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Intergenerational altruism, pessimism bias on tenure insecurity, and sustainable land use: Evidence from household grassland management in China

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A B S T R A C T

This paper investigates the relationship between intergenerational altruism, pessimism bias, and grassland use among rural households in the pastoral region of northwest China. By designing a series of hypothetical questions, we develop measures of intergenerational altruism and pessimism bias, and examine their impact on actual grazing behavior. Our analysis reveals that households with weaker intergenerational altruism and stronger pessimism bias tend to increase their livestock scale without a corresponding increase in supplementary feeding, suggesting that our measures can serve as reliable predictors of grassland overuse. Furthermore, to investigate whether the grant of long-term land rights to rural households mitigates the negative impact of pessimism bias on grassland management, we employ panel data collected before and after a land reform in China. Our results demonstrate that the reform weakens the adverse effects of pessimism bias and promotes the sustainable use of grassland.

1. Introduction

Overgrazing is a major cause of landscape degradation and the disruption of ecosystem processes (Briske et al., 2015; Ibáñez et al., 2007; Yan et al., 2013). This behavior is often attributed to individual selfishness and lack of foresight, with people prioritizing their immediate benefits from overgrazing over the long-term well-being of their offspring (Hardin, 1968; Ostrom, 2015). Therefore, it posits that intergenerational altruism is a crucial determinant of sustainable land use. However, another contributing factor could be the perception bias towards uncertainty in the future, particularly for those with pessimism bias that tend to overestimate the likelihood of negative outcomes while underestimate the chances of positive ones. For instance, if individuals perceive that their land is at risk of being lost in the near future so that they will not be able to pass it on to their children, they may engage in overgrazing to extract as much benefit as possible in the present, even though they have strong intergenerational altruism towards their offspring.

In fact, the impacts of intergenerational altruism and pessimism bias on land tenure insecurity jointly affect individual grazing behavior. Accurately measuring these two factors and then clearly identifying their independent effects poses a significant challenge. While intergenerational altruism has been extensively studied in theoretical literature for its relevance to sustainable natural resource use (Ahlvik, 2022; Bernheim, 1989; Galperti and Strulovici, 2017; Kimball, 1987; Zeckhauser and Fels, 2008), only a limited number of empirical research have quantitatively analyzed intergenerational altruism by conducting lab experiments on campuses with subjects of college students (Fischer et al., 2004; Hauser et al., 2014; Sherstyuk et al., 2016; Lohse and Waichman, 2020). On the other hand, although perception biases on risk probability have been studied in numerous theoretical and experimental studies (Fox and Poldrack, 2009; Kahneman and Tversky, 1979; Price and Jones, 2020; Tversky and Kahneman, 1992), none have focused on pastoralists as subjects or contextualized risk events within the framework of grassland use.

Our study presents a theoretical framework to investigate the intertemporal grazing decisions of pastoralists. Specifically, we propose a two-period model of grazing decisions that incorporates individual

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intergenerational altruism and pessimism bias as determinants of pastoralists' grazing behavior under three different scenarios regarding risk of losing land tenure (i.e., with secure tenure, without land tenure, and with insecure tenure). We then utilize this framework to design a series of hypothetical questions that simulate various grazing decision scenarios, allowing us to elicit respondents' intergenerational altruistic preferences and perception biases towards exogenous risk probabilities of losing land in a simplified yet naturalistic environment.

The design of our hypothetical questions follows the methodology of lab-in-the-field experiments, which uses standardized and validated paradigms in natural settings to target relevant populations. Lab-in-the-field experiments have been widely employed to measure various preferences in contextualized settings with populations of theoretical interest (refer to Gneezy and Imas, 2017, for a review), such as using lottery choices to measure individual risk preferences (Attanasio et al., 2012; Dohmen et al., 2012) and dictator games to measure individual social preferences (Fehr et al., 2008; Binzel and Fehr, 2013). However, our study represents the first attempt, to our knowledge, to elicit individual intergenerational altruism and pessimism bias on tenure insecurity among pastoralists in the context of intertemporal grazing decisions.

Our findings verify that there exist significant heterogeneities in intergenerational altruism and pessimism bias among pastoralists. Furthermore, we examine whether and how intergenerational altruism and pessimism bias elicited from our hypothetical questions impact real decisions about grassland use made by households in northwest China's pastoral area. We hypothesize that intergenerational altruism is always positively associated with sustainable land use practices, regardless of land tenure security. However, the effect of pessimism bias on land use practices is contingent on the level of land tenure insecurity. Specifically, pessimism bias is expected to increase land overuse when land tenure is insecure, while its effect may become insignificant when land tenure is assured.

Drawing on insights from the literature on land reforms, particularly on the issue of tenure insecurity (or tenure security) and its impact on agricultural production (Banerjee et al., 2002; Do and Iyer, 2008; Ali et al., 2014; Deininger et al., 2014; de Janvry et al., 2015), we utilize an exogenous policy intervention to analyze differential responses from pastoralists with varying pessimism biases on risk probability weighting, before and after the policy change. The Rural Land Contracting Law Amendment (RLCLA) implemented in China in 2019 stipulates the renewal of land contracts after their expiration, thereby improving long-term tenure security and potentially reducing the importance of pessimism bias in grazing decisions.

Cross-sectional results using the 2017 data prior to the 2019 RLCLA intervention suggest that both intergenerational altruism and pessimism bias obtained from our hypothetical questions are significantly associated with household livestock scale. Specifically, we observe that pastoralists with weaker intergenerational altruistic preferences and stronger pessimistic perception of losing land in the long term have a larger livestock scale without more supplementary feeding, suggesting that intergenerational altruism and pessimism bias elicited by our hypothetical questions can predict actual grassland overuse. Furthermore, combined with panel data collected before and after the reform in 2017 and 2020, it allows a difference-in-differences (DiD) approach to assess the impact of the 2019 RLCLA. Despite no significant change in supplementary feeding, the DiD estimates show that the 2019 RLCLA reduces the livestock scale for households with stronger pessimism bias on tenure insecurity, highlighting the effectiveness of the 2019 RLCLA in weakening the negative impact of pessimism bias and maintaining the sustainable use of grassland.

Therefore, in addition to a methodological contribution to the measurement of intergenerational altruism and perception bias on risk probability weighting, our study aligns with the negative investment impact of insecure property rights widely documented in the literature in developing countries (Besley, 1995; Banerjee et al., 2002; Jacoby et al., 2002; Deininger and Jin, 2003; Goldstein and Udry, 2008; Ali et al., 2014; Dillon and Voena, 2018). Our study also closely relates to two strands of research on investigating China's changing land institutions (Lin, 1992; Brandt et al., 2002; Bai et al., 2014; Cheng and Chung, 2018; Zhao, 2020; Chari et al., 2021) and measures to restore grassland ecosystems (Liu et al., 2008; Hua and Squires, 2015; Hou et al., 2021).

The remainder of this paper is organized as follows. Section 2 introduces the conceptual model and hypothetical questions that elicit intergenerational altruism and pessimism bias on tenure insecurity. Section 3 describes the data and outlines the identification strategy. Section 4 presents the empirical results, and Section 5 concludes the study with implications for policymaking.

2. Measure of intergenerational altruism and pessimism bias

We combine a grass growth model with an animal intake function to construct a two-period grazing model. Given a unit of grassland, its animal carrying capacity is assumed to be $\overline{N}$ in the current period as the maximum number of sheep grazing on this unit of land. Each respondent is required to choose a grazing number between 0 and $\overline{N}$, which determines their payoff earned in the current period and influences the grazing number and the future payoff of the next generation in the second period. Considering that the respondent chooses a stocking rate of N_0 (i.e., the number of sheep grazing on the land) in the current period, the grass growth in the following period is affected by the animal intake. As a result, the carrying capacity of the land for the upcoming generation, represented as N_1, is determined by the logistic growth function:$N_1 = S + g \bullet S \bullet (1 - S/\overline{N})$, where the parameter $g \in (0, \infty)$ represents the growth rate of grass and S denotes the resource stock still available after grazing N_0 sheep on the land in the first period, so $S = \overline{N} - N_0$. It's worth noting that the logistic growth function is a widely recognized model for the growth of biological renewable resources (see Clark, 1990 and Renshaw, 1991, for reviews), thus we employ this function to estimate grass growth based on the land's carrying capacity.

Suppose that the respondent cares about their utility in the current period and the well-being of the next generation in the second; hence, they have to consider a two-period optimization problem and choose an optimal grazing level (N_0) so that it maximizes the weighted value of the total utility from grazing during the two periods, that is:

$$\max_{0 \le N_0 \le \overline{N}} N_0 + \omega N_1$$

$$s.t. N_1 = (\overline{N} - N_0) + g \bullet (\overline{N} - N_0) \bullet \left(1 - \frac{\overline{N} - N_0}{\overline{N}}\right) \quad (1)$$

For simplicity, to obtain an explicit solution, we assume that the utility of grazing N_0 sheep in the current period is equal to the revenue from selling those sheep in the market, with the price normalized to one. The utility level of the next generation is assumed to be the revenue of grazing N_1 sheep in the second period. Moreover, the weighting factor $\omega \in (0, \infty)$ indicates the weight the respondent places on the well-being of their offspring when making this decision. Notably, if the respondent completely disregards the well-being of their offspring ($\omega = 0$), the objective function simplifies to $\max_{0 \le N_0 \le \overline{N}} N_0$. In this case, the optimal choice $N_0^* = \overline{N}$, indicating that sheep grazing is maximized in the current period without consideration for preserving pasture resources for the next generation.

Using the Lagrangian method, we derive the interior solution for the optimal stocking rate as follows: $N_0^* = \frac{\overline{N}}{2} + \frac{\overline{N}}{2g}\left(\frac{1}{\omega} - 1\right)$, when the condition $\max\{1 - g, 0\} \le \frac{1}{\omega} \le 1 + g$ is satisfied. Consequently, the interior solution for the optimal ratio of stocking rate to carrying capacity is given by: $R^{*} \triangleq \frac{N_0^*}{\overline{N}} = \frac{1}{2} + \frac{1}{2g}\left(\frac{1}{\omega} - 1\right)$.[1]

Apparently, we have $R^* > \frac{1}{2}$ if $\omega < 1$; $R^* = \frac{1}{2}$ if $\omega = 1$; and $R^* < \frac{1}{2}$ if $\omega > 1$. In addition, the R^* and ω ratios are negatively related because $\frac{\partial R^*}{\partial \omega} = -\frac{1}{2g} \bullet \frac{1}{\omega^2} < 0$. In other words, the respondent will choose a lower stocking rate in the current period to save more resources for the next generation in the next period if they have a relatively stronger intergenerational altruistic preference. It's important to note that ω, the key parameter of interest, cannot be directly observed or easily elicited through questions posed to respondents. Given that it is relatively straightforward to elicit responses regarding R^* through questions related to grazing decisions, we designate R^* as a proxy variable for unobservable intergenerational altruistic preferences. This approach allows us to effectively quantify the heterogeneity in intergenerational altruistic preferences among individuals and evaluate the impact of this altruism on actual grazing behavior through subsequent empirical regression analyses.

Furthermore, we utilize this theoretical framework to design a series of hypothetical questions that simulate various grazing decision scenarios (refer to the actual interview card presented to respondents in the Appendix), which enable us to elicit respondents' intergenerational altruistic preferences and perception biases on probability weighting. Building upon the strand of literature on lab-in-the-field experiments, we adjust our design for the target population to differ from those experimental studies in two respects. First, considering the literacy level and mathematical proficiency of pastoralists in northwest China, we simplify the grass growth function, degenerate the multi-period model into a two-period problem, and use colloquial expressions in the instruction with the objective of enhancing ease of comprehension among the respondents, thus enabling them to mirror real-world decision-making processes. Second, different from a standardized experimental design with real economic commitments, our survey does not offer monetary incentives for responses. While hypothetical decisions are generally deemed less reliable than real choices with incentive-compatible rewards, certain situations arise where the realization of decision outcomes is impossible, such as with questions involving moral conflicts, environmental damage, extremely high stakes, or intertemporal choices over a lengthy period. In these cases, hypothetical decisions may still serve as useful forecast indicators, provided that the corresponding incentive mechanisms cannot be implemented in the field (Blackburn et al., 1994; Harrison, 2006). Likewise, our study addresses the issue of resource allocation between parents and children, but the outcomes for future generations are difficult to realize in the present. Therefore, rather than randomly assigning students to different generations in a laboratory and compensating them based on their intergenerational choices, we utilize hypothetical decision-making questions to elicit intergenerational altruistic preferences and pessimism biases in a natural setting, free of any adverse effects from an inappropriate payment mechanism.

To obtain individual intergenerational altruistic preference and perception bias on risk probability weighting, our hypothetical conditions vary as follows: first, considering that land rights can be held by a person's children in the second period, each respondent is required to select a stocking rate in the current period. Second, suppose that the grassland will be converted to be managed collectively in the second period and the land rights cannot be held by their children; then, each respondent is required to select a stocking rate in the current period. Finally, added these two cases, we have a hypothetical condition with land tenure insecurity. We assume that there exists some uncertainty about the future status of land rights; that is, the land rights will be held by a person's children in the second period with a 50% chance, whereas the land will be converted to be managed collectively in the second period with a 50% chance. Each respondent is also required to select a stocking rate for the third case.

In the first case, considering that land rights will be held by a person's children in the second period, the respondent makes the decision by considering the tradeoff between his/her utility and children's utility. Hence, we assume that the grazing ratio in this case (R_{pri}) is a proxy variable for the special altruism for direct descendants (ω_{pri}).

In contrast, in the second case, given that the grassland will be converted to be managed collectively in the second period, the respondent decides by considering the tradeoff between his/her utility and the well-being of the next generation in a broader sense. We treat the grazing ratio here (R_{col}) as a proxy variable for general altruism for the next generation (ω_{col}). In general, people should have stronger altruism for their children (i.e., $\omega_{pri} > \omega_{col}$), thus we hypothesize that a lower ratio R will be observed when the land rights remain in the future than when the land is converted to be managed collectively (i.e., $R_{pri} < R_{col}$).

In the third case, as there is some uncertainty about the future status of land rights (i.e., land rights will be held by a person's children in the second period with a 50% chance, whereas the land will be converted to be managed collectively in the second period with a 50% chance.) The optimization problem with land tenure insecurity is as follows:

$$\max_{0 \le N_0 \le \overline{N}} \pi(p) \bullet (N_0 + \omega N_1) + (1 - \pi(p)) \bullet (N_0 + \omega_{col} N_1)$$

$$s.t. N_1 = (\overline{N} - N_0) + g \bullet (\overline{N} - N_0) \bullet \left(1 - \frac{\overline{N} - N_0}{\overline{N}}\right) \quad (2)$$

where $\pi(p) \in (0, 1)$ denotes the subjective probability weighting for an exogenously given risk probability of p (note that $p = 0.5$ in our design). According to the prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), people tend to overestimate or underestimate a given objective probability due to their personal characteristics. More importantly, decision-making under uncertainty relies on subjective probability weighting rather than objective probabilities. Hence, in our question design, even though all respondents are informed that uncertain events have the same probability distribution, we hypothesize that they may respond differently due to their heterogeneous weighting function of the same risk probability.

For a given p, the maximization problem can be rewritten as follows:

$$\max_{0 \le N_0 \le \overline{N}} N_0 + \left[\pi(p) \bullet \omega_{pri} + (1 - \pi(p)) \bullet \omega_{col}\right] \bullet N_1$$

$$s.t. N_1 = (\overline{N} - N_0) + g \bullet (\overline{N} - N_0) \bullet \left(1 - \frac{\overline{N} - N_0}{\overline{N}}\right) \quad (3)$$

Let $\omega(\pi) = \pi \bullet \omega_{pri} + (1 - \pi) \bullet \omega_{col} \in (\omega_{col}, \omega_{pri})$, then we have the optimal ratio of stocking rate to carrying capacity $R^*(\pi) = \frac{1}{2} + \frac{1}{2g}\left(\frac{1}{\omega(\pi)} - 1\right) \in (R_{pri}, R_{col})$.

As $\frac{\partial R^*}{\partial \pi} = \frac{\partial R^*}{\partial \omega} \bullet \frac{\partial \omega}{\partial \pi} = -\frac{1}{2g} \bullet \frac{1}{\omega^2} \bullet (\omega_{pri} - \omega_{col}) \langle 0$, individual grazing choice $R^*(\pi)$ is expected to gradually drop from R_{col} to R_{pri} as the subjective probability weighting π of keeping private land rights increases. In other words, there should be more sheep grazing on the land in the current period if the respondent has a relatively high subjective probability weighting that the land will be converted to be managed collectively in the future.

Consequently, we take the middle point of two boundaries, i.e., $\frac{1}{2}(R_{pri} + R_{col})$ as a benchmark, and then compare the grazing ratio in the third case with this benchmark to calculate the difference. After controlling for two types of intergenerational altruism (for a person's own children and for the next generation), this difference (i.e., $\widetilde{R}_{ins} \triangleq R_{ins} - \frac{1}{2}(R_{pri} + R_{col})$) can be regarded as a proxy variable for the perception

[1] When $\frac{1}{\omega} > 1 + g$, the optimal stocking rate reaches its boundary solution: $N_0^* = \overline{N}$, resulting in $R^* = 1$. On the other hand, when $\frac{1}{\omega} < max\{1 - g, 0\}$, the boundary solution for the optimal stocking rate $N_0^* = 0$, leading to $R^* = 0$.

bias on risk probability. A higher difference implies that the respondent is more likely to overestimate the probability of losing private land rights in the future and thus is more pessimistic to the long-term tenure insecurity.

In our design, we set $\overline{N} = 10$ and the stocking rate N_0 is restricted to integer numbers. Moreover, we assign a growth rate of grass, $g = 0.6$, which closely aligns with the observed grass growth in our study area, as determined from our field experience.[2] Consequently, we find that the optimal R^* is (non-strictly) decreasing in ω as follows: If $\omega > \frac{4}{3}$, $R^* = 0.1$; If $\omega = \frac{4}{3}$, $R^* \in \{0.1, 0.5\}$; If $\frac{4}{5} < \omega < \frac{4}{3}$, $R^* = 0.5$; If $\omega = \frac{4}{5}$, $R^* \in \{0.5, 0.9\}$; If $\frac{1}{2} < \omega < \frac{4}{5}$, $R^* = 0.9$; If $\omega = \frac{1}{2}$, $R^* \in \{0.9, 1\}$; If $0 \leq \omega < \frac{1}{2}$, $R^* = 1$. In order to enhance the respondents' comprehension of the link between their current choice N_0 in the first period and the maximum grazing number for the next generation N_1 in the second period, Table 1 is presented to all respondents in the instructions.

3. Data and identification strategy

3.1. Data description

To measure integrational altruism and pessimism bias of pastoralists, our hypothetical questions are embedded in a household panel survey conducted in 2017 and 2020, covering 10 pasture-based livestock production counties in Qinghai and Gansu.

Using a stratified random sampling strategy, the surveys divided all counties in Gansu's alpine meadow into four quantiles according to their annual per capita income, and randomly selected one county from each quantile. Similarly, all counties in Qinghai were divided into three tertiles, and two counties were randomly selected from each group. All townships in each of the ten selected counties were divided into three tertiles according to their per capita grassland area. One township was randomly selected from each tertile, yielding a total of 30 townships. One village was then randomly selected from the higher per capita grassland area tertile and the other from the lower tertile of each selected township. Finally, six households were randomly selected from each of the 60 sampled villages, yielding a sample of 360 households. Excluding households that did not engage in livestock production, our effective sample includes 343 households. We randomly selected 70% of the effective sample households to ask hypothetical questions due to financial constraints. The balancing test reported in Table A1 of the Appendix suggests no significant difference between households with and without hypothetical questions in terms of operation scale and household characteristics.

Table 1
Relationship between N_0 and N_1.

If you choose N_0 in the current period:	The carrying capacity becomes N_1 in the next period:
0	10
1	10
2	9
3	8
4	7
5	7
6	5
7	4
8	3
9	2
10	0

[2] In our study, we also examined a faster growth rate of grass (i.e. $g = 1.85$) as a robustness check for our measurement of intergenerational altruism and pessimism bias on tenure insecurity when $g = 0.6$. This analysis reveals a consistent pattern, and detailed results are available upon request.

Table 2 and Fig. 1 illustrate the distributions of respondents' decisions R in three different cases, showing a significant difference between the first case, with secure private land rights, and the second case, with collective land rights. The average ratio of stocking rate to carrying capacity with secure private land rights is 0.42 (with a standard deviation of 0.23), and the mode occurs at 0.5. In contrast, the average ratio with collective land rights is 0.63 (with a standard deviation of 0.27), and the mode occurs at 1. Thus, the respondents choose to herd fewer sheep on average in the first case than in the second ($p = 0.000$, paired t-test between the two cases). Bearing in mind the decisions in the two cases without uncertainty, the grazing ratio in the third case with insecure private land rights is a middle ground between the two. The average ratio of the stocking rate to the carrying capacity is 0.52 (with a standard deviation of 0.23), and the mode is 0.5. In addition, 32% of the respondents choose a ratio lower than 0.5, whereas 42% choose a ratio higher than 0.5. Hence, the distribution is slightly right-skewed.

As mentioned previously, we define a variable $\widetilde{R}_{ins} \triangleq R_{ins} - \frac{1}{2}(R_{pri} + R_{col})$ as a proxy for the perception bias on risk probability after controlling for the two different types of intergenerational altruism. A higher value of $\widetilde{R}_{ins}$ indicates that the respondent has stronger pessimism bias and hence more tend to overestimate the likelihood of losing private land rights in the future. Table 2 suggests that $\widetilde{R}_{ins}$ has a mean value of 0 and a standard deviation of 0.22. Fig. 2 shows the density distribution of $\widetilde{R}_{ins}$. Therefore, the dispersion of the distributions indicates significant heterogeneity in the extent of pessimism bias among respondents. Specifically, only 25% of the respondents have $\widetilde{R}_{ins} = 0$, while 36% of the respondents have a negative $\widetilde{R}_{ins}$, and 39% of the respondents have a positive $\widetilde{R}_{ins}$. It's noteworthy that respondents with a negative $\widetilde{R}_{ins}$ actually exhibit an optimism bias, which tends to underestimate the likelihood of losing land tenure.

3.2. Background of grassland tenure

Grassland tenure in China is essentially similar to farmland tenure (refer to the Appendix for a review). Based on the great success of the Household Responsibility System (HRS) in farmland management, China implemented similar institutional reforms for grassland management in the early 1980s. The livestock and grassland of the commune have been successively distributed to individual households through the "grassland and livestock double contract system compared with the rapid distribution of livestock, the demand for large-scale grassland by nomadic grazing across vast areas has made the distribution of grassland slower and more complicated. While the system has to retain some grassland for public use and contract some to multiple households for joint operation in order to maintain the operation scale required by the traditional grazing method, about 70% of grassland has been contracted to individual households as of 2002 (Su et al., 2021), implying that household tenure insecurity has also been an important issue in the pastoral area.

Moreover, the 2019 RLCLA stipulate that they apply to farmland, forest land, grassland, and other agricultural lands, suggesting that our grassland data collected in 2017 and 2020 are suitable for investigating the impact of the 2019 RLCLA. It's worth noting that the 2019 RLCLA policy document released by the Central Committee of the Communist

Table 2
Descriptive statistics on grazing decisions.

	Mean	Sd.
Stocking rate to carrying capacity with secure private land rights	0.42	0.23
Stocking rate to carrying capacity with collective land rights	0.63	0.27
Stocking rate to carrying capacity with insecure private land rights	0.52	0.23
Pessimism bias on tenure insecurity	0.00	0.22
Number of households	243	243

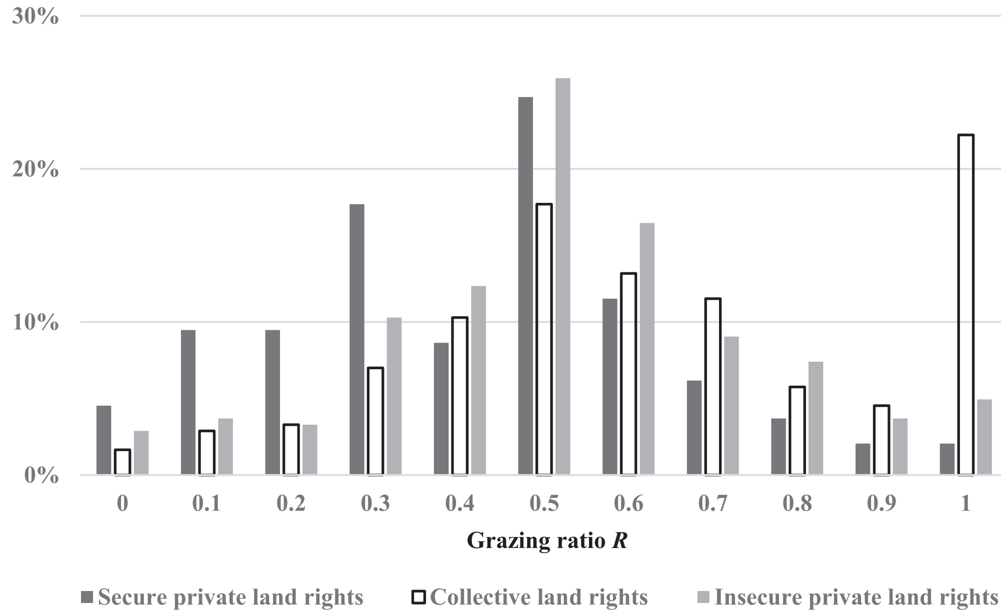

Fig. 1. Distribution of grazing ratio R in three different scenarios.

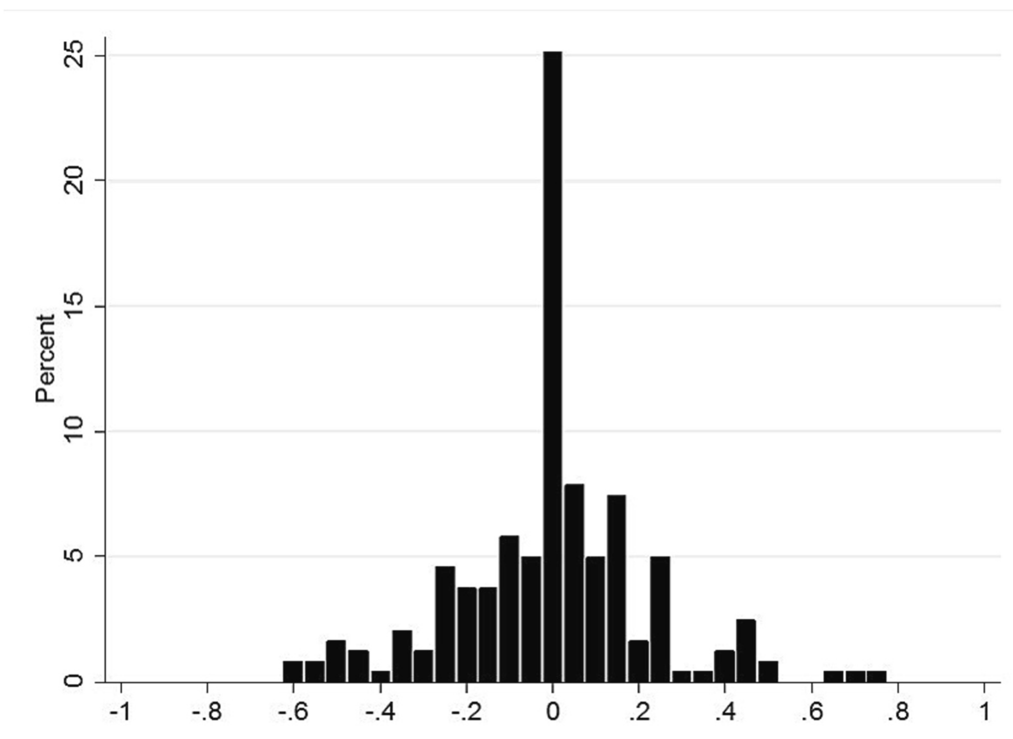

Fig. 2. Distribution of pessimism bias on tenure insecurity.

Party of China (CPC) and State Council is consistent across regions and timeframes. Given that the second round of land contracting is still several years away, with the third round expected to commence as early as 2028, we are confident that, despite potential variations in the efficiency of local government implementations, there will be no disparate effects on pastoralists one year after the policy's introduction.

3.3. *Identification strategy*

Similar to restoring farmland fertility through fallow, an appropriate grazing scale and supplementary feeding help maintain the sustainable use of grassland in our study area, where traditional semi-nomadic pastoralism uses minimal external input (Xia et al., 2020). Using the number of livestock and the cost of per animal supplementary feeding as proxies for long-term land investment,[3] we first estimate the relationship between intergenerational altruism, pessimism bias, and actual land investment decisions with the 2017 cross-sectional data as follows:

$$logY_{ij} = \alpha_j + \beta_1 \widetilde{R}_{ins_{ij}} + \beta_2 R_{pri\,ij} + \beta_3 R_{col\,ij} + \gamma X_{ij} + \epsilon_{ij} \tag{4}$$

where the subscripts indicate household i in village j. Y_{ij} represents land investment, including the number of livestock and the cost of animal feeding, and note that we use separate models of Eq. (4) to estimate for each indicator of Y_{ij}. α_j is village fixed effects that capture cross-village variations in village endowment and policy implementation. For example, it accounts for factors such as the grassland ecological compensation policy, which has been the most important government program implemented in our study area since 2011. This program has dual goals of restoring grassland ecosystems and raising herder incomes (Hou et al., 2021). Based on the hypothetical questions, $\widetilde{R}_{ins_{ij}}$, $R_{pri\,ij}$ and R_{colij} measure perception bias on risk probability, intergenerational altruism for a person's children, and intergenerational altruism for the next generation, respectively. X_{ij} is a vector of household controls. In addition to the basic characteristics, including operated land size in the logarithm, minority status, household size, share of household members by gender and age, share of household members by education level, and household wealth (per capita value of durable goods in the logarithm), we further add time preference and risk attitude to isolate the effects associated with land tenure from general factors affecting grazing decisions. Specifically, we elicit individual time preference and risk attitude through additional experiments in the survey. For time preference, we use the Convex Time Budget method by Andreoni and Sprenger (2012), which identifies both discounting and curvature in intertemporal allocation decisions. For risk attitude, we employ Holt and Laury (2002) risk aversion measure, involving ten binary choices between high-risk and low-risk gambles. ϵ_{ij} is the random error term. Standard errors are clustered at the village level for estimation.[4]

In Eq. (4), β_1, β_2, β_3 are the three coefficients of interest, which capture the association between pessimism bias on tenure insecurity, two types of intergenerational altruistic preferences, and actual land investment decisions. We anticipate that pastoralists with lower intergenerational altruism and greater pessimism bias are more likely to overexploit grasslands.

To investigate whether the 2019 RLCLA, which requires the renewal of land contracts after their expiration, dispels pessimism bias on land tenure insecurity, we introduce time variation into Eq. (4) and estimate the DiD specification:

$$logY_{ijt} = \alpha_{ij} + T_t + \alpha_j {}^* T_t + \delta_1 \widetilde{R}_{ins_{ij}} {}^* T_t + \delta_2 R_{pri\,ij} {}^* T_t + \delta_3 R_{colij} {}^* T_t + \theta X_{ijt} + \epsilon_{ijt} \tag{5}$$

where α_{ij} is household fixed effects. T_t is a binary variable for the post-reform period (i.e., year 2020) that captures the changes between 2017 and 2020 that are common to every household. While time-invariant village characteristics controlled by α_j in Eq. (4) are absorbed by household fixed effects, we add the interaction between α_j and T_t to capture changes between 2017 and 2020 that are specific to each village. Thus, we believe that common and idiosyncratic shocks, such as COVID-19, are fully controlled in Eq. (5).[5] $\widetilde{R}_{ins_{ij}}$, $R_{pri\,ij}$, and R_{colij} are defined the same as Eq. (4), but they interact with T_t to include variations over time. X_{ijt} also adds time variation to the vector of household controls, as specified in Eq. (4).[6] ϵ_{ijt} is the random error term. Standard errors are two-way clustered at the village and year levels for estimation.[7]

In Eq. (5), our primary interest is δ_1, which assesses whether the renewal of land contracts required by the 2019 RLCLA affects outcomes differently for households with varying levels of pessimism bias on land tenure insecurity. In contrast, we expect δ_2 and δ_3 to be statistically insignificant. This expectation arises because intergenerational altruistic preferences, unlike pessimism bias, are formed in scenarios without tenure insecurity. Therefore, we anticipate that the impact of intergenerational altruistic preferences on actual land investments remains consistent both before and after the land reform, irrespective of uncertainties related to grassland tenure.

In addition, to examine whether our results are robust to a standard DiD specification, we use hypothetical grazing decisions to classify individuals into two distinct types: a pessimistic type who have tendency to overestimate the likelihood of losing land tenure (with $\widetilde{R}_{ins} \geq 0$), and an optimistic type who tend to underestimate the likelihood of losing land tenure (with $\widetilde{R}_{ins} < 0$). Consequently, 64% of households are classified as the pessimistic type, while 36% of households are classified as the optimistic type. The two types of households can be further combined with panel data collected before and after the 2019 RLCLA to investigate the impact of the reform in a standard DiD setting. Although the 2019 RLCLA requires renewal of land contracts after their expiration for all rural households, optimistic households who do not fear losing land in the long term are unlikely to be affected by the reform and can be treated as the control group. By contrast, those households with pessimistic bias on land tenure insecurity are regarded as the treatment group (PH). We estimate Eq. (5) with $\widetilde{R}_{ins_{ij}}$ replaced by PH_{ij}, and thus the coefficient δ_1 indicates whether the implementation of 2019 RLCLA affects actual land investment decisions differently between optimistic and pessimistic households.

4. Results

4.1. Association between intergenerational altruism, pessimism bias and actual land investment decisions

The cross-sectional results from estimating Eq. (4) using 2017 data are presented in Table 3, where Panels A and B report the results for the number of livestock and the cost of per animal supplementary feeding, respectively. In both panels, we add the control variables column-by-column to show the robustness of our estimates. Column 1 controls only basic household characteristics; time preference and risk attitude are included as additional variables in columns 2 to 4.

The results in Panel A show that pessimism bias on tenure insecurity and the two types of intergenerational altruism are all relevant to the

[3] The number of livestock is transformed into sheep units using the following criteria: 1 sheep = 1 sheep unit; 1 lamb = 0.8 sheep unit; 1 goat = 0.8 sheep unit; 1 young goat = 0.64 sheep unit; 1 cattle = 5 sheep unit; 1 calf = 3.5 sheep unit; 1 horse = 5.5 sheep unit; 1 foal = 3.85 sheep unit; 1 camel = 8 sheep unit; 1 camel calf = 6.4 sheep unit (Ministry of Agriculture and Rural Affairs, 2015).

[4] We use the wild cluster bootstrap to allow for improvements in inference to asymptotically derived standard errors, since the bootstrap converges faster than asymptotically derived pivotal statistics (Horowitz, 2019). P-values are calculated using "boottest" proposed by Roodman et al. (2019).

[5] Actually, our study area has been among the least affected by COVID-19. Data from the China Data Lab (accessible at https://doi.org/10.7910/DVN/MR5IJN)nnnnnnnnnnnindicates that as of December 13, 2021, Qinghai had only 18 confirmed cases, and Gansu had 182 cases, both considerably lower than the national average of 2809.

[6] While the basic household characteristics themselves can vary over time, time preference and risk attitude interact with R_t to introduce time variation.

[7] In this estimation, we also use the wild cluster bootstrap to allow for improvements in inference to asymptotically derived standard errors (Horowitz, 2019). P-values are also calculated using "boottest" proposed by Roodman et al. (2019).

Table 3
Association between pessimism bias, intergenerational altruism, and actual grazing decisions.

	(1)	(2)	(3)	(4)
Panel A: livestock number				
Pessimism bias on tenure insecurity	0.530**	0.514**	0.511*	0.501*
	[0.040]	[0.042]	[0.050]	[0.052]
Intergenerational altruism for own children	0.650**	0.696**	0.641**	0.685**
	[0.014]	[0.015]	[0.015]	[0.015]
Intergenerational altruism for the next generation	0.312*	0.296*	0.308*	0.294*
	[0.069]	[0.070]	[0.074]	[0.075]
Observations	243	243	243	243
R-squared	0.648	0.649	0.648	0.650
Panel B: Per animal supplementary feeding				
Pessimism bias on tenure insecurity	0.722	0.731	0.763	0.768
	[0.274]	[0.267]	[0.243]	[0.247]
Intergenerational altruism for own children	0.422	0.393	0.441	0.420
	[0.468]	[0.499]	[0.450]	[0.466]
Intergenerational altruism for the next generation	0.152	0.162	0.161	0.167
	[0.683]	[0.667]	[0.673]	[0.654]
Observations	240	240	240	240
R-squared	0.516	0.517	0.517	0.517
Controls				
Year-specific intergenerational altruism for own children	Yes	Yes	Yes	Yes
Year-specific intergenerational altruism for the next generation	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Village-specific year fixed effects	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Year-specific time preference	No	Yes	No	Yes
Year-specific risk attitude	No	No	Yes	Yes

Notes: The dependent variables are logarithms. Household controls include land size in logarithms, minority status, household size, share of household members by gender and age, share of household members by education level, and household wealth (per capita value of durable goods in logarithms). Robust standard errors are clustered by village. The figures in square brackets are *p*-values from the wild cluster bootstrap (Roodman, 2019) with Rademacher weights and 10,000 replications. *** significant at 1%; ** significant at 5%; * significant at 10%.

real livestock scale, suggesting that our question design and background setting mimic the real world well. Households with weaker intergenerational altruism (higher grazing ratio R_{pri} and/or R_{col}) and stronger pessimism bias (higher $\widetilde{R}_{ins}$) tend to have a larger livestock scale. The specific altruism for own children has the highest estimate, significantly higher than the general altruism for the next generation. The estimate of pessimism bias, while slightly smaller than that of intergenerational altruism for one's own children, remains a significant factor in relation to the real livestock scale; Specifically, a half-standard deviation increase (0.11) is associated with a 6% increase in livestock.[8] Combined with the fact that households with greater pessimism regarding long-term land right uncertainties and weaker intergenerational altruism do not significantly use more supplementary feeding for their larger-scale livestock (Panel B), measures of intergenerational altruistic preferences and pessimism bias elicited from our hypothetical questions are proven to be effective predictors of actual land investment decisions.

4.2. Impact of land contract renewal

Before interpreting the DiD results, we test the parallel trend assumption to justify the validity of our DiD estimation. Our 2017 survey complements the 2017 data with the recall data of 2016, which allows us to conduct a panel analysis in the pre-reform period. Descriptive statistics on household characteristics in the three years are reported in Table A2 of the Appendix. We believe that the recall bias in our panel data is not a serious problem for three reasons. First, the number of livestock in the previous year can be calculated using the number in the current year and the changes (including purchase, slaughter, and death due to diseases or accidents) between the two years. Second, as the grazing method in our study area is highly traditional, households can easily recall a few inputs, such as the supplementary feeding used in the previous year. Third, basic household characteristics do not vary much in any two consecutive years, with the exception of certain shocks that can be easily recalled. With T_t indicating year 2016, the parallel trend tests from estimating Eq. (5) suggest that there are no significant differences in the outcomes of our interest among households with different levels of pessimism bias and intergenerational altruism in the pre-reform period (Table 4).

With panels and columns displayed the same as Table 3, the DiD

Table 4
Pre-trend tests on households with varying pessimism bias between year 2016 and 2017.

	(1)	(2)	(3)	(4)
Panel A: livestock number				
Pessimism bias * Year 2016	−0.076	−0.091	−0.044	−0.056
	[0.787]	[0.773]	[0.832]	[0.824]
Intergenerational altruism for own children * Year 2020	−0.209	−0.164	−0.193	−0.139
	[0.269]	[0.328]	[0.281]	[0.379]
Intergenerational altruism for the next generation * Year 2020	0.237	0.226	0.251	0.239
	[0.134]	[0.165]	[0.145]	[0.161]
Observations	486	486	486	486
R-squared	0.949	0.949	0.949	0.949
Panel B: Per animal supplementary feeding				
Pessimism bias * Year 2016	0.002	−0.014	0.052	0.037
	[0.998]	[0.980]	[0.933]	[0.951]
Intergenerational altruism for own children * Year 2020	−0.478	−0.433	−0.456	−0.396
	[0.321]	[0.394]	[0.342]	[0.444]
Intergenerational altruism for the next generation * Year 2020	−0.438	−0.449	−0.415	−0.427
	[0.439]	[0.435]	[0.454]	[0.458]
Observations	478	478	478	478
R-squared	0.887	0.887	0.888	0.888
Controls				
Household fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Village-specific year fixed effects	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Year-specific time preference	No	Yes	No	Yes
Year-specific risk attitude	No	No	Yes	Yes

Notes: The dependent variables are logarithms. Household controls include land size in logarithms, minority status, household size, share of household members by gender and age, share of household members by education level, and household wealth (per capita value of durable goods in logarithms). Robust standard errors are two-way clustered by village and year. The figures in square brackets are *p*-values from the wild cluster bootstrap (Roodman, 2019) with Rademacher weights and 10,000 replications. *** significant at 1%; ** significant at 5%; * significant at 10%.

[8] The number of livestock entering the regression equation in the logarithm means that increasing pessimism bias by one unit is associated with a change of the outcome variable by $100*\beta_1$ percent. Hence, increasing pessimism bias by 0.11 is associated with a change in the number of livestock by about 6% (100*0.5*0.11).

Table 5
Impact of the 2019 RLCLA on households with varying pessimism bias.

	(1)	(2)	(3)	(4)
Panel A: livestock number				
Pessimism bias * Year 2020	−0.884*	−0.901*	−0.899*	−0.909*
	[0.075]	[0.069]	[0.077]	[0.066]
Intergenerational altruism for own children * Year 2020	−0.074	−0.011	−0.083	−0.018
	[0.922]	[0.988]	[0.913]	[0.981]
Intergenerational altruism for the next generation * Year 2020	0.060	0.045	0.051	0.040
	[0.814]	[0.870]	[0.854]	[0.886]
Observations	486	486	486	486
R-squared	0.873	0.874	0.873	0.874
Panel B: Per animal supplementary feeding				
Pessimism bias * Year 2020	−0.381	−0.412	−0.353	−0.371
	[0.661]	[0.630]	[0.670]	[0.661]
Intergenerational altruism for own children * Year 2020	−1.236	−1.091	−1.227	−1.065
	[0.233]	[0.275]	[0.230]	[0.276]
Intergenerational altruism for the next generation * Year 2020	0.482	0.468	0.497	0.489
	[0.478]	[0.482]	[0.462]	[0.459]
Observations	468	468	468	468
R-squared	0.803	0.803	0.803	0.804
Controls				
Village fixed effects	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Time preference	No	Yes	No	Yes
Risk attitude	No	No	Yes	Yes

Notes: The dependent variables are logarithms. Household controls include land size in logarithms, minority status, household size, share of household members by gender and age, share of household members by education level, and household wealth (per capita value of durable goods in logarithms). Robust standard errors are clustered by village. The figures in square brackets are p-values from the wild cluster bootstrap (Roodman, 2019) with Rademacher weights and 10,000 replications. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 6
Pre-trend tests on two types of households between year 2016 and 2017.

	(1)	(2)	(3)	(4)
Panel A: livestock number				
Pessimistic households * Year 2016	−0.129	−0.137	−0.116	−0.122
	[0.164]	[0.158]	[0.177]	[0.172]
Intergenerational altruism for own children * Year 2020	−0.222	−0.173	−0.212	−0.154
	[0.185]	[0.249]	[0.199]	[0.283]
Intergenerational altruism for the next generation * Year 2020	0.170	0.156	0.183	0.170
	[0.226]	[0.272]	[0.235]	[0.264]
Observations	486	486	486	486
R-squared	0.949	0.949	0.949	0.950
Panel B: Per animal supplementary feeding				
Pessimistic households * Year 2016	−0.142	−0.151	−0.122	−0.130
	[0.541]	[0.516]	[0.593]	[0.584]
Intergenerational altruism for own children * Year 2020	−0.512	−0.461	−0.497	−0.432
	[0.285]	[0.349]	[0.307]	[0.371]
Intergenerational altruism for the next generation * Year 2020	−0.536	−0.549	−0.513	−0.527
	[0.361]	[0.363]	[0.372]	[0.369]
Observations	478	478	478	478
R-squared	0.887	0.888	0.888	0.888
Controls				
Household fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Village-specific year fixed effects	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Year-specific time preference	No	Yes	No	Yes
Year-specific risk attitude	No	No	Yes	Yes

Notes: The dependent variables are logarithms. Household controls include land size in logarithms, minority status, household size, share of household members by gender and age, share of household members by education level, and household wealth (per capita value of durable goods in logarithms). Robust standard errors are two-way clustered by village and year. The figures in square brackets are p-values from the wild cluster bootstrap (Roodman, 2019) with Rademacher weights and 10,000 replications. *** significant at 1%; ** significant at 5%; * significant at 10%.

results in Panel A of Table 5 consistently suggest a reduction in the number of livestock for households who are more pessimistic to the long-term uncertainty of land rights after the implementation of the 2019 RLCLA. With a point estimate of −0.909 (column 4), increasing pessimism bias by half a standard deviation (0.11) would be expected to translate into a reduction in the number of livestock by 10%, large enough to offset the pre-reform overuse of grassland due to the pessimism bias on land tenure insecurity. Moreover, there is no evidence that the 2019 RLCLA reduces the use of per animal supplementary feeding for households with a higher level of pessimism bias (Panel B), making the conclusion that the extension of land contracts helps maintain the sustainable use of grassland more reliable. Regarding the two types of intergenerational altruistic preferences, it is evident that the 2019 RLCLA neither significantly alters livestock scale nor supplementary feeding for households with any certain level of intergenerational altruism. This result is consistent with our theoretical prediction that the impact of intergenerational altruistic preferences on actual land investments remains unchanged both before and after the land reform.

Moreover, our results are robust in the standard DiD setting where optimistic and pessimistic households are compared before and after the RLCLA. Before interpreting the standard DiD results, we also test the parallel trend assumption to justify the validity of our standard DiD estimation. With T_t indicating year 2016 and $\widetilde{R}_{ins_{ij}}$ replaced by PH_{ij}, the parallel trend tests from estimating Eq. (5) suggest no significant differences in the outcomes of our interest between optimistic and pessimistic households in the pre-reform period (See Table 6).

Finally, Table 7 reports the standard DiD estimates regarding two different types of households. Regardless of the control variables, the 2019 RLCLA is consistently estimated to reduce the number of livestock for pessimistic households (Panel A). In particular, the point estimate of −0.326 (column 4) suggests that, the reform leads to a 33% reduction in the number of livestock for pessimistic households than optimistic households. By contrast, there is no evidence that the 2019 RLCLA changes the difference between optimistic and pessimistic households in per animal supplementary feeding (Panel B). Once again, it affirms the conclusion that granting rural households long-term land rights weakens the adverse effects of pessimism bias and promotes the sustainable use of grassland.

Table 7
Impact of the 2019 RLCLA on two types of households.

	(1)	(2)	(3)	(4)
Panel A: livestock number				
Pessimistic households * Year 2020	−0.314***	−0.322***	−0.321***	−0.326***
	[0.008]	[0.008]	[0.007]	[0.008]
Intergenerational altruism for own children * Year 2020	0.044	0.107	0.037	0.102
	[0.950]	[0.885]	[0.960]	[0.893]
Intergenerational altruism for the next generation * Year 2020	0.093	0.077	0.084	0.073
	[0.649]	[0.710]	[0.710]	[0.737]
Observations	486	486	486	486
R-squared	0.872	0.873	0.872	0.873
Panel B: Per animal supplementary feeding				
Pessimistic households * Year 2020	0.137	0.118	0.158	0.144
	[0.710]	[0.741]	[0.652]	[0.689]
Intergenerational altruism for own children * Year 2020	−1.135	−0.996	−1.125	−0.968
	[0.258]	[0.308]	[0.257]	[0.309]
Intergenerational altruism for the next generation * Year 2020	0.686	0.668	0.709	0.697
	[0.315]	[0.328]	[0.301]	[0.313]
Observations	468	468	468	468
R-squared	0.803	0.803	0.803	0.804
Controls				
Household fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Village-specific year fixed effects	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Year-specific time preference	No	Yes	No	Yes
Year-specific risk attitude	No	No	Yes	Yes

Notes: The dependent variables are logarithms. Household controls include land size in logarithms, minority status, household size, the share of household members by gender and age, share of household members by education level, and household wealth (per capita value of durable goods in logarithms). Robust standard errors are two-way clustered by village and year. The figures in square brackets are p-values from the wild cluster bootstrap (Roodman, 2019) with Rademacher weights and 10,000 replications. *** significant at 1%; ** significant at 5%; * significant at 10%.

5. Conclusion

This study designs a series of hypothetical questions to simulate real-world decision-making in a simplified and naturalistic environment and gauge the interplay of intergenerational altruism, pessimism bias and land tenure insecurity among rural households in the pastoral region of northwest China. Combined with actual grazing decisions, our analysis demonstrates that weaker intergenerational altruism and/or stronger pessimism bias elicited from our hypothetical questions are associated with a larger household livestock scale without more supplementary feeding. This observation suggests that our measures of intergenerational altruism and pessimism bias can serve as reliable predictors of grassland overuse. Furthermore, we use panel data collected before and after implementing the 2019 RLCLA to investigate the impact of the reform. Relevant DiD estimates suggest that the reform reduces the livestock scale for pessimistic households without any significant change in their supplementary feeding, pointing towards the effectiveness of the 2019 RLCLA for weakening the negative impact of pessimism bias on tenure insecurity and maintaining the sustainable use of grassland.

Methodologically, our question design contributes to the literature by proposing a novel approach to creating proxy variables that effectively uncover the unobservable intergenerational altruism and pessimism bias regarding tenure insecurity within the population. This method has great potential for application in relevant research on the issue of sustainable land use. In addition, as the 2019 RLCLA increases tenure security through the commitment to renew land contracts after their expiration, investigating its impact on land use has policy implications not only for China but also for developing countries without long-term land rights. The effectiveness of the 2019 RLCLA shown in our study suggests that land institutions that grant rural households long-term land rights can increase long-term land investment and promote the sustainable use of land.

Declaration of Competing Interest

The manuscript has not been published or presented elsewhere in part or in its entirety and is not under consideration by another journal. All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. We have read and understood your journal's policies, and we believe that neither the manuscript nor the study violates any of these policies. There are no conflicts of interest to declare.

Data availability

Data will be made available on request.

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Appendix

Interview card

Assume you currently own a unit of grassland with a maximum carrying capacity of 10 sheep per year in the current period. This means you can have no >10 sheep grazing on this land. Your task is to choose a grazing number between 0 and 10. Your choice not only determines your current-period revenue but also affects the maximum grazing capacity and future revenue for the next generation in the second period. A scientific predictive model has estimated the animal carrying capacity for the next generation in the second period, as shown in the table below:

The number of sheep grazing on the land you choose in the current period (unit of sheep)	The maximum carrying capacity of the land for the next generation in the next period (unit of sheep)
0	10
1	10
2	9
3	8
4	7
5	7
6	5
7	4
8	3
9	2
10	0

For example, if you decide not to graze in the current period, the land's maximum carrying capacity will be 10 sheep for the next generation. If you choose to graze 1 sheep in the current period, the maximum carrying capacity for the next generation will still be 10 sheep. If you choose to graze 2 sheep in the current period, the maximum carrying capacity for the next generation will decrease to 9 sheep, and so forth. Please make sure you understand the implications of this table.

Case 1. You currently have the contracted management rights for this grassland, which means all grazing revenue from this land in the current period is yours. Suppose that several years later, your children can take over these rights, implying that future revenue will belong to them in the next period. In this situation, how many sheep would you choose to graze on the land in the current period?

Case 2. You currently have the contracted management rights for this grassland, which means all grazing revenue from this land in the current period is yours. Suppose that several years later, this land will transition to collective management in the next period, and your children won't benefit from future revenue. In this situation, how many sheep would you choose to graze on the land in the current period?

Case 3. You have the contracted management rights for this grassland and enjoy all grazing revenue. Suppose that several years later, there is uncertainty regarding the future status of land rights. There's a 50% chance that your children will inherit the contracted management rights in the next period, and a 50% chance that the land will be converted to collective management. In this situation, how many sheep would you choose to graze on the land in the current period?

Background of farmland tenure in China

Farmland tenure in China has experienced three phases of reform after the Household Responsibility System (HRS) allowed rural households to claim output residuals and separated their contracted management rights from the collective ownership of land in 1979. In 1984, the Central Committee of the Communist Party of China (CPC) released the Circular on Rural Work, known as the third No. 1 Document, formally launching the first round of land contracting for 15 years. However, the benefit of long-term tenure security was limited because the land contract failed to provide protection against periodic land reallocations conducted by village governments to equalize per capita land size across households due to demographic changes (Kung and Liu, 1997; Benjamin and Brandt, 2002).

Policies in the 1990s and 2000s thus began to explore potential new mechanisms for land allocation to stabilize the long-term contracting relationship between rural households and their village governments (Deininger and Jin, 2003). In 1993, the Central Committee of the CPC and State Council released a document entitled "Several Policies on Current Agricultural and Rural Economic Development," specifying three changes in farmland tenure. First, it extended the second round of land contracting to 30 years. Second, it advocated no land reallocations due to household demographic changes during the contract period (i.e., "no land increase for new population, no land decrease for reduced population"). However, it recognized the need for land reallocation in areas with developed secondary and tertiary industries due to the massive shift of rural labor out of the agricultural sector. Third, on the premise of adhering to the collective ownership of land and not changing land use, it allowed the transfer of land rights with the consent of the villagers' committee. Some of these changes were reflected in the 1998 Land Management Law, which granted rural households 30-year land contracts and required land reallocations to be approved by two-thirds of the villagers' assembly together with the township government and the county agricultural department. The 2003 RLCL further strengthened tenure security with a focus on (i) the formalization of transfer rights, (ii) commitment to issue formal certificates for contracted land, and (iii) ban on big land reallocations and establishing conditions for small land reallocations. In big reallocations, the village government takes back all the land and reallocates it in equal shares to the villagers. By contrast, small reallocations are made only among households experiencing demographic changes, leaving other households unaffected. The 2003 RLCL banned big reallocations and recognized natural disasters rather than household demographic changes as the main reason for small reallocations. Small reallocations due to household demographic changes could only be conducted if there was land in the village that had not been contracted or voluntarily returned by the contracted households. Existing studies have shown that the 2003 RLCL leads to large-scale rural-urban migration and an increase in the transfer of land rights (Deininger et al., 2014; Chari et al., 2021).

In practice, transferring land rights gives rise to the separation of land contractors and managers, triggering the latest phase of reforms featured with "three rights separation" (Wang and Zhang, 2017; Gao et al., 2020). While rural land remains owned by the collective, contracted management rights held by households are divided into contract rights and management rights. This reform, originally introduced in 2014 by the Central Committee of the CPC and the State Council through the document titled "Opinions on Guiding the Orderly Transfer of Rural Land Management Rights and Developing Agricultural Moderate Scale Operation" (available at http://www.gov.cn/xinwen/2014-11/20/content_2781544.htm), was subsequently codified in the 2019 RLCLA as the basis on which other legal changes could improve the allocation efficiency of productive resources, including (i) the commitment to renew land contracts after their expiration, (ii) protection of the land rights of rural households settled in urban areas during the contract period, (iii) diversification of participants and modes of land transfer (i.e. allowing industrial and commercial enterprises to participate in agricultural land transfers and rural households to transfer management rights through share-based arrangements), and (iv) use of land management rights as collateral.

Table A1
Balancing test for 2017 households with and without hypothetical questions.

	With hypothetical questions		Without hypothetical questions		t-test (1) = (3)
	Mean	Sd.	Mean	Sd.	
	(1)	(2)	(3)	(4)	(5)
Livestock production					
Number of livestock †	346	285	371	372	0.681
Per animal supplementary feeding (yuan) †	15.63	27.70	18.47	36.23	0.781
Operated land size (ha)	463	1257	505	1253	0.281
Household characteristics					
Minority (0/1)	0.95	0.21	0.98	0.14	1.113
Household size	5.84	2.46	5.59	2.21	−0.865
Number of boys (<16 years old)	0.72	0.86	0.60	0.82	−1.193
Number of girls (<16 years old)	0.71	0.98	0.82	0.96	0.932
Number of men (16–60 years old)	1.90	1.10	1.90	1.11	0.022
Number of women (16–60 years old)	1.93	1.08	1.91	0.98	−0.194
Number of old men (>60 years old)	0.25	0.47	0.19	0.39	−1.141
Number of old women (>60 years old)	0.32	0.48	0.25	0.44	−1.285
Number of people who never attended schools	2.91	2.20	2.78	1.97	−0.526
Number of people with primary/junior secondary edu. ‡	2.15	1.55	1.92	1.50	−1.249
Number of people with senior secondary edu. or above ‡	0.77	0.95	0.89	1.00	1.014
Per capita value of durable goods (yuan)	12,388	21,142	9427	12,208	−1.312
Number of households	243	243	100	100	

Note: † All livestock is converted into sheep units. ‡ Primary and junior secondary education are compulsory in China. *** significant at 1%; significant at 5%; * significant at 10%.

Table A2
Descriptive statistics in 2016, 2017 and 2020.

	2016		2017		2020	
	Mean	Sd.	Mean	Sd.	Mean	Sd.
Livestock production						
Number of livestock †	360	298	346	285	336	278
Per animal supplementary feeding (yuan) †	19.59	27.09	15.63	27.70	29.21	63.40
Operated land size (ha)	468	1269	463	1258	471	1269
Household characteristics						
Minority (0/1)	0.95	0.21	0.95	0.21	0.95	0.21
Household size	5.80	2.45	5.84	2.46	4.84	1.90
Number of boys (<16 years old)	0.76	0.91	0.72	0.86	0.55	0.73
Number of girls (<16 years old)	0.76	1.01	0.71	0.98	0.54	0.81
Number of men (16–60 years old)	1.85	1.08	1.90	1.10	1.65	0.97
Number of women (16–60 years old)	1.88	1.08	1.93	1.08	1.61	0.88
Number of old men (>60 years old)	0.24	0.46	0.25	0.47	0.22	0.42
Number of old women (>60 years old)	0.31	0.47	0.32	0.48	0.27	0.46
Number of people who never attended schools	2.88	2.22	2.91	2.20	2.15	1.43
Number of people with primary/junior secondary edu. ‡	2.21	1.54	2.15	1.55	1.81	1.42
Number of people with senior secondary edu. or above ‡	0.71	0.88	0.77	0.95	0.88	1.01

(*continued on next page*)

Table A2 (*continued*)

	2016		2017		2020	
	Mean	Sd.	Mean	Sd.	Mean	Sd.
Per capita value of durable goods (yuan)	11,424	20,733	12,388	21,142	14,857	19,088
Number of households	243	243	243	243	243	243

Note: † All livestock is converted into sheep units. ‡ Primary and junior secondary education are compulsory in China.

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