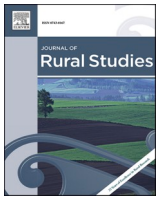
Journal of Rural Studies 123 (2026) 104058



Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud





Land as destiny: How grassland inheritance drives income inequality in pastoral China

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ARTICLE INFO

Keywords:
Grassland tenure reform
Grassland use rights
Grassland rental market
Income inequality
Pastoral China

ABSTRACT

China's 1980s grassland tenure reform allocated long-term, heritable use rights to pastoral households, creating a durable form of inherited wealth. This paper examines the long-term consequences of that foundational allocation and quantifies how its inheritance shapes contemporary income inequality. Using household survey data from China's pastoral regions and an instrumental variable strategy, we identify a causal link between historically allocated grassland area and present-day income. A 1% increase in historical allocation raises current income by 0.119%. We find this effect operates primarily through two pathways: pastoral production income and area-based ecological subsidies. Our heterogeneity analysis demonstrates that the inheritance grassland area shapes income inequality. The income effect is statistically insignificant for households that inherited small allocations, possibly because their holdings fall below a viable production scale. Significant returns appear only among households with the largest allocations, creating a scale-dependent return structure that contributes to current inequality. The analysis also highlights the mitigating role of the grassland rental market. Households that rent in grassland (typically those with smaller historical allocations) can expand to an economically viable scale, weakening the intergenerational link between historical allocations and income.

1. Introduction

In the 1980s, China introduced the Household Responsibility System (HRS) across its pastoral regions, initiating a far-reaching grassland tenure reform. The goal was to address the economic inefficiencies of the collective system, which was widely viewed as weakening individual incentives for effort by delinking rewards from household management practices (Lin, 1988). The reform was therefore explicitly "efficiency-oriented" (Liu et al., 2019). By allocating long-term grassland use rights to individual households, the state aimed to directly tie a household's effort to its economic returns. This secure tenure was expected to encourage sustainable grassland management and long-term investment (Ma et al., 2013).

This institutional design, however, produced an important long-run consequence. By establishing these use rights as quasi-permanent to guarantee tenure security, the reform effectively created a new and durable form of inheritance. The initial allocation in the 1980s was a foundational distribution, shaped by the administrative logic of that period. Grassland use rights were assigned based on ecological assessments of carrying capacity combined with contemporaneous household demographics (Hou et al., 2023). Crucially, policy later prohibited population-based readjustments (Li, 2003), a principle known as "no (grass)land adjustment with population changes." This aimed to prevent frequent reallocations and the further fragmentation of holdings, but it also rendered the original allocation essentially final. Four decades later, this raises a central question: Did the grassland tenure reform inadvertently create a rigid mechanism that perpetuates income inequality across generations?

Answering this question is critical for both theory and policy. From a theoretical perspective, it challenges the assumption that efficiency-oriented reforms automatically lead to equitable outcomes. If initial endowments create permanent wealth gaps, then the reform's legacy may be one of structural inequality. From a policy perspective, understanding this mechanism is essential for rural development. It helps us determine whether current poverty in pastoral regions is a result of contemporary factors or a direct consequence of a forty-year-old

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https://doi.org/10.1016/j.jrurstud.2026.104058
Received 17 August 2025; Received in revised form 26 January 2026; Accepted 29 January 2026
Available online 5 February 2026
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administrative decision. This clarity is needed to design interventions that can effectively break the cycle of inherited disadvantage.

This paper examines the long-term distributional consequences of this institutional choice. How initial endowments shape inequality is a core topic in development economics and rural studies (Aghion et al., 1999; Turner, 2016). Yet most empirical research on inheritance is based on developed countries or urban settings and primarily focuses on financial assets or housing (Elinder et al., 2018; Zhu, 2018). We argue that these mechanisms may operate differently in rural contexts of developing countries, where grassland or farmland is the primary means of production (Winters et al., 2009; Lambert et al., 2014).

Pastoral regions present a distinct context. Grassland is a productive input that requires continuous management, and pastoralism is a land-extensive livelihood. This suggests a key hypothesis: a minimum operational scale may be necessary for grassland-based production to be viable. If so, the economic returns to inherited grassland may be highly uneven. Allocations below this scale may yield limited income, while larger allocations may unlock substantial productive potential. This study investigates how these scale-dependent returns, rooted in the original 1980s allocation, shape contemporary inequality.

To address these questions, we draw on household-level survey data collected during 2018–2020 from 1022 pastoral households across five northern provinces. Because unobserved household characteristics may affect both land holdings and income, we address potential endogeneity by employing an instrumental variable (IV) approach, instrumenting current managed area with the grassland allocated in the 1980s. We extend this IV framework to test for heterogeneous returns and to assess whether the grassland rental market mitigates inequality arising from the historical allocation.

The case of pastoral China provides a unique natural experiment for understanding the long-term consequences of land tenure reform. While the policy context is specific to China, the underlying challenge of balancing initial resource allocation with long-term equity is a universal concern. Our findings offer broader theoretical insights into how institutional legacies can create persistent wealth gaps in rural societies globally. These lessons are particularly relevant for other developing nations currently navigating land rights formalization.

The paper is organized as follows. Section 2 reviews the literature and institutional background. Section 3 introduces the data and descriptive statistics. Section 4 presents the empirical strategy. Section 5 presents the baseline results and analyzes the heterogeneity of returns as well as the role of the rental market. Section 6 concludes.

2. Literature review

This study sits at the intersection of three major research streams: the economics of inheritance and inequality, grassland tenure reform and property rights, and the income effects of land redistribution. We review each of these literatures to position our contribution and identify key gaps that our research addresses.

2.1. Inheritance and income inequality

The empirical literature on inheritance and inequality has expanded rapidly in recent years, driven partly by the United Nations Sustainable Development Goals' emphasis on achieving more equitable income distribution (MacLeavy and Manley, 2018). Since income serves as the primary source of household wealth accumulation, and income gaps constitute a vital force driving wealth inequality (Piketty and Saez, 2003; Benhabib et al., 2017; Ashman and Neumuller, 2020), understanding the distributional consequences of inheritance has become a central concern for economists and policymakers alike (Bowles and Fochesato, 2024).

Theoretical perspectives on inheritance effects remain divided. On one hand, inheritance can perpetuate and amplify existing inequalities by providing advantaged families with resources that compound over time (Bartels et al., 2024). This view emphasizes how inherited wealth creates "opportunity inequality" – systematic differences in access to productive assets, education, and economic opportunities that persist across generations regardless of individual merit or effort. Within the broader context of rural restructuring, such intergenerational transfers act as a stabilizing yet rigid force that dictates the long-term socio--economic trajectory of rural households (Long, 2020). On the other hand, inheritance can potentially reduce inequality if bequests are distributed more equally than the underlying income distribution or if inheritance motivates productive investment and entrepreneurship (Arrigoni et al., 2024).

The empirical evidence on these competing hypotheses has proven mixed and context-dependent. A substantial body of research has investigated the causal relationship between inheritance and wealth inequality, particularly in developed countries. However, findings vary considerably across studies and national contexts. The empirical evidence on these competing hypotheses has proven mixed and context-dependent. A substantial body of research has investigated the causal relationship between inheritance and wealth inequality in developed countries. However, these studies primarily focus on non-productive wealth. For instance, De Nardi (2004) finds that the inheritance of financial assets plays a relatively modest role in explaining U.S. wealth inequality. Boserup et al. (2016) document more substantial effects of inherited financial wealth and housing using Danish administrative data. Similarly, Crawford and Hood (2016) show significant distributional impacts of housing and liquid asset inheritance in England. Elinder et al. (2018) find more limited effects of such transfers in Sweden.

These conflicting results reflect several methodological and contextual challenges. First, inheritance data are notoriously difficult to collect and often suffer from measurement error, leading to inconsistent estimates across studies. Second, the causal identification of inheritance effects is complicated by the endogeneity of bequest decisions to family characteristics that also affect income and wealth accumulation. Third, inheritance effects may be highly heterogeneous across countries due to differences in tax systems, social safety nets, and cultural norms regarding intergenerational transfers.

This context is essential, as the studies cited above (e.g., De Nardi, 2004; Boserup et al., 2016), originating from developed economies, measure inheritance primarily as transfers of financial assets or real estate (Ryan-Collins et al., 2017), not as the allocation of primary land use rights. However, in the rural contexts of developing nations, the mechanism of inequality transmission shifts from passive asset transfers to the inheritance of primary land use rights. From the perspective of land use transitions, this represents a persistent "recessive morphology"—encompassing property rights and management modes—that fundamentally shapes the socio-economic evolution of rural space (Long and Qu, 2018; Long et al., 2019). Unlike financial assets that generate passive income, (grass)land serves as a productive input that requires ongoing management. In the current era of post-productivism, the value of inherited land has further evolved from purely agricultural yields to area-based ecological functions and subsidies, which may further entrench wealth gaps rooted in historical allocations (Wu et al., 2024). Furthermore, while these inherited endowments create initial rigidities, the development of land markets and industrial transformation offer potential pathways for disadvantaged households to overcome historical constraints and enhance their comprehensive development capacity (Kan, 2021; Liang and Zhou, 2025). This interplay between institutional fixity and market-based flexibility—conceptualized as the coupling of land, population, and industry—is central to understanding how inheritance effects operate and persist in pastoral China (Zhang et al., 2021).

2.2. Grassland tenure reform and property rights

A precise understanding of China's grassland property-rights system is essential for this analysis. The Household Responsibility System (HRS)

of the 1980s is sometimes misinterpreted as a form of "privatization," although this characterization is inaccurate. As Chinese law and the existing literature make clear, grassland ownership remains with the state or the collective (Hua and Squires, 2015). The institutional evolution is summarized in Fig. 1.

Under the people's commune system established in the 1960s (Stage 1), grasslands were collectively owned and managed by local production teams. Although this arrangement was relatively egalitarian in access, it was widely regarded as economically inefficient because collective decision-making created coordination problems and weakened individual incentives for effort (Lin, 1988).

Reforms in the 1980s (Stage 2) introduced a fundamental separation of rights. Collective ownership was retained, while contract rights and management rights were allocated to individual households (Banks, 2003). These use rights were intended to be long-term and stable. Unlike the cropland sector, central policy did not specify a uniform national duration for grassland contracts. Instead, it articulated a principle of "long-term, stable, and renewable," and delegated the determination of contract length to local governments. The resulting variation, typically between 30 and 50 years, reflected local ecological and administrative considerations (Banks et al., 2003). Regions with fragile or slowly regenerating grassland ecosystems often adopted longer terms to strengthen households' incentives to engage in conservation, while areas with more intensive grazing systems favored somewhat shorter terms to leave room for future institutional adjustment.

Contract periods of 30–50 years are normally renewed upon expiration (Qi, 2023). This practice is grounded in Chinese land law, which requires that tenure relations remain stable and long-term and does not permit the collective to undertake periodic redistributions (Li, 2003). The 1980s allocation was therefore effectively a one-time distribution. The allocation relied on two factors: quality of grassland and the household's family size at that time. The goal was practical: to ensure each household had enough pasture to match its labor force and household size. This created significant variation in physical land area.

This institutional structure also implies that households that did not receive grassland during the initial allocation cannot obtain contract rights later. Inheritance is limited to new members born into the household, while newly arrived residents have no claim to contract rights (Li et al., 2007). This inheritable structure reflects China's tenure institutions, which define grassland contract rights as long-term household-based rights that remain stable across generations. The resulting de facto heritable and quasi-permanent character of the contract right, as indicated by the transition from Stage 2 to Stage 3 in Fig. 1, forms the institutional foundation for the intergenerational wealth transmission examined in this study. It also sets the stage for the contemporary rental market (Stage 3), in which the management right can be transferred independently. In practice, this tenure arrangement serves as a concrete manifestation of 'institutional fixity' within the rural territorial system (Long, 2020). By prioritizing tenure security through long-term contracts, the reform effectively froze the spatial resource template of the 1980s, creating a 'tenure-induced rigidity' that may increasingly conflict with the demographic and economic shifts inherent in rural reconstruction (Chen et al., 2025).

Recent research underscores that while such stability is crucial for herders' resilience against environmental shocks (Zhang et al., 2021), the lack of population-based adjustments can lead to a structural mismatch between land endowments and household labor dynamics (Ren et al., 2022). Consequently, the contemporary challenge lies in integrating this rigid tenure system with broader rural vitalization strategies. This involves leveraging standardized land transfer markets and land consolidation to facilitate the transition from fragmented, inherited holdings toward more efficient, scale-oriented pastoral production (Jiang et al., 2021; Liang and Zhou, 2025). This evolutionary path, moving from historical administrative logic toward market-based reallocation, is essential for optimizing land use functions and mitigating structural inequality in the modern era (Long et al., 2019; Kan, 2021).

Recent empirical research has begun to evaluate the outcomes of China's grassland tenure reform, though much of this work has focused on environmental rather than distributional consequences. Liu et al. (2019) examine the relationship between tenure reform and grassland degradation, finding mixed results that vary by region and implementation approach. Similarly, Hou et al. (2023) investigate how property rights affect grassland quality, documenting both positive and negative environmental outcomes depending on local conditions, and more recent work by Liu et al. (2024) suggests that the specific configuration of property rights is a crucial determinant of these outcomes, finding that a hybrid structure combining private land with access to communal pastures leads to significantly better grassland conservation than purely private arrangements, particularly in the face of adverse climate shocks.

However, the distributional consequences of grassland tenure reform have received far less attention in the academic literature. This represents a significant oversight, given that the initial allocation of grassland use rights during the reform period created persistent differences in resource endowments that continue to shape pastoral livelihoods today. Understanding these distributional effects is crucial for evaluating the overall welfare impacts of tenure reform and designing complementary policies to address any adverse consequences.

2.3. Grassland-related income effects

To understand how inherited grassland translates into contemporary income inequality, it is necessary to review the main economic channels through which grassland area shapes household income in pastoral contexts. Existing research highlights several pathways that determine the economic returns to an inherited grassland allocation.

The most direct channel is pastoral production. Larger grassland holdings typically support higher levels of livestock production (Borooah et al., 2006; Winters et al., 2009). In pastoral systems, where households rely on livestock as their primary livelihood, productivity depends on access to sufficient and good-quality pasture and feed. Grassland scarcity therefore places especially tight constraints on small-scale herders.

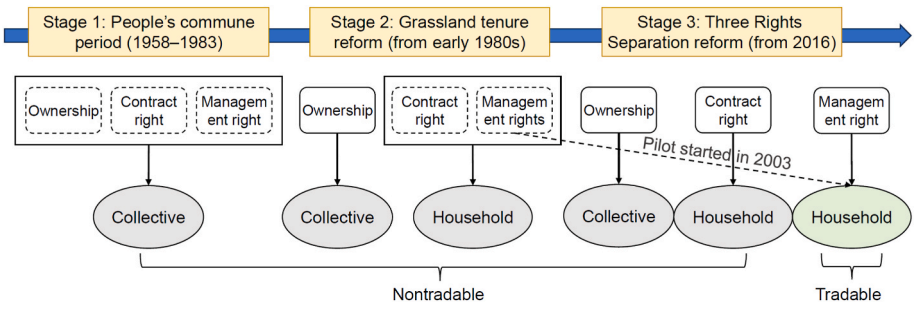

Fig. 1. Institutional evolution of grassland property rights in China.

Grassland tenure can also influence off-farm income opportunities. Households with more grassland may have greater collateral to secure credit for non-farm investments (Shi et al., 2007). At the same time, grassland-abundant households may face weaker incentives to pursue off-farm work (Liu et al., 2014; Winters et al., 2009). More recent evidence from rural China suggests that stronger tenure security—a major outcome of the 1980s reforms—reduces the risk of land loss, which in turn encourages households to shift labor toward higher-return off-farm employment (Chang et al., 2018). This effect operates by relaxing the labor "guarding" constraint induced by insecure land tenure. When tenure is unstable, households must maintain a physical presence on their land to prevent reallocation, limiting off-farm labor mobility. Enhanced tenure security removes this constraint, enabling labor reallocation toward higher-return non-farm activities, a mechanism documented in both rural China and other developing contexts, including Mexico's land titling program (Mullan et al., 2011; de Janvry et al., 2015).

A further channel is government transfer programs. In China's pastoral regions, Grassland Ecological Compensation Policy (GECP) provide payments tied directly to grassland area (Hou et al., 2021). Although these programs raise herder income, the area-based design means that households with larger allocations receive disproportionately higher payments. Studies from Inner Mongolia show that the GECP has widened income disparities among herders (Li et al., 2021), making it a key mechanism through which historical allocation differences continue to shape contemporary inequality.

Grassland can also generate property income through rental markets. Households with excess grassland can lease it out and earn rental income (Benjamin and Brandt, 1997). Grassland-constrained households may rent additional land to reach more efficient production scales. Empirical evidence from rural China confirms that access to land rental markets allows households to scale up production and increase agricultural income (Jin and Deininger, 2009). This suggests that rental markets offer an important avenue for households to mitigate the constraints imposed by their initial endowments.

2.4. Research gaps and contribution

Our review of the existing literature reveals several important gaps that this study aims to address. First, the vast majority of inheritance research originates from developed countries and focuses on financial assets or real estate. There is limited evidence from developing countries where land represents the primary form of inherited wealth. This gap is particularly significant given that inheritance mechanisms may operate differently when the inherited asset serves as a primary productive asset rather than a passive investment.

Second, despite growing interest in the outcomes of land tenure reforms, most existing research focuses on their environmental or aggregate economic effects rather than their long-term distributional consequences. Understanding how these reforms shape inequality across generations is crucial for a comprehensive policy evaluation, yet this dimension has been largely overlooked.

Third, existing research on land-income relationships has not adequately addressed the causal identification challenges that arise when land holdings are endogenous to household characteristics and economic decisions. Our use of the 1980s historical land allocations as an instrument for current land holdings provides a robust approach to this identification problem.

Finally, while land rental markets are increasingly important in rural economies, their role in either exacerbating or mitigating historically-rooted inequality has not been systematically examined. Our analysis of heterogeneous effects based on rental market participation provides new insights into this important policy question.

Furthermore, while the literature on land tenure is extensive, it is predominantly focused on cropland systems, leaving a significant gap in our understanding of how these dynamics unfold in diverse pastoral contexts globally.

By addressing these gaps, our study contributes to multiple literatures and provides policy-relevant insights for China and other nations grappling with similar reforms. Our findings have implications for understanding the long-term consequences of land tenure reform, the persistence of inequality in rural areas, and the potential for market-based mechanisms to address distributional concerns.

3. Data

3.1. Data collection

Our analysis is based on data collected from a large-scale survey of Chinese herder households during 2018–2020. The survey covered five major pastoral provinces and regions in northern China: Inner Mongolia, Xinjiang, Tibet, Qinghai, and Gansu. These regions collectively account for approximately 70% of China's total grassland area, making them representative of the country's pastoral economy and providing sufficient variation for our analysis.

We employed a multi-stage stratified random sampling strategy to ensure representativeness across different grassland types and economic conditions. The sampling procedure involved multiple stages to achieve both geographic and economic diversity. First, we identified the three main grassland types in each province (alpine meadow, temperate steppe, and desert steppe). Within each grassland type, we stratified all counties into two groups based on per capita income levels and randomly selected one county from each stratum. This approach yielded six sample counties per province, with two exceptions due to local conditions.

In Gansu Province, alpine meadow represents the predominant grassland type. Consequently, we divided all counties in Gansu into four income quantiles and randomly selected one county from each, resulting in four sample counties. In Inner Mongolia, we excluded one county where herders had ceased grazing operations, leaving five counties in our sample. This strategy produced 27 counties across the five provinces.

Within each selected county, we implemented an additional stratification procedure based on per capita grassland area (high, medium, and low), randomly selecting one township from each category. This yielded 81 townships. At the village level, we selected two villages from each township: one from areas with higher per capita grassland holdings and another from areas with lower per capita holdings. This approach ensured that our sample captured the full range of grassland endowments within each geographic area.

As shown in Fig. 2, the final sample included 162 villages. Within each of these 162 villages, we obtained a comprehensive household roster and used it to randomly select 6-7 pastoral households for face-to-face interviews. This multi-stage sampling strategy is summarized in Appendix Figure A1. After removing four questionnaires with incomplete or inconsistent responses, our final analytical sample comprises 1022 household observations. We are confident that this sample is representative of the pastoral population in these regions, as it was generated through the rigorous stratified random sampling strategy detailed above.

The questionnaires collected detailed information on household demographics, income sources, current grassland use, and, which is essential for our identification strategy, the grassland area originally allocated to each household (or their parents) during the 1980s reform. Appendix Figure A2 presents the sample distribution based on this historical allocation variable. The figure shows that the vast majority of our sample (97.3%) are households that received (i.e., inherited) grassland rights from the 1980s allocation. Only 2.7% of the sample reported a historical allocation of zero, likely representing newcomers to the villages who are not part of the original intergenerational transfer. While inheritance is thus near-universal in our sample, Figure A2 also highlights the significant variation in the size of these allocations, which is

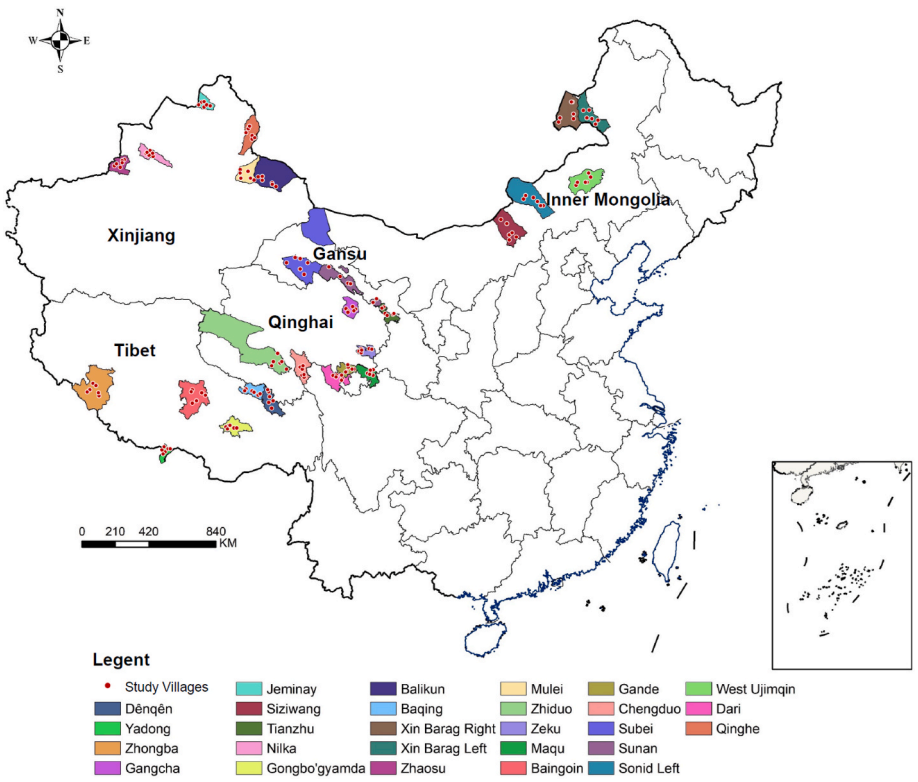

Fig. 2. Study area and sample counties.

the central focus of our study.

It is important to note that our survey targets the current generation of pastoral households residing in these villages. Cases where land was not inherited (e.g., the original family moved away, leaving no heirs) are systemically excluded from this sampling frame, as those households no longer reside in these villages to be surveyed. Our sample therefore correctly captures the population of "inheritors" (the subsequent generation), allowing us to test the long-term effect of the initial allocation as it was passed down.

3.2. Variable definition

3.2.1. Dependent variable

The primary dependent variable is household income (*Income*). This is measured as the total net household income from all sources (pastoral, off-farm, property, and transfer income) for the year 2017. *Transfer income* is a significant component in these regions, notably including payments from the Grassland Ecological Compensation Policy (GECP). In our preferred specifications, we use the natural logarithm, *ln(Income)*, to reduce skewness and interpret coefficients as elasticities.

3.2.2. Explanatory and instrumental variables

Our core explanatory variable is the present-day grassland area ($Area_{present}$), defined as the total area of grassland managed by the household. This variable is treated as endogenous. The instrumental variable is the historical allocation ($Area_{history}$), which is the grassland area allocated to the household's parents during the 1980s reforms.

3.2.3. Control variables

We include a standard vector of household-level control variables (X_{ij}) to account for other determinants of income (Yu and Bai, 2023). These include characteristics of the household head (gender, age, and years of education), household composition (total population and number of off-farm laborers), and production characteristics (number of grassland plots, livestock inventory and rental market participation).

To account for land heterogeneity, we also control for the Grassland Quality Index (*GQI*). This index is constructed based on plot-level data using Principal Component Analysis (PCA). It synthesizes five plot-level indicators (grassland rank, water access, topography, soil type, and aspect) into a single score for each plot, which is then aggregated to the household level using area-weighting. This variable allows us to isolate the effect of grassland area from that of quality.

To sum up, the definition, measurement method, and statistical characteristics of each variable in this paper are shown in Table 1.

3.3. Descriptive statistics

Table 1 presents the summary statistics for the 1022 sample households, providing a profile of the socio-economic context in these pastoral regions. The sample reflects the characteristics of remote rural areas: the average household head is 50.9 years old, predominantly male (90.9%), and has 4.15 years of formal education. The average household consists of 4.7 persons, with 0.78 members engaged in off-farm employment, indicating a high reliance on the pastoral economy.

This reliance is confirmed by the household income structure. The average annual income is 110,500 yuan (approx. 16,500 USD in 2017). Pastoral income is the primary component (70,800 yuan). This income is generated from an average livestock inventory of 290 sheep units—a standardized composite measure used to aggregate different livestock types (e.g., 1 cow = 5 sheep units; 1 horse = 6 sheep units). However, the high standard deviation of the livestock inventory (588.5) suggests significant heterogeneity in production scale.

Transfer income—primarily GECP payments—averages 15,700 yuan per household, accounting for 14.2% of annual income. This substantial share highlights the central role of ecological compensation in herder livelihoods and makes its area-based design potentially important for shaping wealth distribution. The estimated share closely aligns with national evidence from China's pastoral regions, where GECP payments typically contribute around 15% of household income, with reported ranges of 12–18% in major rangeland provinces such as Inner Mongolia

Table 1
Variable definitions and summary statistics.

Variable	Descriptions	Mean	S.D.	Min.	Max.
Income	Household income in 2017 (Unit: $\times 10^4$yuan)	11.05	15.43	0	274.88
$Area_{present}$	The area of grassland present used by households (Unit: $\times 10^3$mu)	6.63	14.40	0	190
$Area_{history}$	The area of grassland allocated in the 1980s (Unit: $\times 10^3$mu)	5.51	9.59	0	100.96
GQI	A composite grassland-quality index based on plot-level indicators: rank, water access, topography, soil type, and aspect.	0	1.285	−3.45	4.02
Gender	1 if a herder is male, and 0 otherwise	0.91	0.29	0	1
Age	Age of household head (in years)	50.88	12.06	22	96
Education	Years of schooling of household head (in years)	4.15	3.94	0	17
Plots	Number of grassland plots	2.59	1.32	0	8
Population	Number of persons in a household	4.70	2.08	1	18
Off-farm population	Number of labors employed by off-farm	0.78	1.09	0	8
Livestock inventory	Mid-year livestock inventory (in sheep units)	290.03	588.55	0	11,988
Rent-in	1 if a herder rents in grassland, and 0 otherwise	0.25	0.43	0	1
Pastoral income	Household pastoral income in 2017 (Unit: $\times 10^4$yuan)	7.08	14.41	0	269.38
Off-farm income	Household off-farm income in 2017 (Unit: $\times 10^4$yuan)	1.69	3.16	0	30
Transfer income	Household transfer income in 2017 (Unit: $\times 10^4$yuan)	1.57	2.54	0	31
Property income	Household property income in 2017 (Unit: $\times 10^4$yuan)	0.71	1.79	0	20.20

Notes: The sample size is 1022. One yuan is approximately equal to 0.14 US dollars; one mu is 0.0667 ha.

and the Tibetan Plateau (Hu et al., 2019). This consistency suggests that our sample of 1022 households reflects a representative income structure, supporting the external validity of our distributional analysis.

The land variables, which are central to this study, reveal the vast disparities in resource endowment. The average presently managed area ($Area_{present}$) is 6630 mu (approx. 442 ha), while the average historically allocated area ($Area_{history}$) is 5510 mu. These mean values, however, mask a profound inequality. The standard deviation of $Area_{history}$ (9590 mu) is nearly double its mean, and allocations range from zero to over 100,000 mu. As shown in Appendix Figure A2, 2.7% of the sample (likely newcomers) received no historical allocation, while 25% received less than 1000 mu. It is this persistent, large-scale variation in the "one-off" 1980s allocation that motivates our causal analysis.

Furthermore, the Grassland Quality Index (*GQI*) exhibits considerable variation (S.D. 1.285; range −3.45 to 4.02), indicating that the quality of these allocations is as heterogeneous as the quantity. Finally, the data show that 25% of households rent in grassland in the rental market. This descriptive statistic is vital, as it establishes that the rental market is an active institution used by one-quarter of herders. This provides the context for our later analysis, which investigates whether this market serves as a mechanism to mitigate the historical disparities we observe.

4. Methodology

4.1. Empirical strategy

This section outlines the empirical strategy for estimating the causal effect of historical land allocations on current income. First, we present a baseline OLS model (Equation (1)) to document conditional correlations and highlight its endogeneity issues. Second, we introduce our main 2SLS (IV) strategy (Equation (2)) to address these issues and identify the causal effect. Finally, we examine heterogeneous returns—the key mechanism behind inequality—by extending the 2SLS model with interactions based on historical allocation quartiles (Equations (3) and (4)).

Our primary objective is to investigate how historical land allocation affects income disparities among the current generation of pastoral households. We first specify a baseline econometric model:

$$Income_{ij} = \alpha_0 + \alpha_1 Area_{present_{ij}} + \alpha_2 X_{ij} + \nu_j + \mathscr{E}_{ij} \quad (1)$$

where $Income_{ij}$ is the income of household i village j for 2017. $Area_{present_{ij}}$ is the area of grassland present used by household i village j. X_{ij} is a vector of household-level control variables. The term ν_j captures village-level fixed effects that control for unobserved heterogeneity in geographic, climatic, and institutional factors that vary across villages. Finally, $\mathscr{E}_{ij}$ represents the idiosyncratic error term.

The estimation of Equation (1) via OLS faces significant endogeneity challenges. First, reverse causality may occur, as households with higher incomes may have a greater capacity to rent or purchase additional grassland. Second, unobserved household characteristics, such as superior management skills, may affect both income-generating capacity and land acquisition decisions.

To address these endogeneity concerns, we employ a two-stage least squares (2SLS) approach. Our instrument ($Area_{history_{ij}}$) is the grassland area allocated to the household's parents during the 1980s reform. The first-stage regression equation is specified as:

$$Area_{present_{ij}} = \beta_0 + \beta_1 Area_{history_{ij}} + \beta_2 X_{ij} + \nu_j + \mathscr{E}_{ij} \quad (2)$$

This strategy relies on the 1980s allocation being exogenous to current income levels, a premise supported by the historical context (Section 2.2) and statistical tests (Section 4.2).

To examine whether the returns to grassland area differ across levels of historical allocation, we extend the baseline 2SLS model by introducing an interaction term (following Yu, 2025). We partition households into quartiles based on the instrument, $Area_{history_{ij}}$, creating four dummy variables $Q_{k,ij}$ (where $k = 1,2,3,4$). Using the first quartile (Q_1, lowest allocation) as the reference group, the second-stage regression is specified as:

$$Income_{ij} = \alpha_0 + \alpha_1 Area_{present_{ij}} + \sum_{k=2}^{4} \alpha_k \left(Area_{present_{ij}} \times Q_{k,ij} \right) + \sum_{k=2}^{4} \delta_k Q_{k,ij} + \alpha_C X_{ij} + \nu_j + \mathscr{E}_{ij} \quad (3)$$

In this specification, $Area_{present_{ij}}$ and its three interactions ($Area_{present_{ij}} \times Q_{k,ij}$) are endogenous. The coefficient α_1 represents the income effect for the lowest-quartile group (Q_1), while α_2, α_3, and α_4 represent the *additional* marginal effects for quartiles Q_2, Q_3, and Q_4, relative to Q_1.

To identify these four endogenous variables, we use a corresponding set of four instruments: $Area_{history_{ij}}$ and its interactions with the quartile dummies, $Area_{present_{ij}} \times Q_{k,ij}$ for $k = 2,3,4$. The first-stage for $Area_{present_{ij}}$ is defined as:

$$Area_{present_{ij}} = \beta_0 + \beta_1 Area_{history_{ij}} + \sum_{k=2}^{4} \beta_k \left(Area_{history_{ij}} \times Q_{k,ij} \right) + \sum_{k=2}^{4} \pi_k Q_{k,ij} + \beta_C X_i + \nu_j + \varepsilon_{ij} \quad (4)$$

4.2. Discussion on instruments

A valid instrumental variable must satisfy two conditions: relevance (correlation) and exogeneity (exclusion restriction).

The relevance condition requires that the instrument ($Area_{history}$ be a strong predictor of the endogenous variable ($Area_{present}$). This condition is well-supported. First, as argued in Section 2.2, China's family-based production determines the intergenerational transfer of historical allocations. Second, Fig. 3 provides strong visual evidence of this correlation, showing a clear positive relationship between the residualized historical and present areas. Finally, the first-stage F-statistics reported in our empirical results are consistently high and well above the conventional threshold of 10, decisively rejecting concerns of a weak instrument.

Another condition is exogeneity, which requires that $Area_{history}$ affects *Income* only through its effect on $Area_{present}$. This assumption is warranted for several reasons, and our empirical strategy is designed to address its primary challenges.

First, the institutional details of the 1980s reform support the exogeneity assumption. As detailed in Section 2.2, the historical allocation was not a simple grassland grant based on political connections, but a complex, quality-adjusted administrative calculation. It was based on 1980s-era ecological assessments (carrying capacity) and demographics (family size). It is highly improbable that this specific, 40-year-old administrative calculation has any persistent, direct effect on current household income through any channel other than the physical land area that was allocated and subsequently inherited.

Second, the most significant threat to exogeneity is a potential omitted variable: land quality. Grassland quality is likely persistent over time, and it directly affects income. If $Area_{history}$ (the 1980s allocation) was correlated with grassland quality, then our IV estimate could be biased. We explicitly address this threat. As detailed in Section 3.2.3, we constructed a comprehensive GQI and have included it as a time-invariant control variable in all OLS and 2SLS specifications. By partialling out the direct effect of grassland quality, we ensure our instrument is identifying the causal effect of inherited area, holding quality constant.

Finally, we test other potential channels through which 'initial differences' from the 1980s context might affect current income. We test the hypothesis that 1980s family characteristics (e.g., historical population) affect current income through human capital persistence. As shown in Appendix Table A1 (Column 4), we find no statistically significant correlation between 1980s household population and current income. We also test for the influence of historical regional development (using 1982 county population density) and find no correlation (Table A1, Column 6).[2] The inclusion of village-level fixed effects in our preferred models further absorbs any time-invariant unobserved geographic or institutional factors.

Based on these institutional details, the inclusion of the GQI, and these empirical tests, we are confident that our instrument satisfies the exogeneity condition.

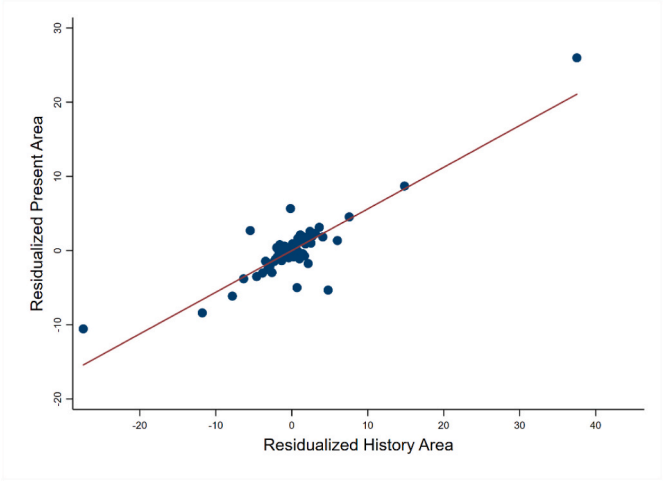

Fig. 3. Residualized plot of present area against history area.
Notes: This figure shows the binned scatter plot of residualized present area against residualized history area. Each dot denotes the in-group average residuals, partialing out country FEs, household controls.

5. Empirical results

This section presents the empirical findings of our study. We first estimate the baseline causal effect of grassland inheritance on household income, then examine the main channels through which this effect operates. Next, we delve deeper into the inequality implications by examining heterogeneous returns, followed by an analysis of the mitigating role of the grassland rental market. Finally, we conduct robustness tests to validate our findings.

5.1. The income effect of grassland inheritance

Table 2 presents the results of our empirical analysis. Columns (1) and (2) show the baseline OLS estimates, which suggest a positive correlation between present grassland area and household income. Columns (3) and (4) report our preferred 2SLS estimates, which address the endogeneity concerns outlined in Section 3.2. These models include all household controls, the GQI, and village-level fixed effects.

The second-stage results (Column 4) reveal a significant positive causal effect of the present grassland area on household income. The magnitude of the 2SLS coefficient is notably larger than its OLS counterpart, which suggests that OLS estimates may understate the true income effect of grassland. To better interpret the economic significance, we utilize the log-log specification (Table 2, Column 5). The result indicates that, all else being equal, a 1% increase in the present grassland area leads to a 0.223% increase in household income.

We also estimate the direct relationship between the 1980s allocation and current income (the reduced-form). Our calculation shows that for every 1% increase in the historically allocated grassland area, the current generation's income rises by 0.119%.

While this elasticity (0.119%) appears modest in magnitude, its implications for income inequality are significant when placed in the socio-economic context detailed in Section 3.3. As established in our descriptive findings (Table 1) and Appendix Figure A2, the 1980s allocation was highly unequal, resulting in extreme variations in endowments. Some households received less than 1000 mu (approx. 67 ha), while others received over 100,000 mu. This elasticity implies that a household that inherited, for example, 10 times more grassland than an otherwise similar household would have a present-day income that is approximately 27% higher, solely due to this historical event. This finding suggests that the 1980s historical allocation, passed down through inheritance, is a key explanatory factor for contemporary income disparities among herders.

[2] It is common in economic literature to reflect the historical economic development level of a city through population density, famous ones include Acemoglu et al. (2002).

Table 2
OLS and 2SLS regression results.

	(1)	(2)	(3)	(4)	(5)
	Income (OLS)		*Income* (2SLS)		*ln(Income)* (2SLS)
$Area_{present}$	0.190*** (0.051)	0.142*** (0.050)	0.245*** (0.080)	0.240** (0.120)	
$Ln(Area_{present})$					0.223*** (0.070)
GQI	2.550*** (0.610)	2.215*** (0.580)	2.490*** (0.750)	2.180*** (0.710)	0.105*** (0.035)
Gender	−0.650 (1.730)	0.690 (1.920)	0.590 (1.780)	−0.455 (1.720)	0.061 (0.090)
Age	0.019 (0.031)	0.030 (0.040)	0.017 (0.037)	0.030 (0.032)	0.003* (0.002)
Education	1.100*** (0.205)	0.570* (0.299)	0.585*** (0.203)	1.085** (0.280)	0.020*** (0.008)
Plots	−0.790* (0.418)	0.300 (0.430)	0.210 (0.415)	−0.870** (0.440)	0.018 (0.023)
Population	0.085 (0.136)	0.403** (0.195)	0.120 (0.137)	0.384** (0.185)	0.031** (0.013)
Off-farm population	1.053*** (0.331)	1.578*** (0.423)	1.045*** (0.325)	1.512*** (0.382)	0.218*** (0.028)
Livestock inventory	0.018*** (0.003)	0.015*** (0.002)	0.017*** (0.004)	0.014*** (0.003)	0.001*** (0.0003)
Rent	7.341*** (1.593)	3.418** (1.461)	7.384*** (1.581)	3.153** (1.351)	0.152** (0.071)
Fixed effects	No	Yes	No	Yes	Yes
R^2	0.182	0.415	0.179	0.402	0.615
Obs.	1022	1022	1022	1022	1022

Notes: The standard errors of the clusters at the village level are in parentheses. *, **, and *** represent 10, 5, and 1% significant level respectively.

5.2. Mechanism analysis

Having established that inherited grassland area causally affects income, we next investigate how. Understanding the specific channels through which this effect operates is essential for designing effective policy. As outlined in our literature review, the primary potential channels linking grassland to income in this context are pastoral production, off-farm income, transfer income, and property income.

We adopt the 2SLS framework to estimate the effect of $Area_{present}$ on each of these four income components separately. The results are reported in Table 3. The analysis reveals that the total income effect is transmitted through two specific and significant channels: Pastoral income (Column 2) and *Transfer income* (Column 4). Conversely, we find no statistically significant effect on Off-farm income or Property income.

These findings are consistent with the specific socio-economic and policy context of China's pastoral regions. First, the strong positive effect on Pastoral income (Table 3, Column 2) confirms the primary role of grassland as a productive asset. As detailed in our descriptive profile, pastoralism is the dominant livelihood. Inheriting a larger grassland area directly enables a herder to sustain a larger, more productive herd, which is the main driver of pastoral income.

Second, the significant effect on *Transfer income* (Table 3, Column 4) reveals a policy-driven mechanism. This income component is dominated by ecological compensation payments. Because these subsidies are explicitly tied to the area of grassland a household holds, inheriting a larger allocation de facto means inheriting a larger, recurring government subsidy claim. As detailed in the descriptive statistics, these ecological payments represent over 14% of the total income for an average household. Since these payments are directly linked to the historical grassland area, this magnitude explains why land inheritance has such a strong effect on contemporary income inequality through the transfer channel. This finding echoes Zhang et al. (2019), who found that Ecological Welfare Forest Program (EWFP) payments contributed to 16% of agricultural income inequality in rural Anhui. Our results extend this observation to pastoral regions, demonstrating that area-based ecological subsidies can reinforce income inequality in grassland allocation.

This analysis clarifies that historical allocations shape current inequality through two distinct pathways. They directly influence income derived from pastoral production by setting the scale of the primary productive asset. Simultaneously, they influence income derived from ecological subsidies that are linked to grassland area. Policies aimed at mitigating intergenerational inequality should therefore address both channels. While strengthening grassland rental markets can weaken the link between historical allocations and production income, transfer programs such as the GECP require a move beyond flat, area-based payments. A tiered compensation scheme, providing higher subsidy rates for subsistence-level holdings and declining marginal payments for larger areas, could preserve a basic safety net without reinforcing scale-based inequality. Further shifting toward performance-based incentives tied to verified ecological outcomes, rather than managed area, would better align public spending with conservation goals while decoupling income support from historical land endowments.

Table 3
The mechanism analysis results.

2SLS	(1)	(2)	(3)	(4)	(5)
	Total income	*Pastoral income*	*Off-farm income*	*Transfer income*	*Property income*
$Area_{present}$	0.251*	0.187*	−0.012	0.085**	−0.010
	(0.136)	(0.103)	(0.019)	(0.042)	(0.010)
First-stage regression	$Area_{present}$				
$Area_{history}$	0.562**	0.562**	0.562**	0.562**	0.562**
	(0.229)	(0.229)	(0.229)	(0.229)	(0.229)
F-value	38.08	38.08	38.08	38.08	38.08
Control variables	Yes	Yes	Yes	Yes	Yes
Fixed effect	Yes	Yes	Yes	Yes	Yes
Obs.	1022	1022	1022	1022	1022

Notes: The standard errors of the clusters at the village level are in parentheses. *, **, and *** represent 10, 5, and 1% significant level respectively.

5.3. Heterogeneous returns and inequality

Our 2SLS estimates confirm that inherited grassland has a significant average positive effect on present-day income. This finding, however, may mask the more detailed mechanisms through which inheritance shapes income inequality. If the income returns to grassland are uneven, varying with the size of the holding, then the intergenerational persistence of land allocations could be actively expanding income disparities. We explore this possibility by moving beyond the average effect and examining heterogeneous returns.

We hypothesize that such heterogeneity in returns is rooted in the biophysical realities of pastoral production. Unlike crop farming, pastoralism is a land-extensive livelihood. A herd requires a minimum area not only for adequate forage but also for seasonal movement and to prevent rapid overgrazing and degradation of a constrained plot (Sallu et al., 2009; Shu and Su, 2015). If the allotted grassland area is too small, it cannot sustainably support a herd of a size sufficient to be economically viable; the fixed costs of labor and herd management cannot be met by the output from a small, ecologically-stressed plot. This implies that a minimum operational scale is required for grassland to generate significant economic returns, particularly for managing cattle (Hu et al.,

2019).

Fig. 4(A) visualizes the results of our 2SLS interaction model (Equations (3) and (4)), which plots the marginal effect of $Area_{present}$ on Income across quartiles of the historical allocation ($Area_{history}$). The findings are consistent with this hypothesis. We define the historical allocation quartiles as Q1 (≤999 mu, approx. 66 ha), Q2 (999–3000 mu), Q3 (3000–6397.5 mu), and Q4 (≥6397.5 mu).

The marginal returns to grassland area for households in the lowest (Q1) and second (Q2) endowment quartiles are statistically insignificant, which means that these households are unable to convert additional land into meaningful income gains. This pattern suggests that their holdings fall below the minimum scale needed for viable production, and that surpassing this threshold is necessary to unlock the land's economic value. In contrast, the income effect becomes both large and statistically significant only for the third (Q3) and highest (Q4) quartiles, with Q4 households earning substantially higher returns than all other groups. These results point to a Matthew Effect in pastoral production: land inheritance shapes inequality not only through the initial size of allocations, but through a scale-dependent return structure in which only those inheriting above a certain threshold can fully realize the economic potential of their land.

This evidence suggests that the 1980s allocation creates a persistent, structural disadvantage for households that inherited low endowments. It is pertinent, therefore, to ask if any mechanisms exist to mitigate this historically-rooted disparity. We next explore the role of the grassland rental market, a modern institution theorized to solve the mismatch between grass and livestock by facilitating land access (Jin and Deininger, 2009; Tan and Tan, 2017).

5.4. The mitigating role of the rental market

The analysis in the previous section demonstrates that historical grassland allocations create a persistent, structural disadvantage, particularly for households that inherited small allotments. It is pertinent, therefore, to ask if any mechanisms exist within the current system to mitigate this historically-rooted inequality. We next explore the role of the grassland rental market.

Our 2SLS analysis of this market is visualized in Fig. 4(B). These results, derived by splitting the sample based on whether households "rented in" grassland, reveal a clear distinction. For households that did "Not rented in," the coefficient for inherited area remains positive and highly significant, confirming their income is strongly influenced by their original allocation. Conversely, for households that actively participate by "renting in" land, the coefficient becomes statistically insignificant. This suggests that the rental market can indeed weaken this intergenerational persistence.

Fig. 5 provides descriptive evidence that explains the mechanism behind this finding, based on a comparison of households engaging in "rent-in" behavior. The data reveals the profile of households that actively participate in the rental market. These households are, on average, historically "grassland-poor." As shown in Fig. 5, the "rent-in" group has a significantly smaller average historical allocation (4540 mu) and currently owns less grassland (3862 mu) compared to the non-renting group (5776 mu and 6,553, respectively). The differences are statistically significant.

Despite this initial disadvantage, these households use the market to overcome their inherited constraints. By renting in a substantial amount of grassland (4172 mu on average), their present managed area (8001 mu) exceeds that of the non-renting group (6250 mu), though this difference is not statistically significant. This pattern in our grassland setting aligns with Jin and Deininger (2009) for farmland, showing that disadvantaged households actively use land markets to expand their operational scale.

This strategy of scaling up translates into substantial income gains. As Fig. 5 shows, the total income of the "rent-in" group (173,250 yuan) is more than double that of the non-renting group (85,040 yuan), with a highly significant difference of 88,200 yuan. The income differential is

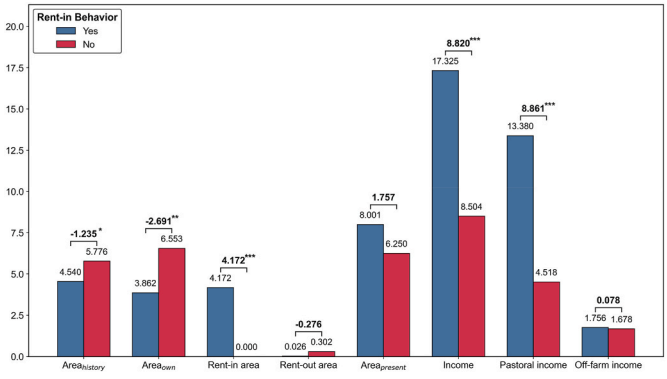

Fig. 5. Comparison of grassland area and income by rent-in behavior.
Notes: Bars show mean values for households engaging in rent-in behavior (Yes, blue) versus those not renting in (No, red). Numbers above bars indicate group means, and brackets show the difference with t-statistics. Grassland area is measured in $\times 10^3$ mu and income is measured in $\times 10^4$ yuan. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively. One yuan equals approximately 0.14 US dollars; one mu equals 0.0667 ha. Sample includes 220 rent-in households and 802 non-rent-in households (N = 1022). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

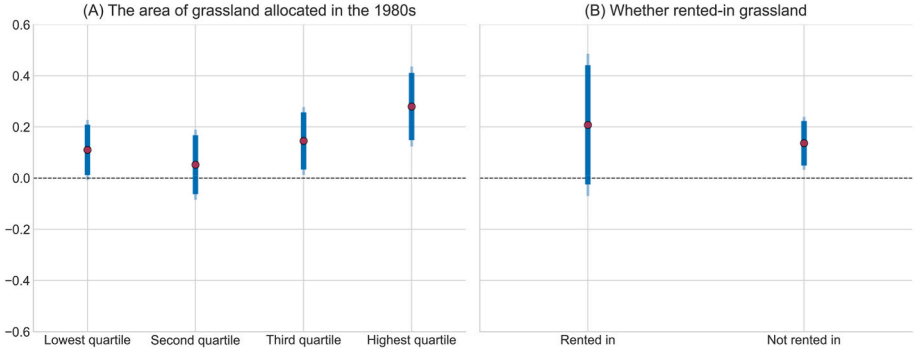

Fig. 4. Heterogeneous income effects.
Notes: The figure plots 2SLS coefficient estimates (red dots) and their 95% (90%) confidence intervals. Panel (A) displays the marginal effects from the 2SLS interaction model (Equations (3) and (4)), estimated for each quartile of the $Area_{history}$. Panel (B) displays 2SLS coefficients from a sub-sample analysis based on "rented in" status. All regressions include household controls, the GQI, and village-level fixed effects. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

driven almost entirely by pastoral income (133,800 yuan versus 45,180 yuan, difference of 88,610 yuan), while off-farm income remains statistically indistinguishable between the two groups (17,560 yuan versus 16,780 yuan). The evidence indicates that the grassland rental market is being used by herders with smaller historical allocations to scale up production and achieve higher incomes from pastoral activities. It thus serves as a mechanism for mitigating the income inequality rooted in the 1980s allocations.

While this evidence highlights the potential of the rental market to mitigate inherited disparities for those who participate, the finding must be interpreted with caution. Our data, which shows that "renting in" is beneficial, does not address potential barriers to entry, such as access to capital, credit, or information, that may prevent the poorest households from participating in the rental market in the first place. Furthermore, this analysis does not capture the long-term, aggregate effects of market development. It is plausible that rental income could flow disproportionately to land-rich households, or that market activity could lead to land concentration, potentially exacerbating inequality through different channels in the long run. These concerns highlight the need for careful policy design and further research into the equity implications of these markets.

5.5. Robustness test

To further ensure the reliability of the conclusions, we also conduct a series of robustness tests based on the instrument regression. The corresponding results are reported in Table 4.

First, the pastoral income is determined only by the number of livestock sold that year. However, some herders raised much livestock but did not choose to sell that year, so the herders' pastoral income may be 0. To make the study samples more comparable, samples with the pastoral income of 0 were excluded. The regression results are reported in Column (1) of Table 4, which are highly consistent with the baseline case. Furthermore, while our log-log specification already mitigates the effect of outliers, we conduct an additional, more stringent robustness check. To ensure our estimates are not driven by a few highly influential observations at the extremes of the distribution, Column (2) of Table 4 removes the samples with the highest and lowest 5% of pasture area. The research results remain unchanged, confirming the stability of our findings.

In addition, the aforementioned explained variable was chosen as the annual income at the household level. A concern is that herders with high household incomes do not necessarily have high per capita incomes. To exclude this adverse effect, Column (3) of Table 4 replaces the explained variable with per capita income, and the regression results are unchanged. Finally, we assume that the sample heteroscedasticity is independent of each other and use robust standard errors to replace clustered standard errors at the village level. Column (4) of Table 4 shows that the results are still robust.

Table 4
The results of robustness test.

	(1)	(2)	(3)	(4)
2SLS				
$Area_{present}$	0.188**	0.728*	0.061*	0.251**
	(0.075)	(0.389)	(0.034)	(0.103)
First-stage regression				
$Area_{history}$	0.699***	0.363***	0.562**	0.562***
	(0.148)	(0.080)	(0.229)	(0.166)
F-value	63.12	298.46	38.08	20.28
Control variables	Yes	Yes	Yes	Yes
Fixed effect	Yes	Yes	Yes	Yes
Obs.	852	971	1022	1022

Notes: *, **, and *** represent 10, 5, and 1% significant level respectively.

6. Discussions and conclusion

Drawing on survey data from 1022 pastoral households in northern China, this study examines how the one-off grassland allocations of the 1980s continue to shape contemporary income inequality. Using a 2SLS strategy that instruments current grassland holdings with their historical allocations, we show that inherited land has a significant causal impact on present-day income. Every 1% increase in historically allocated grassland raises current income by 0.119%.

This confirms that the intergenerational transfer of productive assets is a fundamental driver of pastoral inequality. While traditional inheritance research often focuses on liquid wealth, our results align with the broader rangeland literature which emphasizes how the formalization of grazing rights creates durable wealth gaps (Banks, 2003). By focusing on grassland use rights, we identify a mechanism where the fixed nature of land endowments in pastoral societies creates a more rigid form of inequality than that seen in urban settings. This reflects a global trend where land-based inheritance determines the long-term viability of traditional livelihoods.

We also find that the grassland rental market serves as a critical flexibility mechanism. Unlike some pastoral contexts in West Africa where land formalization has restricted the access of the poorest herders (Turner, 2016), the rental market in our study area allows land-constrained households to overcome their initial endowments. This supports the argument that institutional arrangements which facilitate land access can help maintain the viability of pastoral livelihoods. Our evidence indicates that market-based mobility can mitigate the rigidities of historical land grants. This highlights the importance of inclusive land markets in preventing the permanent marginalization of small-scale herders. Such market-based flexibility is crucial for facilitating multifunctional land use transitions (Bradfield et al., 2023). As pastoral regions navigate the complexities of globalization and industrial transformation, enhancing land transfer mechanisms can help scale-dependent producers overcome historical constraints and achieve more inclusive development outcomes (Liu et al., 2022).

Our findings regarding scale-dependent returns resonate deeply with observations from other land-extensive pastoral systems. In regions like Central Asia and the Mongolian plateau, the transition from collective systems to individual tenure has often created a structural disadvantage for smallholders who fall below a viable production scale. The insignificance of returns for low-endowment households in our study suggests a 'minimum scale' threshold. This mirrors global patterns where a certain land base is required to buffer against environmental risks and maintain herd mobility (Sallu et al., 2009). Our study provides empirical evidence for how historical allocations set households on diverging economic trajectories based on these biophysical constraints.

To reduce the inequality rooted in historical grassland allocations, our findings point to three sets of policy implications. First, expanding stable off-farm employment opportunities is crucial. Many pastoral areas are geographically remote and offer few local wage jobs. Policy should therefore prioritize the development of locally grounded industries, such as ecotourism and value-added processing of pastoral products, to create alternative income pathways for herders with limited grassland resources.

Second, the grassland rental market should be further developed to improve access and efficiency. Our results show that land-poor herders use rental markets to overcome historical constraints and scale up their operations. Improving market efficiency, such as lowering transaction costs, can strengthen this equalizing mechanism. Because renting in land requires capital, market development should be paired with targeted financial support, including preferential lease loans, to ensure that the poorest households are not excluded by high entry costs.

Third, market development must be complemented by regulatory safeguards. Effective monitoring is needed to prevent excessive land concentration and to ensure that rental income does not disproportionately accrue to already land-rich households. Without such

oversight, the rental market could unintentionally reinforce the very inequalities it is meant to mitigate.

Despite the extensive analysis, several limitations remain. This study relies on cross-sectional data, and although the IV strategy helps address endogeneity, it cannot capture the dynamic processes through which inequality evolves. Panel data would provide stronger control for time-invariant household traits. In addition, the analysis centers on inherited grassland use rights as the main source of inequality. Intergenerational transfers in pastoral societies are more complex, and other inherited assets such as livestock, financial capital, and social networks may also shape long-term outcomes. While current asset stocks are controlled for, future research should examine how these different forms of inherited wealth interact to influence economic trajectories.

Availability of data and materials

The authors do not have permission to share data.

Statements and declarations

The authors declare that they have no conflicts of interest related to this work.

CRediT authorship contribution statement

Hefei Bai: Conceptualization, Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. **Zhijian Yu:** Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We are grateful to Yazhen Gong, Lingling Hou, Jikun Huang, Zhibiao Nan for their continuous guidance and support on data and project. We also appreciate comments from Xiaohua Yu, Eric Edwards, Zhen Zhong, Jialing Huang, Xiaolong Peng. We also acknowledge support by the Open Access Publication Funds of the Göttingen University.

Appendix

Table A1
Verify exogeneity of instruments

OLS: Income as the dependent variable						
	(1)	(2)	(3)	(4)	(5)	(6)
$Area_{present}$	0.177*** (0.046)		0.155*** (0.050)			
$Area_{history}$		0.170** (0.067)	0.083 (0.072)			
History pop				0.039 (0.206)		
Grassland resource					0.360 (10.559)	
Pop density						−0.054 (1.570)
Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.357	0.367	0.364	0.352	0.348	0.352

Note: The standard errors of the clusters at the village level are in parentheses. *, **, and *** represent 10, 5, and 1% significant level respectively.

Table A2
First stage regression results

	$Area_{present}$		Ln ($Area_{present}$)
$Area_{history}$	0.993*** (0.054)	0.562** (0.229)	
$Ln(Area_{history})$			0.548*** (0.070)
Control variables	Yes	Yes	Yes
F-value	74.76	38.08	31.37
Obs.	1022	1022	1022

Note: The standard errors of the clusters at the village level are in parentheses. *, **, and *** represent 10, 5, and 1% significant level respectively.

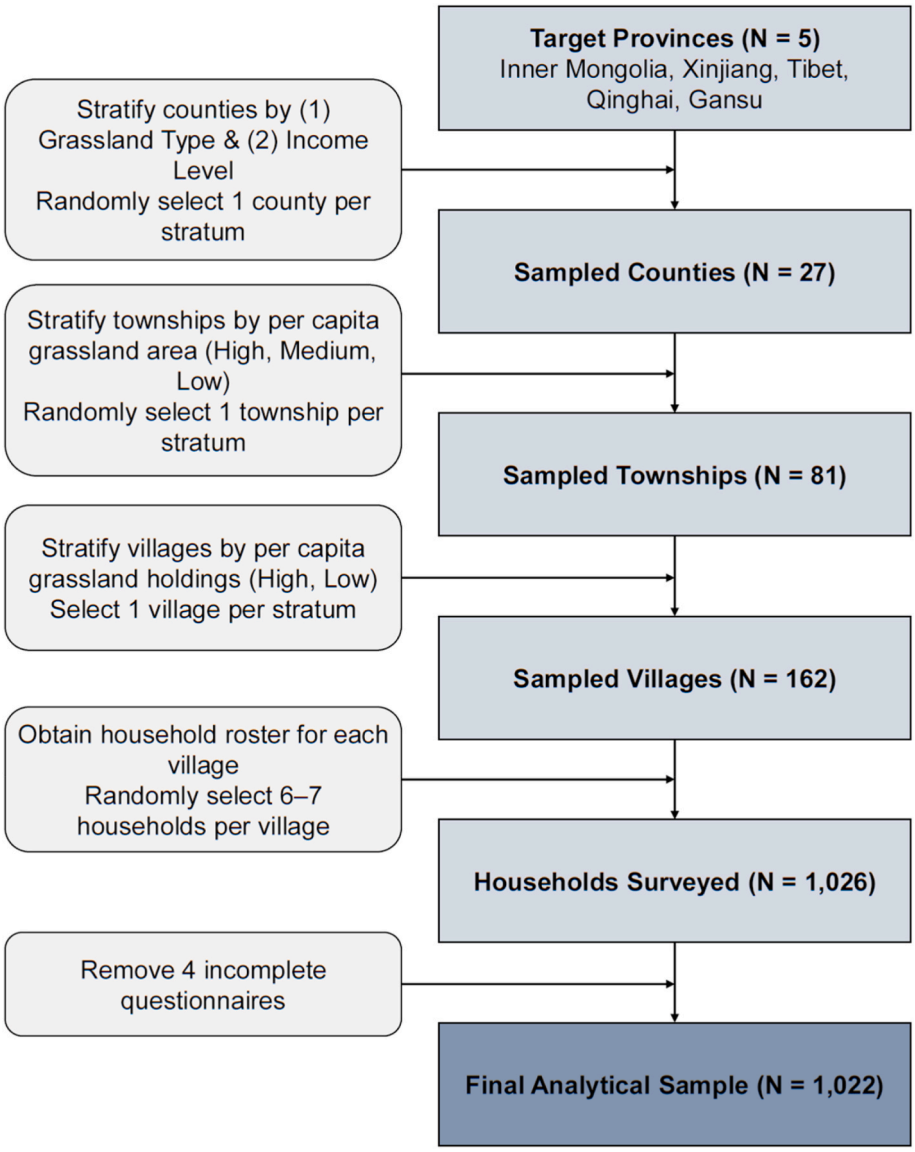

Fig. A1. Multi-stage stratified sampling strategy.

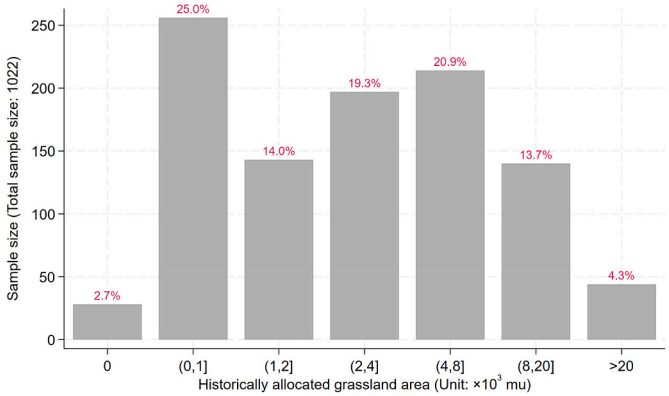

Fig. A2. Sample distribution (based on historically allocated grassland area).

Data availability

The authors do not have permission to share data.

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