head, and 5% another adult household member. The life satisfaction item has a mean of 7.49, a remarkably high value compared to mean values of 7.0, 5.1, and 5.6 recorded in the United States, China, and the Russian Federation, respectively, in 2012 (OECD, 2014).

The second dependent variable is a measure of a household's perceived economic situation compared to other households in their district. Respondents were shown a picture of an 11-step ladder, with the poorest households in the district standing on the bottom (step 0) and the richest households standing on the top (step 10). Respondents were then asked to self-assess their household's current position on the ladder. In a similar way, respondents were asked to indicate their economic situation compared to other households in their district as of 2009, before the extreme winter event struck, and to indicate how they expect their relative economic situation to be in 12 months and in 5 years. The same individuals who responded to the life satisfaction module also answered the relative well-being survey item.

The survey records households' livestock ownership for each of the five commonly held species (sheep, goats, cattle, horses, and camels). During the wave 1 survey interview, all households were asked retrospectively about their livestock holdings in 2009, before the shock.[6] Moreover, households were asked about the number of livestock that died during the 2009/10 extreme winter, which we employ as one of the various measures of shock intensity. This retrospective information on livestock holdings in 2009 and losses in 2010 was recorded again two years later, during the wave 3 interview. Having the same recall information recorded twice at different points in time allows us to examine the consistency in answers. The coefficient of correlation is 0.78 for livestock holdings in 2009 and 0.82 for livestock losses in 2010, even though different household members responded to the retrospective livestock questions in waves 1 and 3 in more than half of sample households. This validation exercise makes us confident that the retrospectively recorded information is robust. In the baseline model, we combine self-reported information on shock losses from panel waves 1 and 3 in order to minimize observations with missing values.

The Coping with Shocks survey also records the migration history of all household members older than 15. Information is available on individuals' district of residence in 2009, just before the extreme winter event occurred. This information is particularly useful, since there is a trend of households leaving rural areas and moving to district or provincial centers following the extreme

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[6] About 44% of sample households only reported the total number of livestock owned in 2009, but not species-specific numbers. It is common practice among Mongolian pastoralists to only refer to the total herd size when speaking about livestock wealth (Murphy, 2011, p. 74f.). To avoid sample size reductions, we use total livestock numbers, treating all animals as equal, in our baseline model. In a robustness test (section 6.2), we also account for herd composition.

winter. By assigning individuals the shock intensity measure at their district of residence in 2009, we avoid potential bias due to endogenous migration (Akresh et al., 2012).[7]

Two secondary datasets that proxy shock intensity complement the survey data. First, we match the survey data with data on temperature and snow from the ERA-Interim model outputs of the European Centre for Medium-Range Weather Forecasts. The weather variables capture different aspects of the extreme winter: Excessive snowfall made it difficult for households to move between campsites and prevented animals from reaching the grass that was covered by thick layers of snow. Extremely cold temperatures led to a sharp increase in calorie consumption and animals froze to death (Rao et al., 2015). We use the average temperature at the earth skin at midnight in each sub-district between December 20, 2009, and February 10, 2010, the time referred to as the "cold period" in Mongolia. The average temperature during the 2009/10 winter is then centered by subtracting the mean of the long-term average midnight temperature in each sub-district over the same period (mid-December until mid-February) between 1991 and 2008. The same approach is applied to the snow measure, which indicates average snow depth in centimeters in each sub-district between November and February during the 2009/10 winter, relative to its long-term local mean. For both weather variables, we aggregate sub-district-level data to the district level by assigning each district the value of the sub-district with the most extreme deviation. In the 2009/10 winter, snow depth was above and winter temperature was below the long-term local mean in every single survey district.

[7] Note that the survey does not retrospectively record the sub-district of residence as of 2009. For households that did not move to another district between 2009 and the wave 1 survey interview, we assume their sub-district of residence remained the same. For the 30 households that left their district of residence after the shock, we impute their sub-district of residence as of 2009 by assigning households to the sub-district that was most centrally located in their district of residence in 2009.

Second, we draw on aggregated data from the historic Mongolia Livestock Census. Each year in mid-December, the NSO gathers data from households on the number of livestock and the number of adult livestock that died over the previous 12 months,[8] separately for each of the five prevalent species. From this data, we calculate average livestock mortality rates in 2010 at the district and sub-district levels.[9]

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[8] Rao et al. (2015) argue that animal deaths recorded in the Mongolia Livestock Census are caused by climate, disease, or predation, but not by old age, as pastoralists usually slaughter their animals before they can die a natural death.

[9] Note that the livestock mortality among survey households was slightly higher, about 45%, compared to livestock mortality at the district and sub-district levels of 37% and 36%, respectively. This is most likely a result of survey design effects, with the survey being representative at the province level, not the district level.

Table 1: Summary statistics

Name	Definition	Mean	S.D.	Min	Max	N
Dependent variables						
life satisfaction	Satisfaction with life, all things considered (0=completely dissatisfied, 10=completely satisfied)	7.49	1.79	0	10	1,631
relative econ situation	Economic situation compared to other households in this district (0=among poorest, 10=among richest)	4.98	1.37	0	10	990
relative econ situation in 12 months	Economic situation compared to other households in this district in 12 months (0=among poorest, 10=among richest)	5.66	1.46	1	10	990
relative econ situation in 5 years	Economic situation compared to other households in this district in 5 years (0=among poorest, 10=among richest)	7.13	1.59	2	10	990
Shock intensity measures						
wintertemp (district)	Winter temperature in 2009/10 minus long-term local mean (Celsius) in district	-3.34	1.75	-6.51	-0.86	1,631
wintertemp (sub-district)	Winter temperature in 2009/10 minus long-term local mean (Celsius) in sub-district	-2.66	1.36	-6.42	-0.4	1,631
snow (district)	Snow depth in 2009/10 minus long-term local mean (cm) in district	6.22	5.05	0.11	17.51	1,631
snow (sub-district)	Snow depth in 2009/10 minus long-term local mean (cm) in sub-district	4.48	4.50	-0.04	17.49	1,631
ls mortality (district)	Livestock mortality rate in 2010 in district	0.37	0.12	0.12	0.61	1,631
ls mortality (sub-district)	Livestock mortality rate in 2010 in sub-district	0.36	0.13	0.04	0.76	1,631
ls mortality (household)	Livestock mortality rate in 2010 per household	0.45	0.22	0.02	1	990
ls losses (district)	Average number of animals lost of pastoralist households in 2010 in district	64.21	26.18	16.28	162.79	1,631
ls losses (household)	Number of animals lost in 2010 per household	128.39	115.73	1	959	990
Individual controls						
age	Age in years	42.93	11.61	17	83	1,631
sex	Male	0.45	0.50	0	1	1,631
eth Khalkh	Ethnicity is Khalkh	0.69	0.46	0	1	1,631
eth Durvud	Ethnicity is Durvud	0.17	0.38	0	1	1,631
eth other	Ethnicity is other	0.14	0.35	0	1	1,631
no educ	No education	0.08	0.26	0	1	1,631
prime educ	Completed primary education	0.47	0.50	0	1	1,631
sec educ	Completed secondary education	0.34	0.48	0	1	1,631
tert educ	Completed tertiary education	0.11	0.32	0	1	1,631
married	Married	0.86	0.35	0	1	1,631
disabled	Disabled	0.07	0.23	0	1	1,631
Household controls						
hh size	Household size	4.60	1.54	1	11	1,631
tent	Household lives in a tent	0.84	0.36	0	1	1,631
herdsize 09	Number of livestock owned by household in 2009	297.5	216.08	5	1,800	990
nonherder 09	Household did not own livestock in 2009	0.32	0.47	0	1	1,631
relative econ situation 09	Economic situation compared to other households in this district in 2009 (0=among poorest, 10=among richest)	5.37	1.63	0	10	1,631
District controls						
desert	Ecozone is desert	0.22	0.41	0	1	1,631
steppe	Ecozone is grass steppe	0.24	0.43	0	1	1,631
forest	Ecozone is forest	0.12	0.33	0	1	1,631
mountain	Ecozone is mountains	0.42	0.5	0	1	1,631
avgherdsize 09	Average herd size of pastoralist households in district in 2009	175.91	47.52	110.07	316.81	1,631
distance	Distance from district center to province center	118.74	100.02	0	345	1,631
urban	District is province center	0.31	0.46	0	1	1,631
hfacility	Hospital, clinic or health center are available in district center	0.61	0.49	0	1	1,631
popdensity 12	Population density in district in 2009	45.85	129.28	0.08	446.90	1,631

Table 1 (continued).

Province controls						
Zavkhan	Province is Zavkhan	0.35	0.48	0	1	1,631
GoviAltai	Province is Govi-Altai	0.28	0.45	0	1	1,631
Uvs	Province is Uvs	0.37	0.48	0	1	1,631

Note: Relative economic situation is only reported for households that owned livestock in 2009. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

5. Identification strategy

We exploit exogenous spatial variation in the intensity of the 2009/10 extreme winter event and estimate its causal effects on subjective well-being measured 2-3 years after the shock, following the approach used by Danzer and Danzer (2016) and Sekulova and Van den Bergh (2016):

$$SWB_{ihdpm} = \beta_0 + \beta_1 shock\ intensity_d + \beta_2 X_i + \beta_3 X_h + \beta_4 X_d + \alpha_p + \delta_m + \varepsilon_{ihdpm} \quad (2)$$

where subjective well-being SWB of individual i living in household h, district d, province p, and surveyed in month m, captured by general life satisfaction measured on a 0-10 scale, is estimated as a function of shock intensity measured at the district or sub-district level, a vector of controls at the individual level $\underline{X_i}$, household level $\underline{X_h}$, and district level $\underline{X_d}$, province fixed effects $\underline{\alpha_p}$, interview month fixed effects $\underline{\delta_m}$, and a stochastic error term $\underline{\varepsilon_{ihdpm}}$. The coefficient of interest is $\underline{\beta 1}$, which measures the average impact of the shock across all individuals residing in the same district or sub-district, irrespective of their specific shock-induced losses, while holding all else constant. All results presented in the following account for survey design effects, including the clustering of standard errors at the PSU level.[10] Following the convention in this field of research, we estimate eq. 2 using OLS and present estimates from an Ordered Probit as robustness test.

From a methodological perspective, the 2009/10 extreme winter exhibits two noteworthy characteristics. First, the intensity of the shock varied strongly in space. In some cases, neighboring districts and sub-districts (Fig. A2 and A3 in the Appendix, respectively) differed remarkably in their shock intensity. Second, its abrupt start, severity, and disastrous effects on livestock came unexpectedly to households, making it the single most severe winter disaster in Mongolia since the 1940s (Sternberg, 2018). We proxy shock intensity with secondary data on temperature and snow

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[10] Clustering standard errors at the district or sub-district level or applying two-way clustering at PSU and district level yields only minimally larger standard errors. All main effects remain significant at least at the 10% level.

depth measured at an aggregate geographical level, in our case the district and sub-district. The choice of the weather variables is informed by studies documenting that winter temperature and snow depth are strong predictors of livestock losses in Mongolia (Nandintsetseg et al., 2007; Rao et al., 2015).

The empirical context exhibits features that allow us to approximate the channels through which the shock may have affected life satisfaction, while using aggregate-level shock intensity measures. The extreme weather event caused excessive livestock losses, thus immediately destroying the income, asset, and consumption base of pastoralists, while it did not have immediate consequences for the income of households not engaged in the herding economy.[11] Hence, we differentiate between individuals living in pastoralist households as of 2009, before the shock, and individuals from households that did not own livestock in 2009. If the shock affects life satisfaction predominantly through the loss of livestock, we would expect to observe negative shock effects for pastoralists.

The individual-level controls comprise age, age squared, gender, ethnicity, education, marital status, and whether the individual is disabled, following common practice in the life satisfaction literature (e.g., Bhuiyan and Szulga, 2017; Kahneman and Krueger, 2006; Powdthavee, 2010). At the household level, we control for household size, whether the household lives in a portable tent, pre-

[11] Existing studies document that the 2009/10 winter negatively affected the anthropometric outcomes (Groppo and Kraehnert, 2016) and the acquisition of education (Groppo and Kraehnert, 2017) of children from pastoralist households, while no significant impacts were shown for children from households that did not own livestock.

shock herd size,[12] and the household's relative economic situation in 2009. These control variables either date back to the pre-shock period or are rather likely to be constant over the short time window considered in this paper.[13] District-level controls include the predominant ecological zone, the average herd size of pastoralists as of 2009, the distance between the district center and the provincial capital, population density as of 2012, and whether health facilities are available in the district center.

Our identification strategy rests on the assumption that the extreme winter struck randomly across space. This assumption would be violated if, for instance, households with lower well-being self-selected to live in areas exposed to a higher intensity of the extreme event. To explore whether the shock was more intense in areas with particular population characteristics, we follow the approach of Ahmadiani and Ferreira (2021) and regress each individual-level and household-level control on measures of district-level shock intensity, while controlling for time invariant or pre-shock district characteristics as well as province and interview month fixed effects. Results (Table A1 in the Appendix) indicate that there are no systematic correlations between shock intensity and most socio-economic characteristics.[14] Second, we estimate the baseline model for a sample of new herders who

[12] We log-transform herd size in 2009 before including it in the regression. To avoid losing observations with zero herd size, we follow the approach suggested by Battese (1997) and include both log(x+d) and d in the regression, where x is the original variable (herd size) and d is a dummy that takes the value 1 if x is 0 and 0 otherwise. The same procedure is applied when log-transforming distance to the provincial capital.

[13] As robustness test, we further control for health (whether the respondent reported any health problem in the previous four weeks) and the experience of an idiosyncratic shock (whether the household faced the death of a member, job loss, collapse of the household business, or theft of assets in the previous 12 months). While all baseline results are maintained, the estimated effect of the extreme event becomes minimally smaller, indicating that the effect (to a small degree) works through those channels.

[14] Exceptions are ethnicity, living in a tent, herd size in 2009 (households living in districts exposed to excessive snow had slightly larger herds), and relative economic well-being in 2009 (households living in districts exposed to colder temperatures had lower well-being).

only started herding after the extreme winter (Table A2, columns 1-2 in the Appendix). The shock intensity measures are not statistically significant at conventional levels for these households. We take this as suggestive evidence that, at least for new herders, there is no systematic selection of households with lower well-being to live in those areas that were exposed to extreme weather conditions in the 2009/10 winter. Third, we conduct a placebo test and explore if weather conditions in the winters of 2005/06, 2006/07, and 2007/08 – none of which featured extreme weather conditions – affected subjective well-being in 2012/13 (Table A2, columns 3-8 in the Appendix). In line with expectations, most estimated coefficients measuring the spatial intensity of the placebo winters are not statistically significant, while the two coefficients that are statistically significant have counterintuitive signs (worse weather conditions correlated with higher life satisfaction). This suggests that the negative effects captured in our baseline model are specific to the 2009/10 extreme event.

Next, we test whether social comparison effects matter for subjective well-being in the aftermath of the extreme weather event. We do so by including a proxy for the average shock-induced damages experienced by the reference population in the area ($\underline{\text{damage}_{d}}$), while holding household-level damages constant ($\underline{\text{damage}_{h}}$), following a common approach in social comparison research (e.g., Brown et al., 2015; Luttmer, 2005; Senik, 2004):

$$\text{SWB}_{\text{ihdpm}} = \beta_0 + \beta_1 \text{damage}_{\text{h}} + \beta_2 \text{damage}_{\text{d}} + \beta_3 \text{X}_{\text{i}} + \beta_4 \text{X}_{\text{h}} + \beta_5 \text{X}_{\text{d}} + \alpha_{\text{p}} + \delta_{\text{m}} + \varepsilon_{\text{ihdpm}} \qquad (3)$$

with all other variables as defined for equation 2 above. We do not have an <u>a priori</u> hypothesis on whether the damages experienced by the reference group has increasing or decreasing effects on an individual's life satisfaction.

The survey data at hand allow us to employ a household-level measure of damages caused by the extreme event: the percentage of livestock lost during the 2009/10 winter relative to the household's pre-shock herd size as self-reported by households. Similar indicators of household-level damages, self-reported by respondents during surveys, are used to study the impacts of extreme events in the

Philippines (Fernandez et al., 2019), Germany (Kahsay and Osberghaus, 2018), and Bulgaria (Sekulova and Van den Bergh, 2016).

The household-level damage measure provides a precise account of the extent to which households are affected by the shock, thus unmasking the likely heterogeneity in shock impacts across households living in a given area. However, it is noted that self-reported shock measures can be subject to reporting bias. For instance, a recall error materializes if a respondent cannot recall their household's pre-shock asset endowments or the shock-induced losses (Guiteras et al., 2015). A common approach to reduce bias in self-reported data is the use of re-interviews (Morton et al., 2008). This approach is applied in the questionnaire design of the Coping with Shocks in Mongolia survey, which recorded pre-shock asset holdings and shock-induced losses twice in different panel waves (see section 4). Furthermore, it is shown that the more salient an event, the easier it is for respondents to recall correctly (Dex, 1995; Smith and Thomas, 2003; Sudman et al., 1996). Applied to our research context, a once in 50-years event, we consider recall errors less likely. Other potential sources of reporting bias are social desirability, which incentives respondents to underreport their losses to avoid disparaging their professional skills, and justification bias, which results in over-reporting of losses to justify the receipt of aid or claims to receive assistance in the future (Nguyen and Nguyen, 2020). Given the severity of the event and the time lag of at least two years between the occurrence of the event and the survey interview, we do not deem social desirability bias or justification bias to be major issues.

Another concern is potentially omitted variables that correlate with both household-level damages and subjective well-being and that could lead to biased estimates. Importantly, the survey data comprise two proxies for household well-being from before the shock: the number of livestock owned by households in 2009 and households' self-assessment of their economic situation in comparison to other households in the district before the shock. The seven years preceding the 2009/10 winter exhibited particularly mild climatic conditions, resulting in below-average annual livestock mortality rates. Hence, we propose that households' livestock holdings in 2009 can be considered as households' medium-term wealth equilibrium that mirrors both observed and unobserved characteristics, such as ability, experience, and success in herding. This point is underlined by a study by Middleton et al. (2015), who find that wealth and experience in herding did not significantly influence the number of livestock lost in 2010, thus suggesting that the severity of the 2009/10 extreme winter limited the effectiveness of coping strategies applied by households. Nevertheless, the coefficient of the household-level shock measure should be interpreted with more caution than those measures derived from weather data.

We approximate the average damages of the reference group with livestock mortality based on calculations from the historic Mongolia Livestock Census. We consider two alternative reference groups. The first consists of pastoralist households residing in the same district (Mongolian soum), the second-level administrative unit in Mongolia. Each district has a small permanent settlement as its administrative center and is governed by a district parliament headed by the district governor. Districts in the survey area had an average area of 4,865 km^2 and an average population of 902 households in 2012, with the number of pastoralist households ranging between 180 and 1,320. Pastoralist households cooperate by exchanging labor and collectively controlling pastureland (Murphy, 2011). Residential mobility across administrative borders is discouraged in Mongolia and requires substantial paperwork. Public services, such as schooling and medical services, are only accessible for registered residents in a given district. There are even contracts between districts that regulate nomadic movements by pastoralists who cross district boundaries during their annual movements. As a result, the population in the district remains relatively stable over time, which makes it a useful reference group.

The second reference group are pastoralists living in the same sub-district (Mongolian bag). Sub-districts do not necessarily have an administrative center and may exist as virtual units only. The sub-district governor is the state representative at the lowest level of the administrative division. While nomadic herders may cross the boundaries of several sub-districts during their annual movements, they usually spend the winter months in the same campsite, which is the sub-district where households are officially registered. In 2012, sub-districts in the survey area averaged 1,072 km^2, with a population of 190 households, of which 36 to 277 were pastoralist households.

To explore how social comparison effects evolve over time, we additionally estimate the model based on waves 2 and 3 of the panel survey, implemented 3-4 and 4-5 years after the extreme event, respectively.

Lastly, we employ an alternative outcome that provides complementary insights into social comparison effects: the economic situation of a household compared to other households in the district, measured on a 0-10 scale, as self-assessed by respondents. Here, the explicit reference group is the whole population in the same district, including both pastoralists and households that do not own livestock. If the extreme whether event had more dire economic consequences for pastoralist households, we would expect the wealth inequality across pastoralists and non-pastoralists to increase, thusly, in turn, expecting stronger impacts of the shock on this outcome compared to life satisfaction.

6. Results

6.1. Effects of the extreme weather event on life satisfaction

Results from the OLS estimation on the determinants of individuals' life satisfaction are displayed in Table 2. Each column shows results obtained for different measures of the intensity of the extreme winter event and alternative samples, while the estimated coefficients of the full set of control variables are displayed in Table A3 in the Appendix.

We find evidence for a strong and negative impact of the extreme weather event on individuals' life satisfaction 2-3 years after the event. Individuals living in districts in 2009 where the temperature during the 2009/10 winter was far below the long-term local average report significantly lower life satisfaction in the post-shock period compared to individuals residing in districts where the winter temperature was only mildly below the long-term local average, holding everything else constant (Table 2, column 1). Similarly, exposure to higher snow depth during the 2009/10 winter relative to the long-term local average significantly lowered life satisfaction 2-3 years after the event (column 2).

Interestingly, for the sub-sample of individuals living in households that did not own any livestock before the shock (columns 3-4), the sign of the estimated coefficients of both temperature- and snow-based shock proxies reverses, and the snow-based shock measure is no longer significant at conventional levels. Given that the livelihood of households not engaged in animal husbandry was not immediately affected by the extreme weather event, this could suggest that the extreme event affected life satisfaction through the loss of livestock and, hence, through an income, asset, or nutritional channel. In turn, this suggests that merely witnessing the overall damages caused by the event – with millions of animal carcasses scattered across the open space, intense media coverage of the extreme weather event, and humanitarian aid activities[15] visible in most affected regions – did not significantly lower life satisfaction. Theories from social psychology provide further explanations for this result. For instance, applying social identity theory to the Mongolian context, one may argue that in an inter-group comparison, individuals from non-herding households may feel better off than pastoralists (Hogg, 2000). Interpreting this finding from the perspective of relative deprivation theory, individuals from non-herding households may benefit from the economic damages of pastoralists if they perceive the damages as deserved, for instance because they may think pastoralists did not prepare well for the winter or mismanaged pasture land (Feather, 2015). Alternatively, applying a moral exclusion perspective, conceptualized by Opotow and Weiss (2000) in the context of environmental conflicts, one may hypothesize that individuals from non-herding households deny self-involvement by blaming pastoralists for their livestock losses instead of considering the occurrence of extreme weather events a collective problem.

[15] All baseline results hold if we additionally control for the amount of humanitarian aid distributed per district or the receipt of food aid by pastoralist households (Tables A4 and A5 in the Appendix, respectively).

On the contrary, for individuals living in pastoralist households as of 2009 (columns 5-8), the negative impact of the extreme weather event on life satisfaction becomes much more pronounced. The estimated coefficient of winter temperature more than doubles in magnitude compared to results obtained for the full sample, with both winter temperature and snow depth now significant at the 1% level (columns 5- 6). The negative impact of extreme weather conditions also holds when employing the temperature- and snow-based shock intensity measures at the sub-district level (columns 7-8). Here, the effect size is smaller and only significant at the 5% level, which may be a result of measurement errors in the sub-district of residence in 2009. In all further models, we focus on the sub-sample of individuals living in households that owned livestock before the shock.

Table 2: Determinants of life satisfaction across groups of households (OLS)

	Dependent variable: Life satisfaction							
	Full sample		Non-herding households		Herding households			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
wintertemp (district)	0.09* (0.09)		-0.27* (0.09)		0.20*** (0.00)			
snow (district)		-0.05*** (0.00)		0.05 (0.23)		-0.06*** (0.00)		
wintertemp (sub-district)							0.13** (0.02)	
snow (sub-district)								-0.05** (0.01)
Constant	6.39*** (0.00)	5.95*** (0.00)	5.75*** (0.00)	7.01*** (0.00)	6.80*** (0.00)	6.14*** (0.00)	6.78*** (0.00)	6.29*** (0.00)
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.20	0.20	0.30	0.30	0.19	0.19	0.18	0.19
Observations	1,631	1,631	641	641	990	990	990	990

Note: The same control variables as in Table A3 in the Appendix are included. Columns 3-4 are estimated for individuals from non-herding households as of 2009, while columns 5-8 are estimated for individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

Next, we expand the focus on individuals' satisfaction in various sub-domains (Table 3). Exposure to either below-average temperature (panel A) or above-average snow depth (panel B) during the 2009/10 winter significantly and strongly lowers individuals' satisfaction with their personal income (column 1) and their satisfaction with the overall economic situation of their household (column 2) 2-3 years after the event. Exposure to extreme weather conditions also reduces individuals' satisfaction with their dwelling (column 3), family life (column 4), and their health (column 5), although the effect size is much smaller. Taken together, these results suggest that the extreme weather event mostly worked through an economic channel.

Table 3: Determinants of life satisfaction across domains (OLS)

	Dependent variable: Satisfaction in sub-domain				
	Respondents' personal income	Economic situation of the household	Dwelling	Family life	Health
	(1)	(2)	(3)	(4)	(5)
Panel A: Shock measured with temperature					
wintertemp (district)	0.33***	0.25***	0.13**	0.13**	0.08
	(0.00)	(0.00)	(0.03)	(0.01)	(0.39)
Constant	2.54	4.10***	9.32***	9.80***	12.11***
	(0.10)	(0.01)	(0.00)	(0.00)	(0.00)
R-squared	0.27	0.30	0.15	0.20	0.21
Observations	990	990	990	990	956
Panel B: Shock measured with snow depth					
snow (district)	-0.11***	-0.12***	-0.06***	-0.05***	-0.07***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	1.33	2.88*	8.72***	9.22***	11.41***
	(0.40)	(0.06)	(0.00)	(0.00)	(0.00)
R-squared	0.27	0.31	0.15	0.20	0.22
Observations	990	990	990	990	956
Individual controls	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES

Note: The same control variables as in Table A3 in the Appendix are included. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

The estimated coefficients of most other control variables fit well with the existing literature (Table A3 in the Appendix). For instance, the level of education, being married, and economic well-being before the shock are associated with significantly higher life satisfaction. Disability, household size, and living in a simple dwelling are significant and negatively associated with life satisfaction. We do not observe significant effects for age and gender, which contrasts with most existing studies.

Since life satisfaction is an ordinal measure, the Ordered Probit is the obvious estimator. However, as Ferrer-i-Carbonell and Frijters (2004) argue, treating life satisfaction as ordinal or cardinal variable makes little difference in cross-sectional analyses where the dependent variable is measured at a single point in time. While OLS is our preferred model due to its intuitive interpretability, the baseline models are also estimated with Ordered Probit (Tables A6 and A7 in the Appendix). As expected, the estimated coefficients of the shock proxies have the same sign and similar significance levels.[16]

6.2. Social comparison effects

The negative impact of the extreme weather event is confirmed when considering shock-induced losses as self-reported by respondents (Table 4). Living in a household that lost a high share of its herd in 2010 relative to the household's pre-shock herd size significantly and strongly reduces life satisfaction 2-3 years after the shock compared to living in a household that faced minor livestock losses, while controlling for pre-shock herd size and other individual, household, district, and

[16] Indeed, all other results discussed in the paper also hold when estimated with Ordered Probit; these are not reported for the sake of brevity.

provincial characteristics (column 1). A similar result is obtained when considering the absolute number of livestock lost by a household as proxy for shock-induced damages (column 2).[17]

Interestingly, the magnitude of the shock effect is of similar size when capturing shock intensity with household-level losses compared to using weather-based indicators at an aggregate level. When transforming all shock intensity measures into z-scores with a mean of zero and a standard deviation of one for comparability, we find that an increase in the shock intensity by one standard deviation reduces life satisfaction by 0.22, 0.33, 0.29, and 0.29 units when considering the percentage of livestock lost by a household, the total number of livestock lost by a household, winter temperature in the district, and snow depth, respectively. We take this finding as supportive evidence that the self-reported information on shock-induced losses is reliable.

Next, we explore the relative impacts of damages incurred to the household and average damages incurred to different reference groups on individuals' life satisfaction. When additionally controlling for the average livestock mortality experienced by pastoralists in the reference group, both losses inflicted on the own household and the losses incurred to the reference group are significantly and negatively associated with individuals' life satisfaction 2-3 years after the shock, holding all else constant (columns 3-5). Qualitatively similar results are obtained when considering pastoralists in the same district (columns 3 and 5) and the same sub-district (column 4) as the reference group. Interestingly, the effects of household-level damages and damages incurred to pastoralists in the same district or sub-district on individuals' life satisfaction are of similar

[17] Recall that in the baseline model, we combined self-reported information on shock losses from panel waves 1 and 3. As robustness test, we repeat the estimations with livestock losses reported in wave 1 only (Table A8 in the Appendix) and losses reported in wave 3 only (Table A9 in the Appendix). Results are qualitatively similar.

magnitude: The p-values from an adjusted Wald test on the equality of the estimated coefficients suggest that we cannot reject the equality hypothesis at conventional significance levels.

As outlined in the conceptual framework, the negative relationship between individuals' life satisfaction and shock-induced damages incurred to the reference group may work through various channels. Informal risk sharing is one possible explanation. Thrift and Ichinkhorloo (2015) argue that mutual support among Mongolian pastoralists is an essential part of their risk mitigation strategies. Typically, these encompass pooling labor, collaborating in hay production as reserve fodder during the winter months, jointly organizing campsite moves, and providing severely-affected households with additional livestock (Fernandez-Gimenez et al., 2012). Murphy (2011) finds that cooperation and assistance mostly occurs within kinship networks. While the risk sharing channel seems plausible in the Mongolian context, we lack data to formally test this hypothesis.

An alternative explanation is signal theory, which states that the well-being of the reference group carries information for an individual's expectations regarding their own future well-being. Applied to the context of the extreme winter event in Mongolia, this implies that observing the excessive livestock losses incurred to other pastoralists in the same area dampens individuals' expectations on their own economic recovery. If the social comparison effects are in line with signal theory, we expect to find no significant effects for pastoralists who quit herding in the aftermath of the extreme event, since fellow pastoralists are no longer their relevant reference group. Indeed, this is what we find (column 6): The estimated coefficient of the damages experienced by the reference group is no longer statistically significant at conventional levels when estimating the baseline model for the sub-sample of individuals living in households that quit herding. In contrast, the magnitude of the household-level losses becomes much larger and is highly significant. This appears plausible, since the decision to quit pastoralism may be influenced by the livestock losses a household experienced. Thus, results go along well with signal theory. Nevertheless, we caution that, with only 115 households, this sub-sample is small.

In column 7, we use an alternative approach to test if relative losses matter for own well-being. The test builds on the hypothesis of asymmetric income comparison originally developed by Duesenberry (1949) and tested empirically by Ferrer-i-Carbonell (2005) and Amendola et al. (2019), among others. Accordingly, individuals with an income below that of their reference group are negatively affected by the income of their richer peers, while no positive effect is expected for individuals with an income above that of their reference group. The implicit assumption is that individuals compare themselves with higher income groups, referred to as upward social comparison. We apply the idea of asymmetric comparison to the case of damages and include two additional variables, worse damages and less damages, which measure if a household experienced higher or lower livestock losses than peer herders in the same district, while holding a household's absolute losses constant.[18] Results show that the estimated coefficient of experiencing worse damages than the reference group has a significant and positive effect on own subjective well-being, while the estimated coefficient of experiencing less damages is not statistically significant, holding the household's own losses constant. A test on the equality of the coefficients indicates that the effect size differs significantly, with the p-value from the adjusted Wald test being 0.15. This suggests that comparison is indeed asymmetric. Notably, only individuals with worse shock experience than the reference group are positively influenced by others doing relatively better, holding all else constant. Again, this finding would fit well with either mutual support or signal theory.

[18] If $damage_h > damage_d$ then $worse = damage_h - damage_d$ and $better = 0$. If $damage_h < damage_d$ then $worse = 0$ and $better = damage_d - damage_h$.

Table 4: Life satisfaction and social comparison (OLS)

	Dependent variable: Life satisfaction						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ls mortality (household)	-1.01*** (0.00)		-0.89*** (0.00)	-0.82*** (0.00)		-1.58*** (0.00)	-2.19*** (0.01)
ls losses (log) (household)		-0.42*** (0.00)			-0.38*** (0.00)		
ls mortality (district)			-1.24* (0.05)			-1.13 (0.60)	
ls mortality (sub-district)				-0.90** (0.04)			
ls losses (log) (district)					-0.38* (0.06)		
worse damages than peers ($damage_h$ - $damage_d$ > 0)							1.60** (0.02)
less damages than peers ($damage_h$ - $damage_d$ < 0)							-0.35 (0.71)
Constant	7.68*** (0.00)	6.79*** (0.00)	8.70*** (0.00)	8.18*** (0.00)	8.61*** (0.00)	15.10* (0.05)	8.51*** (0.00)
Individual controls	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES
R-squared	0.20	0.20	0.20	0.19	0.20	0.55	0.20
Observations	990	990	990	978	875	115	990
p-value from adjusted Wald test on equality of coefficients of hh-level damages and district/sub-district-level damages			0.64	0.88	0.99	0.74	

Note: The same control variables as in Table A3 in the Appendix are included. In columns 1-5 and 7, the sample comprises individuals living in households that owned livestock in 2009. In column 6, the sample consists of individuals that lived in livestock-owning households 2009, but that no longer owned livestock at the time of wave 1. The variables worse damages and less damages are calculated based on the livestock mortality rate at the household and district level. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, and Mongolia Livestock Census.

Next, we explore how social comparison effects evolve over time. Table 5 displays cross-sectional results obtained from all three panel waves implemented 2-3 years, 3-4 years, and 4-5 years after the extreme event. For transparency, we estimate the model for different samples. Columns 1-3 show results obtained for the largest available sample of individuals in each wave, ignoring sample attrition. Columns 4-6 show estimates for a slightly reduced balanced sample, where we only consider individuals living in households from whom data on life satisfaction is available for all three waves. Lastly, the sample in columns 7-9 is restricted to a balanced sample of individuals who answered the life satisfaction survey item in all three waves. The household-level proxy for shock-induced damages is statistically significant at the 1% level in all three waves.[19] Finding such strong effect even 4-5 years after the event again underlines the severity of this once-in-50-years disaster. The contrary is true for average damages experienced by the reference group. The negative impact of the average livestock mortality of pastoralists in the district on individuals' life satisfaction is only statistically significant and large in magnitude in the first wave and then vanishes over time, though not linearly. This finding fits well with the informal risk sharing explanation: If indeed mutual support between pastoralist households is the main channel explaining why social comparison matters, we would expect such support to be of greatest importance immediately after the event.

[19] We performed a cross-equation test on the equality of coefficients of household-level damages across panel waves and find no statistically significant differences in the magnitude of the shock impact over time.

Table 5: Life satisfaction and social comparison over time (OLS)

	Dependent variable: Life satisfaction								
	Maximal sample size in each wave			Same households surveyed across waves			Same individuals surveyed across waves		
	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ls mortality (household)	-0.89***	-1.13***	-1.39***	-0.99***	-1.27***	-1.40***	-0.66*	-1.03***	-0.48
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.08)	(0.01)	(0.27)
ls mortality (district)	-1.24*	-0.27	-0.89	-1.86**	-0.40	-0.88	-2.76***	-1.81*	-1.82
	(0.05)	(0.67)	(0.33)	(0.01)	(0.58)	(0.33)	(0.01)	(0.06)	(0.10)
Constant	8.70***	6.37***	7.20***	8.99***	6.35***	7.13***	8.77***	7.75***	6.50***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.20	0.20	0.26	0.21	0.20	0.26	0.29	0.27	0.27
Observations	990	974	845	843	843	843	433	433	433
p-value from adjusted Wald test on equality of coefficients of hh-level mortality and district-level mortality	0.64	0.23	0.63	0.31	0.28	0.61	0.08	0.49	0.30

Note: The same control variables as in Table A3 in the Appendix are included. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * p < 0.1, ** p < 0.05, *** p < 0.01. Sources: Coping with Shocks in Mongolia Household Panel Survey (waves 1-3), Mongolian Statistical Information Service, and Mongolia Livestock Census.

In all models presented so far, we did not distinguish between livestock species, treating all animals as equal. As robustness test, we transform all livestock-related variables into sheep forage units (SFUs)[20] in order to account for potential differences in herd composition across households. This comes at the cost of reducing the sample size to the 569 households that reported their species-specific losses in 2010. Results, displayed in Table A10 in the Appendix, confirm the baseline findings, with the social comparison effect being even slightly larger in magnitude.

Overall, results with self-reported losses presented in this section should be interpreted with caution, since, lacking panel data from the pre-shock period that would allow us to employ an individual fixed effects approach, we cannot rule out a potential overestimation of the shock effect due to omitted variable bias.

6.3. Effects of the extreme event on relative well-being

Lastly, we capture social comparison effects with an alternative outcome, which broadens the reference group to the non-herding population: A household's economic situation compared to all households in a given district. This outcome is available for three alternative time periods: the current situation at the time of the survey interview, respondents' expectations for the situation 12 months in the future, and respondents' expectation for 5years in the future. Results, displayed in Table 6, are shown when proxying shock intensity with winter temperature (columns 1-3), snow depth (columns 4-6), and household-level damages (columns 7-10).

Throughout the different shock proxies, we find that exposure to higher shock intensity during the extreme winter event reduces a household's perceived relative economic well-being compared to other households in the district of residence. This holds both for the perceived relative

[20] One horse, cow, camel, and goat is equivalent to 7, 6, 6, and 0.9 SFU, respectively.

situation today and in the future. All estimated coefficients of the shock proxies have the expected sign and are statistically significant, at least at the 10% level in all but one specification.

When comparing the effect size across shock proxies, the impact of household-level damages on relative economic well-being is much stronger than when proxying shock intensity with weather data.[21] Further, pastoralists living in urban areas perceive their relative economic well-being to be significantly lower compared to pastoralists living in rural areas, despite the fact that the impact of livestock losses on relative well-being is lower in urban areas (column 10). This fits well with another finding: The negative impact of household-level losses becomes much more pronounced when considering its effect on a household's economic well-being relative to the whole population in the district (coefficient of -1.65, Table 6, column 7) compared to its effect on life satisfaction (coefficient of -1.01, Table 4, column 1). All three results point in the same direction: Shock-induced damages in household assets experienced by pastoralists increase the perceived inequality between pastoralists and households not engaged in herding.

[21] The effect of household-level livestock mortality remains economically strong and highly statistically significant when considering data from waves 2 and 3 (Table A11 in the Appendix).

Table 6: Determinants of relative economic well-being (OLS)

	Dependent variable: a household's relative economic situation compared to all households in the district									
	today	in 12 months	in 5 years	today	in 12 months	in 5 years	today	in 12 months	in 5 years	today
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
wintertemp (district)	0.04 (0.39)	0.10* (0.06)	0.11** (0.05)							
snow (district)				-0.03** (0.02)	-0.04*** (0.00)	-0.06*** (0.00)				
ls mortality (household)							-1.65*** (0.00)	-1.77*** (0.00)	-1.32*** (0.00)	-1.88*** (0.00)
urban										-1.10** (0.02)
urban * ls mortality (household)										0.95*** (0.00)
Constant	0.49 (0.55)	2.11** (0.02)	5.34*** (0.00)	0.19 (0.83)	1.64* (0.07)	4.71*** (0.00)	2.16*** (0.01)	3.86*** (0.00)	6.62*** (0.00)	2.40*** (0.00)
Household controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.42	0.39	0.36	0.42	0.39	0.36	0.47	0.44	0.38	0.47
Observations	990	990	990	990	990	990	990	990	990	990

Note: The same control variables as in Table A3 in the Appendix are included. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * p < 0.1, ** p < 0.05, *** p < 0.01. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

7. Conclusion

This paper provides new insights on the effects of unequal asset losses caused by an extreme weather event on subjective well-being. Our identification strategy exploits exogenous variation in the intensity of an extremely severe winter that struck Mongolia in 2009/10, causing more than 10 million livestock to perish. The analysis builds on a rich household panel survey collected 2-5 years after the shock. The survey contains detailed information on self-reported asset losses experienced by pastoralist households, pre-shock asset holdings, as well as households' place of residence just before the shock unfolded. We complement the survey data with temperature and snow data as well as aggregated data from the historic livestock census.

Our analysis has three main findings. First, exposure to the extreme weather event strongly and significantly reduces life satisfaction 2-3 years after the event for individuals who have assets at risk. The effect is of similar magnitude when employing self-reported losses or indicators derived from weather data as measures for shock intensity. The effect size is largest when considering satisfaction with respondents' economic situation as the outcome and still significant, but less pronounced, when considering satisfaction with other life domains, such as health, family life, and the dwelling.

Second, we find that the subjective well-being among pastoralists decreases when the reference group faces shock-induced damages. The economic losses experienced by peer herders, proxied by the average livestock mortality among pastoralists living in the same district, significantly lower individuals' life satisfaction even when controlling for individuals' own losses. This result is robust to considering herders in the same sub-district as reference group. The effect size of the damages experienced by the reference group is large 2-3 years after the extreme event and vanishes over time. The effect is no longer significant 4-5 years after the event. The opposite is true for households' own losses: the negative impact on life satisfaction remains highly significant even 4-5 years after the extreme event.

Third, we find that exposure to the extreme weather event negatively affects the perceived relative economic well-being of herders in comparison to the whole district population, comprising both pastoralists and non-pastoralists. This effect becomes even larger in magnitude when considering respondents' expectations on their relative economic well-being over the next year and 5 years in the future.

With this paper, we provide new evidence on the role of social comparison for individuals' subjective well-being. Existing social comparison research mostly focusses on contexts where the reference group fares economically better, for instance as a result of receiving a wage increase (Clark et al., 2009). Many, but not all, studies find a positive relationship between the well-being of others and own well-being (e.g., Amendola et al., 2019; Kingdon and Knight, 2007; Kubiszewski et al., 2019). Our results provide complementary insights on social comparison effects derived from a context where a large covariate shock caused massive asset destruction among a population sub-group with assets at risk. Indeed, our analysis documents that the positive relationship between the well-being of others and individuals' own subjective well-being also holds when the reference group fares economically worse on average. Observing the massive damages of peer herders caused additional reductions in own well-being even when holding own damages constant. We propose that our findings go well with both signal theory and informal risk sharing, although we lack appropriate data to put those theories to a formal test. Overall, our paper provides evidence on how climate change results in economic costs that go beyond the damages experienced by individual households.

Our results contrast with studies focusing on social comparison in the context of unemployment, which commonly find that unemployment among the reference group alleviates the negative effects of an individual's own unemployment status (Frey and Stutzer, 2002). The opposite effect signs may possibly be explained by the nature of each shock. High unemployment among the reference group may reduce the stigma and loss in social status that an unemployed individual faces. In contrast, large economic damages experienced by peers as a result of a severe covariate weather shock may have concrete economic implications in an economy where mutual support is important.

Our analysis shows that the negative effects of the extreme weather event exclusively hold for a population with assets at risk, in our case livestock. Accordingly, our findings underline the importance of distinguishing between population sub-groups when examining the impacts of shocks, as opposite effects across population sub-groups may cancel each other out. Aggregate-level shock intensity measures derived from secondary data sources may be unsuitable to unmask the heterogeneity in effects. Our analysis demonstrates the benefits of recording household-level damages in household surveys in order to more accurately identify population sub-groups at risk that may be targeted by policy programs. In terms of policy implications, our results suggest that the promotion of climate change adaptation aimed at reducing the risk of economic damages caused by extreme weather may prevent a decline in life satisfaction among pastoralists. To this end, index-based weather insurance (Bertram-Huemmer & Kraehnert, 2018), higher nomadic mobility (Fernandez-Gimenez, 2015), and enhanced early warning systems are adaptation instruments that are currently discussed in Mongolia. Moreover, post-disaster aid delivered to affected pastoralists has been shown to alleviate shock-induced economic damages (Gros et al, 2022).

One caveat of the analysis presented here is that the household survey data may miss the worst affected households. Pastoralist households that lost their entire herd or that had too few surviving animals to pursue a livelihood based on herding alone may have left rural areas after the extreme event and moved to urban centers, searching for alternative income opportunities. Former pastoralists that moved outside the survey area of Western Mongolia between 2010 and 2012/13, when the first panel wave was collected, are not covered by the household survey. Consequently, our results should be regarded as lower-bound estimates of the total shock effects.

Declarations of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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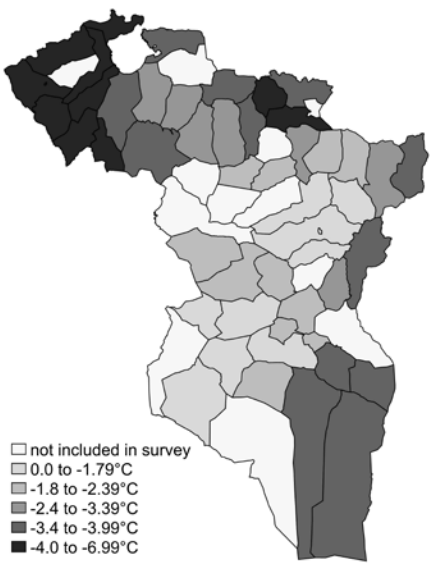
Appendix A.

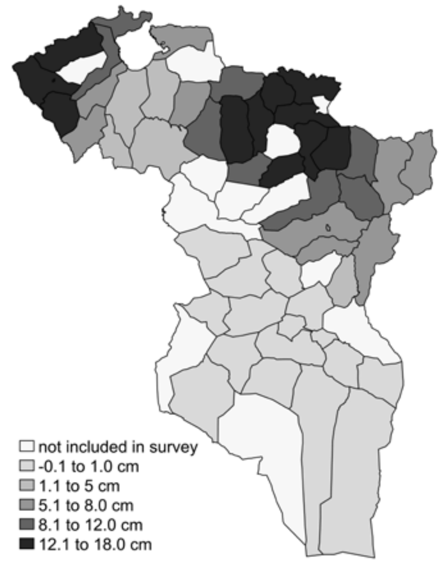
Fig. A1: Map of Mongolia, survey provinces are dark shaded

Fig. A2: Spatial variation in shock intensity across survey districts

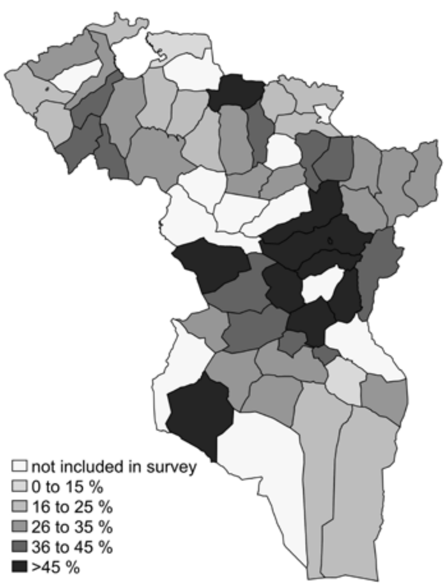
(a) Deviation in winter temperature in 2009/10 winter from long-term local mean



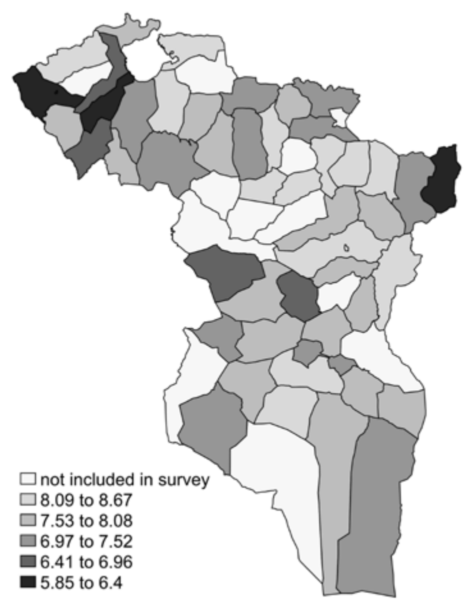
(b) Deviation in snow depth in 2009/10 winter from long-term local mean



(c) Livestock mortality in 2010 from Mongolia Livestock Census



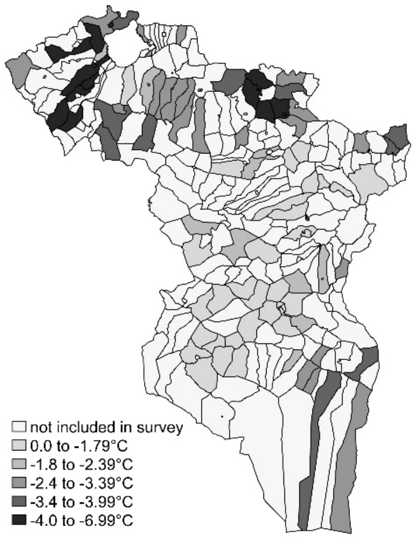
(d) Life satisfaction in 2012/13



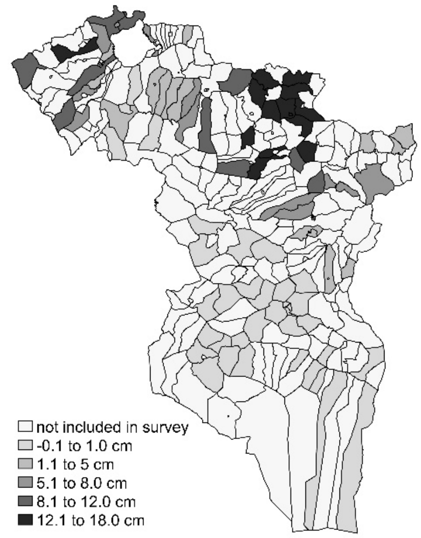
Sources: ERA-Interim, Mongolia Livestock Census, and Coping with Shocks in Mongolia Household Panel Survey (wave 1).

Fig. A3: Spatial variation in shock intensity across survey sub-districts

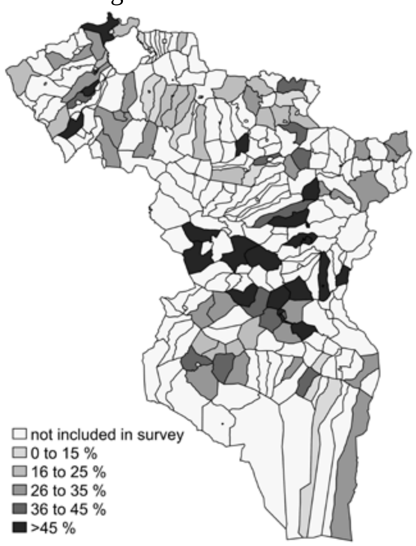
(a) Deviation in winter temperature in 2009/10 winter from long-term local mean



(b) Deviation in snow depth in 2009/10 winter from long-term local mean



(c) Livestock mortality in 2010 from Mongolia Livestock Census



Sources: ERA-Interim, Mongolia Livestock Census, and Coping with Shocks in Mongolia Household Panel Survey (wave 1).

Table A1: Correlation between shock measures and population characteristics

Dependent variable:	age	female	eth Khalk	eth Durvud	eth other	no educ	prime educ	sec educ	tert educ
Panel A: Shock measured with temperature									
wintertemp (district)	-0.11	-0.01	0.09***	-0.05***	-0.04***	-0.01	0.00	-0.00	0.01
	(0.77)	(0.41)	(0.00)	(0.00)	(0.00)	(0.34)	(0.82)	(0.96)	(0.37)
Panel B: Shock measured with snow depth									
snow (district)	0.04	0.00	0.00	-0.01**	0.00	-0.00	-0.00	0.01	0.00
	(0.74)	(0.44)	(0.34)	(0.02)	(0.16)	(0.49)	(0.55)	(0.37)	(0.78)

Dependent variable:	married	disabled	hh size	tent	herdsize 09 (log)	relative econ situation 09
Panel A: Shock measured with temperature						
wintertemp (district)	0.01	0.00	-0.05	-0.03***	0.01	0.18***
	(0.57)	(0.60)	(0.36)	(0.00)	(0.65)	(0.00)
Panel B: Shock measured with snow depth						
snow (district)	0.00	-0.00	0.00	0.00*	0.02**	0.00
	(0.17)	(0.68)	(0.78)	(0.06)	(0.04)	(0.79)

Note: Displayed are coefficients obtained from 30 separate OLS regressions. All regressions include time invariant and pre-shock district controls, province fixed effects, and month fixed effects. Standard errors clustered at the PSU level. The sample comprises individuals living in households that owned livestock in 2009. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

Table A2: Placebo tests

	Dependent variable: Life satisfaction							
	2009/10 winter sample: new herders		2005/06 winter		2006/07 winter		2007/08 winter	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
wintertemp (district)	-0.16		-0.16**		-0.09		0.02	
	(0.69)		(0.02)		(0.20)		(0.88)	
snow (district)		-0.04		0.03		0.13		0.39***
		(0.62)		(0.64)		(0.10)		(0.00)
Constant	7.59*	7.32*	6.92***	6.48***	6.29***	6.77***	6.60***	5.56***
	(0.06)	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.61	0.61	0.18	0.18	0.18	0.18	0.18	0.20
Observations	80	80	990	990	990	990	990	990

Note: The same control variables as in Table A3 in the Appendix are included. Columns 1-2 are estimated for individuals from herding households that started herding only after the 2009/10 winter. In columns 3-8, the sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

Table A3: Determinants of life satisfaction across groups of households with full set of control variables displayed (OLS)

	Dependent variable: Life satisfaction									
	Full sample		Non-herders		Herders in 2009					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
wintertemp (district)	0.09*		-0.27*		0.20***					
	(0.09)		(0.09)		(0.00)					
snow (district)		-0.05***		0.05		-0.06***				
		(0.00)		(0.23)		(0.00)				
wintertemp (sub-district)							0.13**			
							(0.02)			
snow (sub-district)								-0.05**		
								(0.01)		
ls mortality (household)									-1.01***	
									(0.00)	
ls losses (household) (log)										-0.42***
										(0.00)
age	-0.01	-0.01	0.03	0.03	-0.04	-0.04	-0.04	-0.04	-0.04	-0.03
	(0.53)	(0.56)	(0.44)	(0.39)	(0.21)	(0.24)	(0.17)	(0.22)	(0.23)	(0.28)
age (sq)	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.94)	(0.91)	(0.15)	(0.12)	(0.36)	(0.41)	(0.31)	(0.38)	(0.39)	(0.45)
sex	-0.14	-0.14	-0.25*	-0.25*	-0.10	-0.10	-0.10	-0.10	-0.09	-0.08
	(0.14)	(0.13)	(0.09)	(0.08)	(0.38)	(0.39)	(0.40)	(0.37)	(0.45)	(0.49)
eth Durvud	-0.48**	-0.67***	-1.00***	-0.83***	-0.37	-0.79***	-0.51*	-0.79***	-0.76***	-0.75***
	(0.03)	(0.00)	(0.00)	(0.01)	(0.18)	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)
eth other	-0.07	-0.23	-0.81**	-0.62**	0.11	-0.25	-0.03	-0.25	-0.30	-0.31
	(0.76)	(0.30)	(0.01)	(0.05)	(0.71)	(0.39)	(0.93)	(0.38)	(0.29)	(0.28)
prime educ	0.04	0.06	0.49	0.38	-0.01	0.01	0.00	0.01	-0.03	-0.04
	(0.82)	(0.74)	(0.10)	(0.23)	(0.97)	(0.98)	(1.00)	(0.98)	(0.87)	(0.85)
sec educ	0.32*	0.34*	0.88***	0.78***	0.16	0.17	0.16	0.16	0.11	0.09
	(0.09)	(0.07)	(0.00)	(0.01)	(0.49)	(0.44)	(0.50)	(0.47)	(0.63)	(0.67)
tert educ	0.52**	0.53**	0.69**	0.62**	0.63**	0.65**	0.60**	0.62**	0.50*	0.47*
	(0.01)	(0.01)	(0.02)	(0.05)	(0.03)	(0.02)	(0.03)	(0.03)	(0.07)	(0.09)
married	0.46***	0.47***	0.36**	0.36**	0.55***	0.58***	0.56***	0.58***	0.48***	0.48***
	(0.00)	(0.00)	(0.04)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
disabled	-0.36**	-0.36**	-0.74***	-0.74***	-0.32*	-0.33*	-0.30	-0.32	-0.35*	-0.33*
	(0.02)	(0.02)	(0.00)	(0.00)	(0.10)	(0.10)	(0.12)	(0.11)	(0.08)	(0.09)
hh size	-0.09***	-0.09***	-0.16***	-0.17***	-0.04	-0.05	-0.05	-0.05	-0.05	-0.05
	(0.01)	(0.00)	(0.00)	(0.00)	(0.30)	(0.26)	(0.30)	(0.27)	(0.27)	(0.26)
tent	-0.41***	-0.41***	-0.32*	-0.29*	-0.45***	-0.46**	-0.47***	-0.46***	-0.48***	-0.49***
	(0.00)	(0.00)	(0.06)	(0.08)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Table A3 (continued)

nonherder 09	0.21	0.23								
	(0.53)	(0.56)								
herdsize 09 (log)	0.05	0.05			0.06	0.06	0.06	0.07	-0.00	0.41***
	(0.66)	(0.70)			(0.43)	(0.47)	(0.42)	(0.40)	(0.95)	(0.00)
relative econ situation 09	0.26***	0.26***	0.36***	0.37***	0.19***	0.20***	0.20***	0.20***	0.21***	0.22***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
desert	-0.23	-0.28*	0.01	0.02	-0.28	-0.27	-0.18	-0.23	-0.17	-0.17
	(0.17)	(0.09)	(0.98)	(0.96)	(0.12)	(0.14)	(0.31)	(0.20)	(0.34)	(0.32)
steppe	-0.16	-0.15	0.42	0.17	-0.09	-0.01	0.01	0.03	0.04	0.03
	(0.26)	(0.26)	(0.41)	(0.66)	(0.60)	(0.96)	(0.97)	(0.83)	(0.80)	(0.84)
forest	0.06	0.15	0.35	0.13	0.10	0.23	0.16	0.23	0.12	0.10
	(0.77)	(0.48)	(0.38)	(0.75)	(0.67)	(0.35)	(0.52)	(0.34)	(0.62)	(0.66)
popdensity 12	0.00	0.00	0.00	0.00	0.00	0.00**	0.00**	0.00***	0.00***	0.00***
	(0.18)	(0.11)	(0.13)	(0.24)	(0.21)	(0.05)	(0.01)	(0.00)	(0.00)	(0.00)
avgherdsize 09 (log)	0.00**	0.00***	0.00	0.00	0.00**	0.01***	0.00**	0.01***	0.00***	0.00***
	(0.02)	(0.00)	(0.21)	(0.91)	(0.04)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)
distance (log)	0.08	0.13	-0.32	-0.37	0.17	0.17	0.11	0.11	-0.03	-0.04
	(0.48)	(0.25)	(0.27)	(0.24)	(0.17)	(0.18)	(0.36)	(0.36)	(0.81)	(0.74)
urban	0.30	0.63	-1.75	-1.91	0.49	0.58	0.11	0.22	-0.42	-0.49
	(0.59)	(0.27)	(0.21)	(0.21)	(0.42)	(0.37)	(0.86)	(0.73)	(0.48)	(0.41)
hfacility	-0.23*	-0.32**	-0.11	0.01	-0.25*	-0.33**	-0.25*	-0.32**	-0.25*	-0.24*
	(0.07)	(0.02)	(0.77)	(0.97)	(0.07)	(0.02)	(0.07)	(0.03)	(0.07)	(0.08)
Constant	6.39***	5.95***	5.75***	7.01***	6.80***	6.14***	6.78***	6.29***	7.68***	6.79***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.20	0.20	0.30	0.30	0.19	0.19	0.18	0.19	0.20	0.20
Observations	1,631	1,631	641	641	990	990	990	990	990	990

Note: Standard errors clustered at the PSU level. P-values in parentheses with $*$ $p < 0.1$, $**$ $p < 0.05$, $***$ $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

Table A4: Robustness test: Controlling for the amount of aid per district (OLS)

	Dependent variable: Life satisfaction							
	Full sample		Non-herding households		Herding households			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
wintertemp (district)	0.09*		-0.28*		0.20***			
	(0.07)		(0.07)		(0.00)			
snow (district)		-0.05***		0.05		-0.06***		
		(0.00)		(0.27)		(0.00)		
wintertemp (sub-district)							0.13**	
							(0.02)	
snow (sub-district)								-0.05**
								(0.01)
Amount_aid (district)	0.00	-0.00	-0.01	-0.00	0.00	-0.00	0.00	-0.00
	(0.40)	(0.94)	(0.45)	(0.91)	(0.42)	(0.75)	(0.63)	(0.88)
Constant	6.33***	5.95***	6.01***	7.05***	6.72***	6.16***	6.73***	6.30***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.20	0.20	0.31	0.30	0.19	0.19	0.19	0.19
Observations	1,631	1,631	641	641	990	990	990	990

Note: The same control variables as in Table A3 in the Appendix are included and additionally the amount of food aid and animal fodder (in tons) per district that was distributed by any organization or the Government during the 2009/10 extreme winter. Columns 3-4 are estimated for individuals from non-herding households as of 2009, while columns 5-8 are estimated for individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), ERA-Interim, and Mongolia Livestock Census.

Table A5: Robustness test: Controlling for whether households received aid (OLS)

	Dependent variable: Life satisfaction			
	(1)	(2)	(3)	(4)
wintertemp (district)	0.22***			
	(0.00)			
snow (district)		-0.06***		
		(0.00)		
wintertemp (sub-district)			0.14**	
			(0.01)	
snow (sub-district)				-0.05**
				(0.01)
Received_aid (household)	0.08	0.11	0.07	0.10
	(0.53)	(0.35)	(0.56)	(0.40)
Constant	6.39***	5.71***	6.37***	5.86***
	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES
Household controls	YES	YES	YES	YES
District controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
R-squared	0.19	0.19	0.19	0.19
Observations	952	952	952	952

Note: The same control variables as in Table A3 in the Appendix are included and additionally an indicator variable taking the value one if the household reported the receipt of any food aid during the 2009/10 extreme winter. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), ERA-Interim, and Mongolia Livestock Census.

Table A6: Robustness test: Determinants of life satisfaction (Ordered Probit)

	Dependent variable: Life satisfaction							
	Full sample		Non-herding household		Herding household			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
wintertemp (district)	0.06*		-0.15		0.13***			
	(0.06)		(0.11)		(0.00)			
snow (district)		-0.03***		0.04		-0.04***		
		(0.00)		(0.20)		(0.00)		
wintertemp (sub-district)							0.08**	
							(0.03)	
snow (sub-district)								-0.03**
								(0.01)
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,631	1631	641	641	990	990	990	990

Note: The same control variables as in Table A3 in the Appendix are included. Columns 3-4 are estimated for individuals from non-herding households as of 2009, while columns 5-8 are estimated for individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, Mongolia Livestock Census, and ERA-Interim.

Table A7: Robustness test: Life satisfaction and social comparison (Ordered Probit)

	Dependent variable: Life satisfaction				
	(1)	(2)	(3)	(4)	(5)
ls mortality (household)	-0.60***	-0.55***			-1.17***
	(0.00)	(0.00)			(0.01)
ls mortality (district)	-0.83*				-1.84
	(0.06)				(0.68)
ls mortality (sub-district)		-0.62**			
		(0.04)			
h_lsloss (log)			-0.26***		
			(0.00)		
d_avg_lsloss (log)			-0.25*		
			(0.07)		
d_avg_herdsize_09				6.14***	
				(0.00)	
Individual controls	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES
Observations	990	990	875	875	115

Note: The same control variables as in Table A3 in the Appendix are included. The sample comprises individuals living in households that owned livestock in 2009. In column 5, the sample consists of individuals that lived in livestock-owning households 2009, but that no longer owned livestock at the time of wave 1. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, and Mongolia Livestock Census.

Table A8: Robustness test: Household-level damages recorded in wave 1 (OLS)

	Dependent variable: Life satisfaction				
	(1)	(2)	(3)	(4)	(5)
ls mortality (household)	-0.88***		-0.77***	-0.71***	
	(0.00)		(0.00)	(0.01)	
ls losses (log) (household)		-0.28***			-0.25**
		(0.00)			(0.01)
ls mortality (district)			-1.12*		
			(0.09)		
ls mortality (sub-district)				-0.76	
				(0.10)	
ls losses (log) (district)					-0.28
					(0.18)
Constant	7.31***	6.43***	8.23***	7.68***	7.80***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES
R-squared	0.18	0.19	0.19	0.18	0.19
Observations	947	947	947	935	947
p-value from adjusted Wald test on equality of coefficients of hh-level damages and district/sub-district-level damages			0.65	0.93	0.89

Note: The same control variables as in Table A3 in the Appendix are included except herd size in 2009 and livestock losses in 2010, which are calculated from wave 1 data. Standard errors clustered at the PSU level. P-values in parentheses with * p < 0.1, ** p < 0.05, *** p < 0.01. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1) and Mongolia Livestock Census.

Table A9: Robustness test: Household-level damages recorded in wave 3 (OLS)

	Dependent variable: Life satisfaction				
	(1)	(2)	(3)	(4)	(5)
ls mortality (household)	-0.86**		-0.56	-0.65*	
	(0.01)		(0.10)	(0.06)	
ls losses (log) (household)		-0.31**			-0.22*
		(0.01)			(0.06)
ls mortality (district)			-3.27***		
			(0.00)		
ls mortality (sub-district)				-2.40***	
				(0.00)	
ls losses (log) (district)					-0.89***
					(0.00)
Constant	7.37***	6.79***	10.00***	9.13***	11.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES
R-squared	0.20	0.20	0.22	0.22	0.22
Observations	629	631	629	627	631
p-value from adjusted Wald test on equality of coefficients of hh-level damages and district/sub-district-level damages			0.00	0.01	0.03

Note: The same control variables as in Table A3 in the Appendix are included except herd size in 2009 and livestock losses in 2010, which are calculated from wave 3 data. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * p < 0.1, ** p < 0.05, *** p < 0.01. Sources: Coping with Shocks in Mongolia Household Panel Survey (waves 1&3) and Mongolia Livestock Census.

Table A10: Robustness test: Life satisfaction and social comparison with livestock variables transformed into SFU (OLS)

	Dependent variable: Life satisfaction			
	Livestock in heads	Livestock in SFU	Livestock in heads	Livestock in SFU
	(1)	(2)	(3)	(4)
ls mortality (household)	-0.86*	-1.03**	-0.55	-0.71*
	(0.05)	(0.02)	(0.20)	(0.09)
ls mortality (district)			-3.07***	-2.92***
			(0.00)	(0.00)
Individual controls	YES	YES	YES	YES
Household controls	YES	YES	YES	YES
District controls	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
Constant	7.06***	6.74***	9.43***	9.05***
	(0.00)	(0.00)	(0.00)	(0.00)
R-squared	0.23	0.24	0.25	0.25
Observations	569	569	569	569
p-value from adjusted Wald test on equality of coefficients of hh-level mortality and district-level mortality			0.03	0.05

Note: The same control variables as in Table A3 in the Appendix are included. In columns 2 and 4, all livestock- related variables are transformed into sheep forage units. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (wave 1), Mongolian Statistical Information Service, and Mongolia Livestock Census.

Table A11: Robustness test: Relative economic situation over time (OLS)

	Dependent variable: relative economic situation								
	today			in 12 months			in 5 years		
	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ls mortality (household)	-1.66***	-1.37***	-1.04***	-1.83***	-1.42***	-1.07***	-1.48***	-1.26***	-0.92***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	1.99**	3.95***	4.06***	3.77***	4.18***	5.54***	6.80***	7.15***	6.91***
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Individual controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Household controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
District controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.45	0.34	0.33	0.43	0.34	0.32	0.38	0.34	0.33
Observations	843	843	843	843	843	843	843	843	843

Note: The same control variables as in Table A3 in the Appendix are included. The sample comprises individuals living in households that owned livestock in 2009. Standard errors clustered at the PSU level. The sample consists of all households surveyed across all three waves. P-values in parentheses with * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Coping with Shocks in Mongolia Household Panel Survey (waves 1-3), Mongolian Statistical Information Service, and Mongolia Livestock Census.