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Impacts of covid-19 lockdown measures on pastoralism on the Tibetan plateau: risk analysis of pastoralism under increasing marketization

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Key words: Pastoralism; COVID-19; Marketization; Risks; Tibetan Plateau

Abstract

With the animal husbandry production transformed from subsistent to commercial, the marketization in China pastoral areas has been increasingly developed. It is characterized by increasing dependency on fodder purchase, pasture lease, microcredit, and strategic livestock sale in response to market fluctuations. Marketization is a double-edged sword, offering both opportunities and challenges. However, the mechanisms leading to negative outcomes, especially in pastoral areas, have been understudied. The COVID-19 pandemic and subsequent lockdowns provide a natural experiment to understand the impacts of sudden shocks on marketized pastoralism. Here we examine the lockdowns' impacts on herders' daily life and livestock production in two counties with different marketization degree on Tibetan Plateau, using data from semi-structured interviews and field surveys conducted from December 2022 to August 2023. We find that the lockdowns' effects on herders' daily life and livestock production, revealing a direct link between market engagement and vulnerability of facing lockdown. This vulnerability stems from lacking local risk-management institutions through the nascent marketization in Tibetan pastoral areas. The replacement of traditional uncertainty management by market mechanisms has also amplified market risks. Therefore, we recommend enhancing herders' involvement in designing markets to reduce risks and integrating traditional pasture knowledge with market mechanisms to build a more resilient and sustainable pastoral economy.

Introduction

The pastoral rangeland is a complex nexus of social, economic, and ecological systems. Over millennia, the interplay between human activities and the natural rangeland ecosystem has culminated in an intricate and inseparable triadic system of "grass—livestock−humans".Pastoralism−the extensive use of rangelands through mobile livestock—is a vital livelihood practice globally（Scoones and Nori, 2023）. Today, rangelands are home to billions of people, providing food that feeds us. Rangelands are vast and diverse, covering over half of our planet's land（ILRI et al., 2021）. This system delivers key ecosystem services and contributes to landscape functionality, thereby benefits a broader demographic (Hoffmann et al., 2014).

Pastoralism has encountered risks from natural disasters such as droughts, heavy snow, and storms, yet the nomadic practices rooted in traditional customs have demonstrated resilience and adaptability. However, nowadays, herders confront a wider spectrum of risks and uncertainties, which are caused by structural shifts within global political and economic spheres, including land acquisition and marketization as well as climate change (Scoones and Nori, 2023). In China's pastoral regions, along with the privatization of livestock ownership and rangeland management rights, marketization mechanism has been increasingly applied to cope with the risks and uncertainties, rather than the traditional nomadic practices. . Consequently, the livestock production and herders' livelihoods have been becoming more market-dependent (Dalingtai et al., 2010; Gongbuzeren, 2019). The dynamics of pastoralism under marketization needs to be in-depth studied..

Following the emergence of COVID-19 in China in December 2019, the pandemic outbroke and spread across the nation. Consequently lockdown was taken as the main measure to control the pandemic in China in the next 3 years until the official lifting on December 5, 2022, although the stringency and timing of lockdown varied by regions. For herders on the Tibetan Plateau, the primary lockdown period was from June 2022 to the early December 2022, which lasted around half year. The COVID-19 crisis presents a unique opportunity to re-evaluate the human-environment relationship. Additionally, the lockdown provides a natural experiment to study the impacts of sudden external shocks on pastoralism under a marketized context.

Current researches related to the impacts of the COVID-19 pandemic on pastoralism mainly focus on two aspects. Firstly, some studies examined pastoral health conditions and disease prevention from health and safety perspectives, proposing comprehensive public health measures such as the "One Health approach" (Egeru et al., 2020; Elsevier, 2020; Griffith et al., 2020; Griffith et al., 2021). Secondly, by rapid surveys and interviews during the pandemic, scholars investigated the immediate and direct effects of the lockdown on herders' lives(Gelgelo and Tsedu, 2022), focusing on human and livestock mobility(Simula G, et al.,2020; Gelgelo and Tsedu, 2022), livestock product sales(Ilukor J et al., 2022;), children education(Simula G, et al.,2020;), and herders' coping strategies(Maryam R et al., 2020). These studies underscored the flexibility, innovation, and resilience of herders in the face of restrictions of lockdown (Simula G et al., 2020; Simula G, 2023; Joana et al., 2023). However, the lockdown's impacts on pastoralism transcends regional and temporal boundaries, affecting not only the immediate and local system but also continuous and broader ones, particularly in the context of increasing marketization.

In this paper, taking two pastoral counties with varying degrees of marketization on the Tibetan Plateau as case study sites, we assess the impacts of the COVID-19 lockdown on herders' lives and livestock production, including both immediate and post-pandemic impacts. By using comparative analysis, we evaluate the lockdown's impacts on these areas, and explore the the causes behind the different outcomes from the perspective of institutional risks

The marginal contributions of this article include two aspects. First, in addition to the immediate impacts, our studies report the subsequent impacts on post-pandemic pastoralism. Second, we report the new challenges that market and credit brings to pastoralism, which are often considered effective ways to avoid or mitigate risks caused by climate or natural disasters (Lu, et al., 2022). We suggest that increasing herders' participation in market design to mitigate risks and integrating traditional pasture knowledge with market mechanisms to foster a more resilient and sustainable pastoral economy.

Methods

1. *Case areas*

This study examines two case areas on the Tibetan Plateau: Qilian County within the Haibei Tibetan Autonomous Prefecture of Qinghai Province, and Maqu County within the Gannan Tibetan Autonomous Prefecture of Gansu Province (Figure 1). Both regions are characterized by their high-altitude pastoral settings. Qilian County is nestled in the central part of the Qilian Mountains in northeastern Qinghai, whereas Maqu County is positioned on the eastern periphery of the Tibetan Plateau. Despite their similarities in altitude, topography, and climate, the two areas exhibit distinct marketization levels, with livestock husbandry being the principal economic activity for the local herders. Yak, Tibetan sheep, and a modest number of horses constitute the primary livestock, and the herder demographic is predominantly Tibetan.

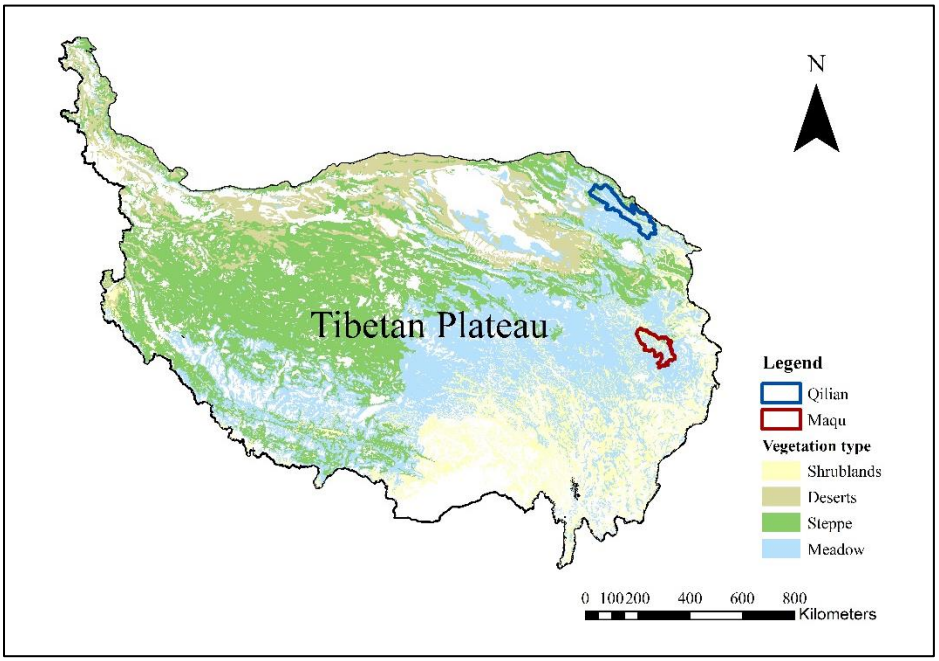

Figure 1. Map of the study case areas, Qilian and Maqu

2. *Data collection*

The research methodologies encompassed in-depth interviews and the administration of questionnaires, with key informants including village authorities, and the survey was directed at herder households within the villages. The in-depth interviews with principal stakeholders delved into lockdown protocols, overall impacts, coping strategies, and timelines, which shaped the questionnaire's content and pinpointed potential variables of impact. Employing a snowball sampling technique, one village per case area was selected for the survey, yielding data from 51 households: 20 from H Village in Qilian County and 31 from G Village in Maqu County. The study captured the strict lockdown period from June to December 2022, with the nationwide lockdown being rescinded on December 7, 2022. Data was collected for one year prior to and one year following the lockdown, encompassing 2021 (pre-pandemic), 2022 (pandemic period), and 2023 (post-pandemic), facilitating a comparative analysis. However, certain variables, such as loans livestock mortality and reproduction exhibited delayed effects: the majority of herders procured bank loans in early 2023 to meet heightened living and production expenses, suggesting that 2023 loan data is indicative of the 2022 pandemic impacts, while 2022 loan data reflects pre-pandemic cash needs from 2021. Similarly,

despite the stringent lockdown measures being implemented in the autumn of 2022, the production impact leading to increased livestock mortality and decreased reproductive rate occurred in the following spring. Therefore, the data for 2023 represents the effects of the 2022 lockdown, while the data for 2022 represents a normal year before the lockdown. Other variables align with this pattern: 2022 data signifies the lockdown's impacts, 2021 pre-lockdown, and 2023 post-lockdown conditions. The questionnaire's first section evaluated the lockdown's overall impacts on herders' lives, including effects on routine herding practices, healthcare accessibility, shopping, and education. The second section concentrated on livestock production data across eight dimensions: livestock, pricing, fodder costs, pasture leasing or quota trading, loans, livestock mortality, reproduction and growth. Additionally, as ancillary data, the study collected temperature and precipitation statistics for the case areas from the EU and the European Centre for Medium-Range Weather Forecasts. Moreover, the principal author of this paper, being a Tibetan scholar, ensured that language barriers were surmounted during interviews and surveys.

3. Research Hypothesis

During our fieldwork in the two case study areas, a striking disparity was observed by the research team regarding the perceived impacts of COVID-19 lockdown measures on herders. Despite the lockdown's duration and nature being uniform across both locations, the experiences of herders in Qilian and Maqu diverged markedly. Herders in Qilian articulated a significantly heightened impacts from the lockdown, which impeded their ability to sell yak and sheep. Consequently, they encountered substantial financial strain, resulting in economic losses, accumulated debt, and the looming threat of insolvency. Conversely, Maqu herders reported a negligible impact from the lockdown. Although they also encountered challenges in livestock sales, they viewed the deferral of such transactions as a minor inconvenience, confident in their ability to sell their animals in the subsequent year. This observation begets a critical inquiry: under seemingly identical geographical and social conditions, how did uniform lockdown measures yield such divergent outcomes?

Considering transportation, regional connectivity, and pasture usage methods in our two case studies, we speculate that Qilian's pastoral region exhibits a higher degree of marketization compared to Maqu. This leads us to wonder if the marketization levels affect a region's resilience to external shocks or disaster mitigation. Consequently, we advance the central hypothesis of our study: There is a positive correlation between the level of marketization in pastoral areas and the severity of the impacts on livestock production due to pandemic-induced lockdowns.

4. Variables and Measurements

4.1 Life and Production

From initial in-depth interviews, it emerged that China's "zero-COVID" policy had kept COVID-19 infections nearly non-existent in pastoral regions prior to the lockdown's end in late 2022. The pandemic's influence in these areas was largely indirect, stemming from lockdown measures' disruption to the daily lives and livestock operations of herders. Consequently, this study identifies two key dependent variables: the lockdown's impacts on herders' lives and on livestock production (Table 1). The effects on herders' lives are distilled into four core domains: herding, healthcare, shopping, and schooling. Herding, while a production component, is primarily a daily life aspect for herders, encompassing tasks like looking after livestock, watering, feeding, and so forth. Healthcare captures non-COVID-19 hospital visits for illnesses, check-ups, childbirth, and medication. Shopping pertains to the procurement of daily necessities, and schooling covers the educational continuum from primary to university levels for students in pastoral regions.

The pandemic lockdowns' influence on livestock production is primarily evident in three key areas: impediments to sell, increased herding expenses, and production losses. This study employs these indicators to gauge the lockdowns' production effects. Firstly, livestock sale, a vital economic activity for herders, were disrupted by lockdowns that hindered mobility and transportation, affecting the trade between herders and traders. The impact on sale is twofold: timing and volume. Timing refers to sale delays or cancellations due to lockdowns, typically aligning with the optimal selling period from September to mid-October when livestock are in peak condition. In 2022, this period coincided with strict lockdowns, severely limiting trader movement and livestock transport, obstructing sales during this critical time. Volume indicates whether the number of livestock sold decreased or vanished due to lockdowns, compared to planned sales. Although some traders re-entered pastoral areas post-lockdown in December 2022, the prime selling window had passed, with livestock in poorer condition, leading to lower purchase offers. Consequently, some herders refrained from sale or sold only a portion of their livestock due to unsatisfactory prices, while others remained unsold due to lack of trader contact. Thus, livestock sale is deemed the primary indicator for assessing the lockdowns' impacts on production in this study. Secondly, restrictions on livestock sale pose dual financial challenges for herders: a cash flow crisis for livelihoods and increased costs for retaining livestock over winter, which demands more capital for feed and herding. To cope, herders often turn to loans to cover both living expenses and production costs. Therefore, this study analyses production costs for herders by examining expenses related to feed purchasing, pasture leasing, and loan status. Thirdly, the impediment to livestock sale not only raises production costs but also indirectly results in production losses. Herders may prolong their stay on overgrazed pastures, reduce feed to cut costs, or neglect livestock care due to pandemic-related distractions like assisting with online education. These practices can degrade livestock health, leading to higher mortality rate in spring and reproductive issues like infertility or miscarriages, thereby affecting breeding success. Hence, this study employs mortality and reproductive rate of livestock as metrics to evaluate the production losses incurred by pandemic lockdowns.

4.2 Degree of Marketization

To substantiate or refute the hypothesis that increased marketization in pastoral regions exacerbates the impacts of pandemic lockdowns on livestock production, this study adopts the level of marketization as the independent variable. It encompasses four precise indicators: the status of pasture use rights transactions, the ratio of feed purchases and pasture leasing costs to overall production expenses, the ratio of livestock sold relative to the total herd size, and the ratio of breeding livestock to the total herd (Table 1).

Sudden impact of pandemic lockdown measures shares similarities with natural disasters. Under market mechanisms, when faced with disastrous weather, herders need to purchase more fodder externally, rent more pastures through the market, or buy herding quotas to supplement the shortage of forage (Gongbuzeren, 2016). Conversely, in areas lacking market systems, herders, confronted with reduced natural forage during disasters, often resort to selling more livestock unless they practice communal rangeland use. In such cases, by reallocating pastures, they can optimize the use of remaining natural rangelands, thereby internalizing external costs. Hence, the exchange of pasture use rights, including leasing and quota trading, and feed purchases are pivotal metrics for gauging marketization levels. The volume of livestock sale by herders is indicative of their integration with the market. Herders with a higher degree of marketization typically sell more livestock annually to maximize economic returns. Thus, the paper adopts the ratio of livestock sold to total livestock as the third marketization indicator. As marketization intensifies, so does the proportion of female livestock in herds. Herders in market-accessible regions, aiming to maximize commercial profits (Scoones, 1994), prioritize output under constrained rangeland resources and herd size. In profit-driven livestock farming, after accounting for the production costs of male livestock,

herders opt not to raise males beyond a few breeding animals. The herd predominantly consists of females, with young livestock being sold annually (in Qilian, female livestock can comprise up to 70% of a herder's herd). Post-sale, the remaining livestock are mostly female. Traditional subsistence farming, focused on herd expansion rather than direct economic profit, sells mature males over six years old and maintains a higher proportion of males aged two to six. Consequently, non-breeding females may constitute nearly half the herd, with the remainder being females. Hence, the proportion of female livestock serves as the fourth indicator in this paper for assessing marketization levels.

4.3 Meteorological Conditions and Infrastructures

Additionally, variations in infrastructures and extreme weather events significantly affect livestock production. On the Tibetan Plateau, the presence of shelter facilities for livestock can mitigate mortality and boost reproductive rate during winter and snowy conditions. Moreover, extreme climate events like snowstorms and droughts can escalate production costs and diminish livestock output. Consequently, this study incorporates these factors as control variables to isolate their effects from the study's competitive explanations.

Table 1 Variable Definitions and Measurements

Variable		Indicator		Measurement	Assessment Criteria
Dependent Variables	Life	Herding, Healthcare, Shopping, and Schooling		The proportion of affected households to the total sample, but in schooling only to samples with students	Higher affected proportion indicates more severe impact
		Livestock Sale		The proportion of households affected in terms of selling time or quantity out of the total sample size.	Higher proportion of affected households compared to pre-lockdown indicates more severe impact
	Production	Herding Costs	Foder and Pasture rent	Per household expenditure on foder purchase + pasture rent (unit:10 thousand yuan)	Higher increase compared to pre-lockdown indicates more severe impact
			Loans	Loan coverage rate (loan households/total sample households, %); Loan amount (households with different loan amount /total sample households, %)	Higher increase compared to pre-lockdown indicates more severe impact
		Production Loss	Livestock Mortality Rate	Per household livestock deaths/total livestock number (%)	Higher increase compared to pre-lockdown indicates more severe impact
			Reproductive Rate of Female Livestock	Number of offspring born and survived in the year/number of breeding female livestock (%)	More significant decline in reproductive rate compared to pre-lockdown indicates more severe impact
Independent Variables	Marketization Level	Pasture Use Rights Transactions		Whether there are pasture lease or herding quota transactions	Yes indicates high marketization level; No indicates low marketization level
		Total Foder Expenditure (purchase of foder + rent cost + purchase of herding quotas)		Proportion of foder expenditure/total production cost (%)	Higher proportion indicates higher marketization level
		Per Household Selling Rate		Number of sold livestock/end-of-year livestock number (%)	Higher proportion indicates higher marketization level
		Per Household Female Livestock rate		End-of-year female livestock number/total livestock number (%)	Higher proportion indicates higher marketization level
Control Variables	Infrastructures	Shed Construction		Whether there are modern warm sheds	Yes requires excluding the impact of shed facilities from the study's

				competitive explanations
	Meteorological Conditions	Abnormal Weather	Whether there are abnormal changes in temperature and precipitation before and after the lockdown	Yes requires excluding the impact of climate factors from the study's competitive explanations

Results

1. Marketization Level in the Case Areas

In Qilian, with winter pastures managed and fenced individually, pasture use rights are commonly traded among herders, which all sampled households participate in. Despite summer and autumn pastures being collectively managed, there is a clear system for herding quotas and compensations. Conversely, in Maqu County, pastures are collectively managed without clear household boundaries, and pasture leasing is absent. Although a quota system exists, it is restrictive, and none of the sampled households partake in pasture leasing or quota transactions. To sum up, the marketization level in Qilian County is higher than in Maqu County, as evidenced by four key indicators (Figure 2).

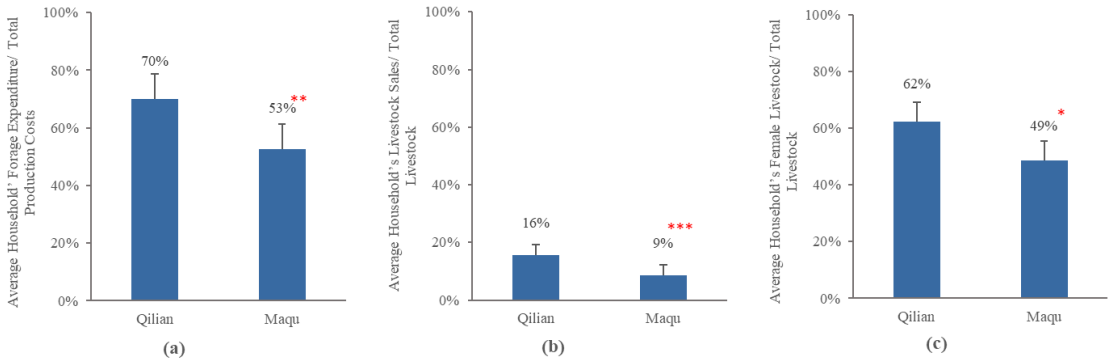

Figure 2. Marketization Level: a) Proportion of Average Household' Foder Expenditure to Total Production Costs ; b) Proportion of Average Household's Livestock Sales to Total Number; c) Proportion of Average Household's Female Livestock Number to Total Livestock Number

2.Impacts of Herder's Lives

Analysis of interviews indicates that daily life was moderately disrupted in both areas, with Qilian experiencing slightly greater impacts than Maqu (Table 2). More households in Qilian report difficulties with herding, healthcare, shopping, and schooling. Disruption to students' schooling is the most severe impact across both areas. Our findings (Table 3) detail specific disruptions to herding activities, with herders unable to reach herds 7–10 kilometers away during lockdowns, leading to water shortages for yaks and conflicts over stray animals (Case #1). Healthcare access was impeded, with some herders missing timely medical care (#2) and facing disruptions back to pasture after hospital quarantine (#3). Lockdowns also led to increased expenses and difficulties in procuring food (#4) and daily necessities (#5). Education was severely impacted, with families buying additional phones for online classes, renting accommodations in town (#6), or driving over 30 kilometers daily for internet access to continue their children's education (#7). In both areas, lockdown's impacts led to increased household expenses and indirectly effects on livestock production.

Table 2. Number and Percentage of Households Affected by Lockdowns in Daily Life (The "Schooling" Category Includes Only Households with School-Aged Children)

Case Areas	Herding	Healthcare	Shopping	Schooling
Qilian（20 in total, 12 with students）	4(20%)	4(20%)	2(10%)	12(100%)
Maqu(31 in total, 18 with students)	1(3%)	5(16%)	1(3%)	18(100%)

Table 3. Case Descriptions of the Impacts of COVID-19 Lockdowns on Herders' Lives

Case	Aspect of Life	Description of the Impacts During the Lockdown	Case areas
#1	Herding	I come from a single-parent household with a school-age son, residing in our village's pastoral area while our livestock were herded 7-10 kilometers away in the mountains. With only yaks in my herd, which are confined by barbed wire, I usually visit them every few days on my motorcycle to provide water. However, lockdown measures sealed all roads, preventing me from reaching the pasture. After several days, I learned from a villager that my yaks had broken the fence and entered another's pasture, prompting a demand for my immediate presence or risk losing my livestock. Despite my pleas to the roadblock guards, I was denied passage. Left with no alternative, I embarked on a grueling journey, traversing mountains and streams, to reach the pasture on foot. It consumed an entire day, but I managed to resolve the conflict by compensating the affected villager and returned my herd to safety.	Qilian
#2	Healthcare	My wife, who has a chronic stomach condition, was hospitalized for two months before the lockdown and was due for a follow-up in six months. However, her condition worsened during the lockdown, making it impossible to reach either the provincial or county hospital. We had to postpone her treatment until late 2023, resulting in a three-month delay.	Maqu
#3	Healthcare & Herding	In late August 2022, I was admitted to a Tibetan hospital in the prefecture for a minor ailment, planning a week-long stay. However, a COVID-19 outbreak in a neighboring county led to a prefecture-wide lockdown on my third night, halting all traffic. Initially, I received basic care, but within days, most staff were redirected to COVID-19 testing, leaving only a few nurses for us stranded patients. Treatments ceased, and we were confined to the inpatient building, receiving meager meals from centralized distribution. I remained stranded for nearly a month, coinciding with my family's seasonal pasture migration, which was also impeded by travel bans. Unable to move without me, my family managed to pick me up under cover of night and we evaded checkpoints via a mountain path, effectively "escaping" to our home.	Qilian
#4	Shopping	Over the pandemic's three-year span, pastoral area prices saw a notable uptick. The cost of flour, a staple for herders, escalated from 90 yuan per bag in 2019 to 95 yuan in 2020, then to 105 yuan in 2021, and during the 2022 lockdowns, it spiked to a range of 125 to 150 yuan per bag. Similarly, a 5-pound bag of tsampa climbed from 10 yuan in 2021 to 12 yuan in 2022.	Qilian
#5	Shopping	From early to late November 2022, our county faced a severe "smoke shortage", prompting the emergence of cigarette smugglers who inflated prices drastically—selling packs that normally cost 5 yuan for 30-40 yuan, and individual cigarettes, like Black Lanzhou, for over ten yuan, despite the market price being 18 yuan per pack. Compounding this, a gasoline shortage arose during the continuous mass nucleic acid testing period, when we were confined to our village and all stores and gas stations were shuttered. The dilemma was	Qilian

		exacerbated by the need to drive or ride a motorcycle for tests, often leading to cars running out of fuel. Fortunately, the lockdown was short-lived, and in its final days, restrictions were relaxed, permitting one person per household to refuel.	
#6	Schooling	I have two sons, one in the first and the other in the third year of middle school, both studying at our county's ethnic middle school. During the pandemic, our greatest wish was for our children to return to school as online learning was challenging for us. I initially bought each son a phone for online classes, but after two months in the autumn pasture, their phone bills soared past 400 yuan. The situation deteriorated further when we moved to the winter pasture, where there was no internet signal. Unable to provide for their online education despite the expenses, I rented a small house in town for them to study. Their mother would join them occasionally due to our busy home life.	Qilian
#7	Schooling	I have a son in high school and another in elementary school, both of whom required online classes during the 2022 pandemic. Lacking signal or electricity on our farm, I had to drive them daily to an area with reception, a round trip exceeding 30 kilometres. This daily commitment to their education significantly reduced my time for tending to our yak and sheep, leading to a high mortality rate among our livestock that year.	Maqu

3. Impacts on Herders' Production

3.1 Livestock Sale

In both areas, livestock sale constitutes the predominant source of income, with Maqu over 75% and Qilian 85% out of total household's income. Notably, Qilian's reliance on livestock sale is 10% greater than Maqu's, suggesting a higher dependence on such sell to cover living and production costs. Among the sampled herders in Qilian, 90% encountered impediments to livestock sell due to pandemic-induced lockdowns, significantly higher than the 31% reported in Maqu. This result underscores the more pronounced adverse effects of lockdown on livestock sale in Qilian. The description of herder household BC (Table 6) provides a typical example of the lockdown's effect on livestock sale.

3.2 Herding Costs

（1） Expenditure on foder purchases and pasture rentals

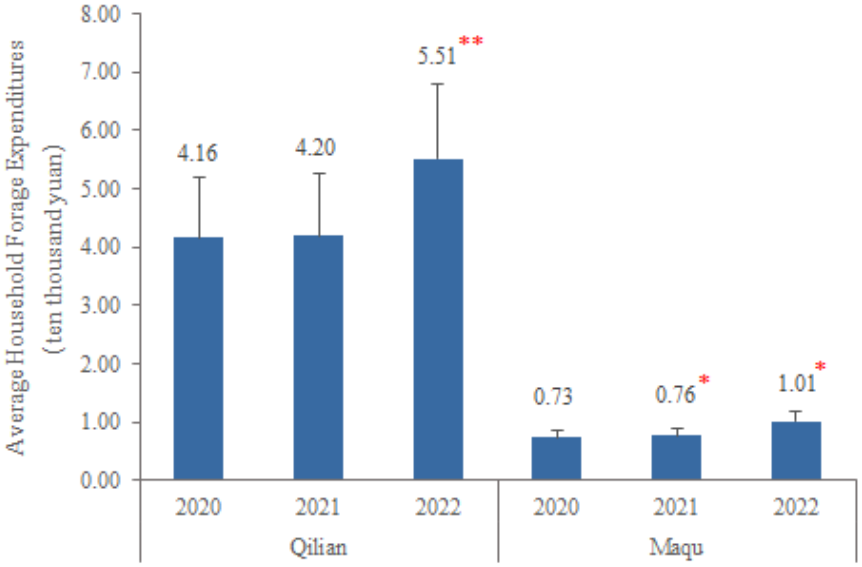

Figure 3. Average Household Foder Expenditures (Foder Purchases + Pasture Rentals + Herding Quota Purchases) (Note: Asterisks indicate significant differences, *p<0.05, **p<0.01, ***p<0.001)

Table 5. Comparison of Foder Prices in Qilian County from 2020 to 2022(Unit: Yuan)

Year	Mixed Foder (per ton)	Alfalfa Hay (per bale)	Oat Hay (per bundle)
2022	3100-3500	45-60	6
2021	2800-3100	35-50	3
2020	2800-3000	34-48	3

（2） Loans

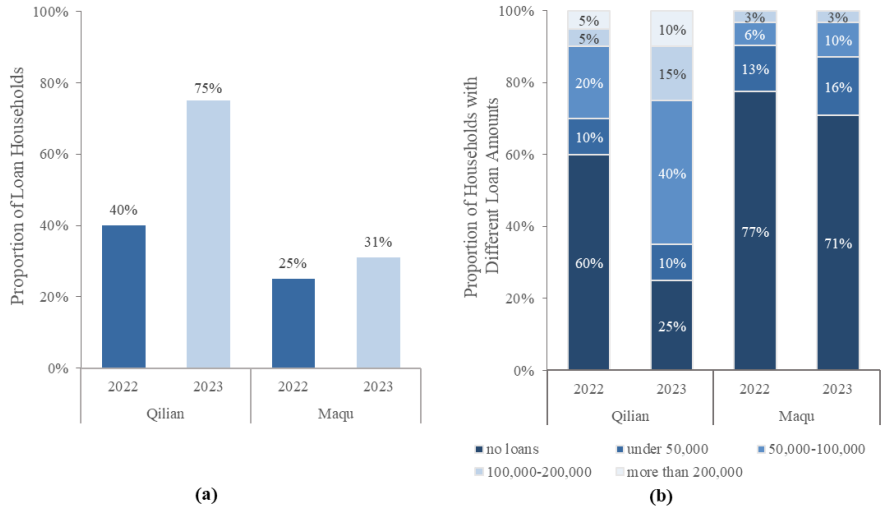

Figure 4. Loans: a) Changes in the Proportion of Loan Households Pre-and Post-Pandemic Lockdown; b) Changes in the Proportion of Households with Different Loan Amounts Pre-and Post-Pandemic Lockdown

3.3 Production Loss

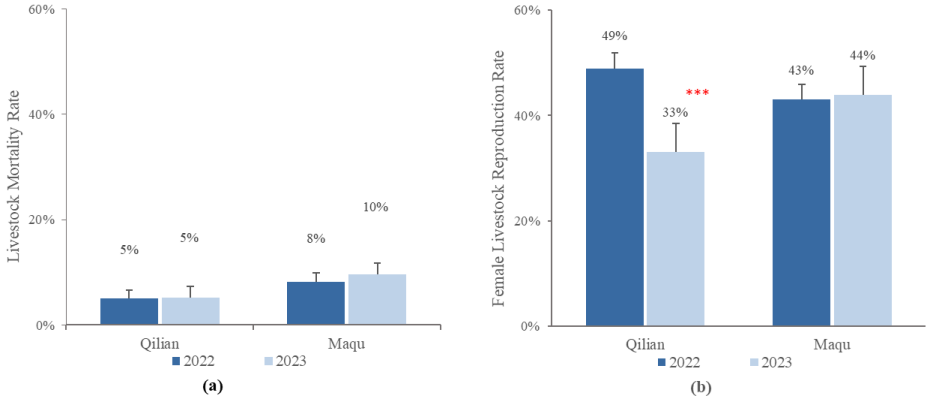

Figure 5. Livestock Morality and Reproductive rate: a) Changes in Average Household Livestock Mortality Rate Pre-and Post-Pandemic Lockdown; b) Changes in Average Household Female Livestock Reproductive rate Pre-and Post-Pandemic Lockdown (Note: Asterisks indicate significant differences, *p<0.05, **p<0.01, ***p<0.001)

Table 6. Case Descriptions of the Impacts of the Lockdown on Herders' Production

Case	Aspect of Production	Descriptions of the Impacts During Lockdown	Case areas
#BC	Livestock Sale & Loans	Herder BC, a relatively well-off member of his community with a family of four, started 2023 with a livestock count of 500 sheep (350 ewes) and 280 yaks (180 female), with over 65% being female. His usual strategy is to sell 90% of the lambs and culled animals annually, constituting 60% of his stock. He had planned to sell 300 sheep and 60 yaks in late 2022, expecting 1,300 yuan per ewe and 850 yuan per lamb. The pandemic lockdown disrupted these plans, and he could only sell a fraction in November 2022 at reduced prices—900 yuan per ewe and 700 yuan per lamb. Consequently, he sold only 35 ewes and 65 lambs, totalling 100 sheep, which was one-third of his intended sales, with no yak sold. Being unable to sell as anticipated meant he had to buy additional foder for the winter to feed his livestock. To cover these costs, BC took a bank loan of 250,000 yuan, of which 44,000 yuan was used to purchase foder and 100,000 yuan was allocated for pasture rental, totalling 144,000 yuan in production costs for 2022.	Qilian
#MJ	Rise of Production Cost	Herder MJ's household consists of five members, with herding rights to two portions of pasture (800 mu). In 2023, he had a livestock inventory of 510 sheep and 106 yak, compared to 100 sheep and 206 yak in 2022. From 2020 to 2022, he leased an additional four portions of pasture (1,200 mu), with rental costs rising from 30,000 yuan in both 2020 and 2021 to 50,000 yuan in 2022—an increase of 20,000 yuan compared to the previous year. In 2021, MJ's feed expenses were 3,000 yuan, which jumped to 30,000 yuan in 2022. His foder costs also increased from 5,000 yuan to 12,000 yuan over the same period. Overall, pasture rental costs tripled, while foder and feed expenses quintupled from 2021 to 2022.	Qilian
#Q	Livestock Sale, Production Cost & Loss	Herder Q, part of a four-member household with rights to two pasture sections (800 mu), had a herd of 180 yak and 718 sheep in 2023. Due to pandemic restrictions in 2022, he missed the optimal time to sell livestock and had to rely on supplemental feeding to maintain and fatten the herd. His foder-related expenses included 74,000 yuan for pasture rental, 79,000 yuan for foder, 50,000 yuan for renting wheat fields, and 10,000 yuan for other production costs, totalling 213,000 yuan—a 67,300 yuan increase compared to 2021. After three to five months of fattening, the selling price was nearly the same as it would have been during the regular season. However, the fattening process required significant labour and herding resources, reducing the attention available for other livestock. Additionally, to cut costs, he delayed moving to winter pastures by staying on (communal) summer pastures for an extended period, which not only damaged the summer pasture but also led to higher livestock mortality rate and lower reproductive rate in spring 2023. Livestock mortality more than doubled from 2022, with 14 yak and 28 sheep deaths, to 40 yak and 53 sheep in 2023, with a significant number of losses among the young.	Qilian
#Z	Livestock Sale, Production Cost & Loss	Herder Z's household, comprising three members with herding rights to two pasture sections (350 mu), owned 56 yak and 226 sheep in 2023. Pandemic lockdowns in 2022 resulted in the sale of only 15 yak, generating 90,000 yuan. However, that year's production costs escalated to 96,550 yuan, including 47,000 yuan for additional pasture rent, 18,750 yuan for foder, and 40,800 yuan for feed. The household also suffered the loss of 37 sheep and took a 300,000 yuan loan, leading to expenses that dwarfed income and brought the family to the brink of financial ruin.	Qilian

1. Meteorological Conditions and Infrastructures

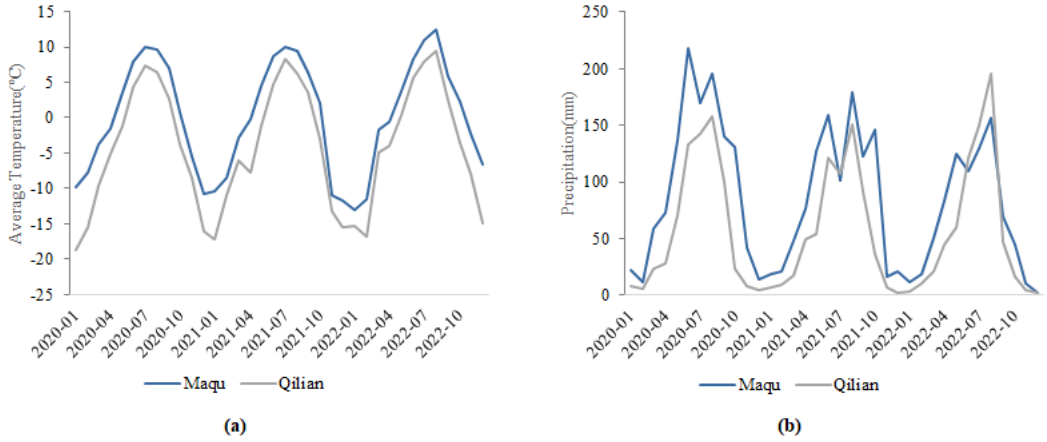

Figure 6 Meteorological Conditions: a) The Monthly Average Temperature Changes From 2018 To 2022; b) The Cumulative Monthly Precipitation From 2018 To 2022.

In terms of livestock infrastructure, Qilian herders are all equipped with at least one modern warm shed, which is crucial for protecting new-born lambs from freezing during winter lambing. Conversely, Maqu herders lack access to such facilities, including warm sheds, which are essential for livestock management.

5.Argumentation: The Closer the Connection with the Market, the Greater the Impacts of Lockdown

Drawing from the research data and information presented, it has been observed that the pandemic-induced lockdown had impacts on herders' daily lives in both areas, with Qilian experiencing a marginally greater effect than Maqu. However, when considering production, the lockdown's effects on Qilian were markedly higher than those on Maqu. In the following analysis, we will first delve into the factors contributing to the lockdown's influence on livestock production in Qilian. Subsequently, adopting a marketization lens, we will elucidate the divergent impacts of identical lockdown measures on the two areas, thereby validating or refuting our initial research hypotheses.

5.1 Lockdown Hindered Livestock Sale

As previously highlighted, the sale of livestock constitutes the principal source of household revenue for herders in both areas, implying that their annual earnings are contingent upon the sale of livestock considerably. The COVID-19 lockdown imposes constraints on livestock sale for that year, impacting both the transaction avenues and price.

The lockdown restrained the transaction avenues for herders. Within China's pastoral regions, the sale of livestock is heavily reliant on the role of "middlemen," who function as intermediaries in the procurement of yak and sheep. Customarily, the livestock selling season spans from early September to mid-October, a period during which middlemen from diverse regions converge on herders to engage in livestock purchases. However, the 2022 selling season coincided with the most stringent phase of the pandemic lockdown. The lockdown's restrictions on human and vehicular movement impeded middlemen from accessing herders, thereby preventing herders from executing their planned sales (Table 6, herder BC, Q, and Z).

The pandemic lockdown exerted indirect influences on livestock sale prices, diminishing the herders' willingness to sell. Following the relaxation of restrictions in mid-December 2022, while some middlemen ventured into the pastoral regions, the livestock had passed their optimal selling condition. On one hand, the livestock's condition had declined relative to the peak selling period. On the other hand, middlemen, who have the pricing power, lowered the purchase price as they predicted an increased livestock inventory (Table 6, herder BC). From the perspective of market demand, the pandemic lockdown also impacted the market price indirectly. Interviews with middlemen revealed that during the lockdown, tourists to the Tibetan Plateau were significantly depressed. Restaurants and butcher shops experienced prolonged closures, leading to a contraction in local demand for beef and mutton. Concurrently, slaughterhouses grappled with inventory backlogs acquired before the pandemic. Resulted surplus ultimately depressed the prices of beef and mutton, influencing herders' selling decisions.

Different levels of marketization have precipitated distinct pastoral strategies, amplifying the lockdown's impacts on herders with higher marketization. In Qilian, a substantial 90% of herders encountered obstructions in their sale, contrasting with only one-third of Maqu herders who perceived an inability to execute their livestock sale as anticipated. Despite of equivalent lockdown durations and measures, under distinct pastoral strategies generated from different marketization level, their reliance on livestock sale is varied.

Maqu herders, with a lower degree of marketization, adhere to a more traditional, subsistence-based pastoralism. They invest less capital in livestock production and prioritize herd stability over economic profit maximization. Their annual sales are relatively modest (Figure 2.b), directed at covering basic livelihood expenses, thereby reducing their dependence on any certain livestock sale round. In contrast, Qilian herders engage in a more commercially oriented pastoralism. They frequently incur debts to augment investments in foder, feed, or leased pastures, leading to a significantly higher cash outlay expenses in livestock production compared to Maqu herders (Figure 3). In Qilian, the proportion of breeding livestock is more substantial (Figure 2.c), and a larger segment of the herd is marketed (Figure 2.b), with an emphasis on little livestock (mainly lambs) for enhanced output. Livestock sale serve two purposes: meeting living expenses and covering current production costs. Consequently, Qilian herders exhibit a heightened dependence on every livestock sale round to satisfy both subsistence and investment demands. Thus, the pandemic lockdown's restrictions on sale had a more remarkable effect on Qilian herders, attributable to their increased reliance on sale to fulfil cash flow and production cost.

5.2 The Increasing Number of Livestock in Hand Lead to Increased Feeding Costs and Greater Production Losses

Impediments to livestock sale leading to herders with higher levels of marketization incurring higher production costs and losses. The blockage of livestock sale resulted in an increased livestock on hand, which subsequently rose the demand for fodder and natural pastures, thereby augmenting production expenses. The impacts on the two areas are distinct, characterized by varying degrees of marketization. Qilian herders, already heavily reliant on market-procured fodder and pasture rentals, faced an increased prices of commodities in response to the heightened demand because of the market mechanisms (Table 5). This surge significantly magnified herding costs, and the concomitant rise in fodder demand and prices substantially escalated the cash requirements for herders (Table 6, herder MJ). In this context, loans become herders' only solution, resulting in a notable increase in both the numbers and amount of loans taken by Qilian during the lockdown (Figure 4,a). In the pastoral context, loans not only fail to alleviate risks but also introduced the burden of interest and repayment obligations, exacerbating the financial strain on herders

(Table 6, Herder Z). Consequently, when the sale in Qilian were impeded, herders whose predominant revenue stream is livestock sale, confronted escalating production costs, particularly for fodder.

Moreover, an increase in livestock numbers necessitates additional labour input for feeding and care. Any shortfall in fodder supply or animal care can lead to heightened risks of livestock mortality or reduced reproductive rate among female animals, as demonstrated in the case of herder Q (Table 6). Without adequate funds to procure sufficient fodder to sustain livestock through the winter, there is an elevated risk of increased mortality rate (Table 6, herder Q and Z) and malnutrition among female animals, which, in turn, adversely impact reproductive performance (Figure 5,b).

In contrast, Maqu herders exhibit a lower cash outlay expenses in livestock production. With no market for herding rights and limited fodder usage, Maqu's production costs are much lower than in Qilian, resulting in fewer loans. Therefore, when faced with impediments to livestock sale, Maqu herders incur no additional financial losses beyond basic living expenses. Additionally, since the Maqu herders share grazing land within small groups and do not engage in market-based leasing or quota trading, an increase in herding demand by certain herders due to sale disruptions does not lead to intense competition over pasture resources. Instead, they mitigate herding costs through multiple relocations within the group, thereby externalizing herding costs and avoiding the risk of increased expenses from rising pasture prices. Consequently, after the pandemic lockdown, Maqu herders, with their lower degree of marketization encounter less production costs and production losses in comparison to Qilian herders.

5.3 Exclusion of Competing Explanations

Beyond the sufficiency of fodder supply, livestock mortality and reproductive rate are also contingent upon natural disasters and the state of livestock production infrastructure. Meteorological data indicate that neither of the areas exhibited anomalous temperature or precipitation patterns in 2022 (Figures 7, a and b), and herders surveyed reported no occurrences of droughts, snow disasters, or other climate-related events during the lockdown. This excludes any correlation between production losses in the two areas with climatic anomalies or natural disasters. In the sampled populations of the two areas, all herders in Qilian County possessed at least one modern warm shelter and sheep pen, in contrast to none of the sampled herders in Maqu. The slightly elevated livestock mortality rate in Maqu, relative to Qilian, is partly ascribed to less supplemental feeding and inadequate livestock infrastructure. Although the post-pandemic increase in livestock mortality rate was not significant in either area, mortality rate alone does not comprehensively represent production losses in livestock farming. Reproductive rate explicitly indicate that Qilian witnessed a marked decline in production following the pandemic lockdown, while Maqu's reproductive rate not only remained stable but actually increased by 1% (Figure 5,b).

In conclusion, the research findings substantiate the initial hypothesis of this study: the primary reason for the more serious impacts of the pandemic lockdown on Qilian compared to Maqu is associated with the level of marketization. The closer the market ties, the more severe the lockdown's impacts.

Discussion and Conclusion

This study illustrates the divergent impacts of a uniform pandemic lockdown on two case study areas with varying marketization level. The research findings underscore that Maqu, characterized by a lower degree of marketization, experienced muted effects from the lockdown. Qilian, however, with a higher degree of marketization, encountered more substantial repercussions. Maqu exhibited enhanced stability and sustainability when facing the pandemic lockdown's abrupt external shock. However, the market-integrated Qilian endured severe outcomes, with numerous herders encumbered by significant loan debt, and some

even confronting insolvency, such as herder Z (Table 6). Hence, the inquiry into the root cause of this divergence arises.

Marketization is a pivotal avenue for economic growth and modernization; however, it can engender risks concurrently. The extant mainstream research on credit and fodder markets for pastoral socio-ecological systems, particularly in the context of extreme climatic events, has predominantly posited that market mechanisms facilitate herders' resilience to disasters (Agrawal, 2010; Addison and Brown, 2014; Carter et al., 2007; Ouma et al., 2011; Turner and Williams, 2002; World Bank, 1994; Horn et al., 2003; Müller et al., 2015; Schulze et al., 2016). Nevertheless, some case-based studies have unveiled that while market mechanisms might offer short-term alleviation for herders confronting disaster-induced impacts, over the long term, they may result in a severe deterioration of natural rangeland ecosystems, potentially generating the collapse of the pastoral economic system (Li and Li, 2021; Lu et al., 2022; Briske et al., 2015). This phenomenon arises from the dependency on external loans to procure fodder, which can disrupt the negative feedback loop between the pastoral economic system and the local ecosystem, culminating in an imbalance within the local socio-ecological system (Lu et al., 2021; Zhang et al., 2018).

The advent of the COVID-19 and its attendant control measures bear resemblances to the meteorological calamities commonly encountered in pastoral regions, given their inherent unpredictability and catastrophic nature. However, diverging from prior research that highlighted the potential long-term perils associated with market forces, this study discerns that in the context of abrupt occurrences, such as the pandemic, the risks intrinsic to market integration materialize swiftly, manifesting even within the short term.

In pastoral areas with high climate variability, pastoralists have historically employed strategies such as livestock mobility, livelihood diversification, communal herding, and storage to navigate such fluctuations (Scoones 1994; Xie and Li 2008), thereby sustaining a resilient socio-economic system (Fernández-Giménez and Swift 2003). However, the advent of land privatization (Fernández-Giménez 2001; Li et al. 2007; Li and Huntsinger 2011) and shifts in policy direction (Gongbuzeren et al. 2015) have encumbered the sustainability of these traditional practices. Consequently, pastoralists have sequentially gravitated toward market-oriented tactics. Through market mechanisms, they have amplified their socio-economic systems by integrating external resources, including fodder, feed, and credit facilities. Nevertheless, in the face of sudden incidents akin to pandemic lockdowns, these market-reliant pastoralists are exposed to associated risks, culminating in a surge of production costs and economic losses. This mode of livestock production, heavily contingent upon external resources, has transcended local ecological thresholds, with the socio-economic system effectively expanding outward and progressively diss-embedded from the indigenous ecosystem, leading to deleterious environmental impacts (Table 6, herder Q). The elevated stocking rates, sustained by substantial external fodder inputs, have intensified the overgrazing of indigenous pastures, further depleting natural forage reserves. This, in turn, fosters an increased dependency on external market inputs, establishing a vicious cycle that jeopardizes the stability of the pastoral economic system and potentially precipitating its collapse.

The incursion of market mechanisms does not inexorably signify the obsolescence of traditional strategies designed to navigate uncertainty. A crucial factor that attenuated the pandemic lockdown's impact on Maqu herders, relative to Qilian, is the preservation of a communal pasture management approach. Despite some households confronting heightened herding demands consequent to impeded livestock sale, they effectively internalized financial burdens by employing community-based practices, such as rotational herding. This traditional strategy showcased a more robust resilience to abrupt shock compared to the scenario in Qilian,

where herders, who wholly dependent on market mechanisms, were severely affected by the COVID-19 lockdown.

In the process of transitioning from traditional subsistence-based pastoralism to commercialized livestock production, pastoral areas on the Tibetan Plateau have yet to establish effective mechanisms for managing market risks. This study reveals that herders lack direct channels for livestock sale and depend on intermediaries to access the market, highlighting the vulnerabilities and risks inherent in pastoral markets. To enhance the stability and sustainability of rangeland pastoralism amid market-oriented development, this study offers the following recommendations: 1. Enhance herders' participation in market design: strengthen herders' involvement in various market stages, from purchasing fodder to selling livestock, by developing a market chain that centers on herders. This approach would mitigate the risks associated with market fluctuations. 2. Support traditional pastoral strategies: recognize and support traditional pastoral strategies and knowledge, such as community-based reciprocal herding and resource-sharing systems, which are crucial for coping with uncertainties and sudden disasters. Policy measures should encourage the preservation of these traditional practices, allowing local experience to play a more significant role in sustainable development.

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