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Different Paths Lead to the Same Success: Examining Design Principles in Grassland Collective Governance in China

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Abstract: Collective action remains a fundamental approach to governing common pool resources, and Ostrom's design principles (DPs) have been widely used for analyzing such governance. However, grasslands, as typical common pool resources, have received limited attention within this framework in China. Based on the village-level survey data in Yushu, Qinghai, we utilized DPs as fuzzy sets to discern nuances among cases and identify necessary and sufficient conditions for successful collective governance using the fsQCA method. Our findings are as follows: (i) Diverse combinations of institutional rules can lead to favorable collective governance outcomes. Achieving good outcomes requires a comprehensive approach that encompasses rules, rule enforcement, and rule-making arenas. (ii) Congruence with local conditions (DP2) emerges as a pivotal and foundational condition in collective grassland governance. Therefore, it is crucial to formulate strategic governance rules that adapt to local realities and capitalize on regional advantages to ensure long-term success. (iii) The establishment of ecological husbandry cooperatives is in line with local realities and can help achieve high grassland governance performance. The improvement in ecological, economic, and social benefits brought about by cooperatives constitutes a crucial factor for promoting herders' active involvement in the collective management of grasslands.

Keywords: collective governance; design principles (DPs); grassland; collective action; fsQCA

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1. Introduction

Grassland serves as a crucial asset in both productivity and ecological sustainability, carrying indispensable functions and values across ecology, economy, and society. As a productive factor, it offers essential grazing grounds for herdsmen, facilitating diverse activities and ensuring the stable and efficient growth of animal husbandry in pastoral regions. Simultaneously, as an ecological resource, it is an indispensable fundamental element in the ecosystem, undertaking vital roles in energy flow and nutrient cycle to uphold overall balance [1]. However, the tragedy of the commons will appear within grasslands when the usage surpasses its carrying capacity [2], attributable to the inherent characteristics of common pool resources (CPRs) like non-exclusive benefits and competitive utilization.

In China, grassland is the largest ecosystem, accounting for 40.9% of the total land area, approximately 393 million hectares, as reported by the National Forestry and Grassland Administration. Over the final years of the previous century, China experienced severe grassland degradation, emerging as a pressing ecological and environmental concern. By 2001, the environment bulletin issued by the State Environmental Protection Administration revealed that nearly 90% of the usable natural grasslands, covering roughly 135 million hectares, suffered from various degrees of degradation, desertification, and salinization. Alarmingly, the problem escalated rapidly, with 2 million hectares deteriorating annually on average at that time. This degradation, attributed to irrational usage and climate change [3–5], directly disrupts ecosystem balance [6], leading to environmental decline

and imposing numerous adverse effects on the economic production and social livelihoods of herdsmen. Several grassland management policies were subsequently introduced to address these challenges. Following the grassland tenure reform in the early 1980s, the grassland household contract responsibility system (HCRS) was gradually established in pastoral regions, drawing on the successful experience of the HCRS in agricultural areas. A joint production contract responsibility system was implemented first, along with co-management strategies, wherein the ownership of grasslands belonged to collectives, while herdsmen possessed the right to utilize them. Then, a dual contracting system for grassland and livestock was introduced in the 1990s, whereby individuals contracted grasslands while owning the livestock. However, the application of the HCRS alone cannot fully resolve pastoral issues due to the unique geographical locations and land use methods compared to traditional agricultural areas. The segmentation of grasslands of varying qualities for herdsmen further exacerbates grassland fragmentation, posing another significant challenge in China [7].

Collective action remains a pivotal approach for governing commons [8], specifically common pool resources. Ostrom significantly advanced the theory of common pool resources (CPRs) and distilled corresponding institutional conditions into design principles (DPs) based on extensive research into long-standing CPR management institutions [9]. DPs delineate a set of institutional conditions conducive to robust governance [10], elucidating the circumstances under which collective action can be initiated and sustained to effectively address CPR dilemmas [11], recognized as vital for long-term CPR management [12]. DPs have been investigated to assess various facets of CPR management [13], particularly for governance of fisheries, pastures, forests, irrigation systems, and water resources [14]. Moreover, the presence of more DPs correlates with higher likelihoods of successful CPR management outcomes [15]. In specific contexts, community-based management (CBM), encompassing collective and small-group tenure arrangements [16], emerges as a viable alternative [17]. CBM offers substantial advantages in resource integration, achieving economies of scale, and risk mitigation, thereby aligning closely with DPs. Guttmann suggested that linking commons to cooperatives can foster good governance, representing a potential transformational approach for CBM [18].

In line with CBM, cooperative-based management proves effective in rural areas, and cooperatives are effective carriers for connecting small-scale farmers with modern agriculture [19]. They play important roles in controlling the quality and safety of agricultural products [20], optimizing the allocation of production factors [21], and providing diversified socialized services for members [22], and also bring about income-increasing effects for farmers [23]. China put forward the development of ecological husbandry in the early 21st century, and ecological husbandry cooperatives may be effective carriers for connecting herders with modern animal husbandry. Qinghai Province started to explore the construction of ecological animal husbandry relatively early. In 2008, it clearly proposed work contents such as determining the number of livestock according to the amount of grassland, improving the infrastructure of animal husbandry, and enhancing the development capacity of cooperative organizations. In June 2014, with the approval of the former Ministry of Agriculture, Qinghai Province established a national grassland ecological animal husbandry experimental zone, taking innovating grassland ecological protection, exploring the intensive operation of grassland ecological animal husbandry, and improving new mechanisms for industrialized development as the key tasks for the development of ecological animal husbandry. Ecological animal husbandry cooperatives help herders to transform from "natural persons" to "professionals" participating in the social division of labor [24]. Through joint-stock cooperative operation, resource integration and large-scale operation are achieved, and member herders obtain benefits according to their shares, which is an effective form for the development of animal husbandry [25].

While collective grassland governance has shown efficacy [26], few studies have explicitly utilized Ostrom's design principles (DPs) framework to evaluate its potential outcomes. Therefore, elucidating "which institutional design principles contribute to high grassland

collective governance performance" holds significance in Qinghai, China. This study aims to address the following questions: (1) To what extent does grassland governance in Qinghai adhere to the DPs? (2) Which combination of DPs can optimize governance performance? Our analysis offers at least two contributions. First, unlike previous research, we employ the DPs framework to assess overall performance in grassland, thus enriching existing knowledge. Second, we provide empirical evidence to enhance grassland governance by identifying configurations of DPs conducive to positive outcomes.

The remainder of this paper is organized as follows: Section 2 provides an introduction to the theoretical framework. Section 3 outlines the methods, variables, and data employed in the analysis. The empirical results are then presented and discussed in Sections 4 and 5, with further elaboration and conclusions presented in Section 6.

2. Theoretical Framework

Ostrom initially introduced design principles (DPs), defined as "elements or conditions that facilitate the success of institutions in maintaining the CPR" [9]. These principles offer guidelines for future use and development of common pool resources. DPs, comprising a suite of institutions encompassing rules, norms, and strategies, enable collective action among resource users, ensuring long-term sustainability. They are described as follows:

(1) Clearly defined boundaries: the delineation of the CPR's boundaries and the rights of individuals or households to utilize it must be clearly established. (2) Congruence with local conditions: the congruence with local conditions necessitates that the appropriation and provision rules be equivalent, aligning with the specific local conditions. (3) Collective choice arrangements: the majority of individuals impacted by the regulations have the opportunity to engage in decision-making processes aimed at their modification. (4) Monitoring: an accountable monitoring system is imperative for both the CPR and its users to guarantee the protection of the CPR. (5) Graduated sanctions: users who breach regulations pertaining to resource-related institutions are likely to encounter graduated sanctions, which are commensurate with the severity and context of the offense. (6) Conflict resolution mechanisms: it is imperative that low-cost local arenas, designed to efficiently address conflicts among users or between users and officials, are readily accessible. (7) Minimal recognition of rights to organize: the right of users to establish their own institutions is not impeded by external governmental authorities. (8) Nested governance: everything, encompassing appropriation, provision, monitoring, enforcement, conflict resolution, and governance, is organized within multiple, nested layers, specifically applicable to CPRs that are parts of a larger system.

Initially employed in research on fishery [27], irrigation [28], and forestry [29], these principles have found additional application in the governance of expansive or more intricate common pool resources, including international rivers [30], protected areas [31], and wildlife protection [32]. Moreover, they can be extended to address global resource management challenges with suitable modifications and elaboration [33]. For instance, Lacroix and Richards analyzed environmental policy within the design principles framework [34]. Innovative insights emerge when integrating DPs with knowledge from different disciplines, like elucidating how power dynamics intersect with DPs [10]; exploring these principles through an evolutionary perspective, which then emphasized the importance of collective action in achieving common goals [35]; and envisioning guidelines for enhancing healthcare systems based on Ostrom's thought [36]. Notably, it is not imperative to consider every principle in every instance; allowing researchers to tailor their own analyses to specific aspects of common pool resource management may be better [37].

Ecological animal husbandry serves as a pillar industry for farmers and herdsmen in Qinghai Province in China. Over the past decade or more, co-management strategies have been explored with local characteristics, relying on ecological animal husbandry cooperatives, and abundant governance experience has been amassed. Locally, joint-stock cooperation is primarily promoted to maximize the concentration of resources such as grasslands, livestock, and labor force, establish an appropriate scale, optimize the allocation

of animal husbandry resources, bring into full play the skills of herdsmen, and ensure the fair sharing of benefits. Simultaneously, it can also satisfactorily meet the requirements of the eight principles of self-governance (DPs). Due to the particularities of collective property rights, the national background, and cultural roots, when employing DPs for analysis, the specific content needs to be refined and adjusted to better conform to the actual research situation.

DP1: In China, the grassland contracting system is in place, and the state encourages the use of fences for property right confirmation. Herdsmen who have contracted grasslands can utilize them, and others should rent grasslands to use. Thus, the boundaries of resources and users should be considered jointly from institutional and physical aspects. Institutionally, the grassland contracting situation and restrictions on transfer need to be clarified. Physically, it is necessary to determine the degree of fence construction and whether the minimum construction unit is based on a herdsman's household or a village group's grassland.

DP2: A series of specific rules on grassland utilization and governance has emerged since the implementation of ecological husbandry in Qinghai Province, including dismantling household fences for joint grazing, implementing rotational grazing in designated areas, dividing labor among herdsmen, and constructing infrastructure like hay storage sheds. It is necessary to assess whether different villages have such regulations and if they will be adjusted according to actual circumstances.

DP3: The above rules need to be passed by vote at villagers' assemblies to ensure herdsmen's democratic participation rights generally in China's governance context. Therefore, regarding collective choice arrangements, it is essential to understand the form in which grassland governance rules are reached and whether herdsmen are truly involved.

DP4 and DP5: There must be supervision and evaluation for rule implementation. Then, an effective reward and punishment system should be established based on supervision results to give actual meaning to the rules. Thus, we should understand the supervisors and supervision methods for grassland governance and know the punishment methods when violations are found. Meanwhile, it is important to consider whether punishments will be aggravated due to an individual's repeated mistakes and whether to implement differentiated punishment measures from lenient to severe. For example, a warning for the first discovery, a notice of criticism for the second, and fines thereafter.

DP6: Due to illegal occupation of grassland resources and other situations, grassland conflicts frequently occur. DP6 requires an understanding of the ways to resolve conflicts after they occur and the difficulty level of the resolution.

DP7 and DP8: Minimal recognition of rights to organize in grassland governance manifests as the recognition and support from higher-level governments including towns and counties for collective grassland governance methods within villages. DP8 aims to determine whether there is nested governance.

Specifically, we employed the corresponding questionnaire items in Table 1 to comprehend the degree of conformity of grassland governance in China to these principles in the field investigation.

In light of the assertion that design principles form a robust foundation for subsequent research [11], this study employs the DPs to scrutinize the correlation between institutional regulations and the collective governance performance of grasslands in Qinghai, China. The survey data pertaining to management measures typically embody these principles, which are subsequently verified and deliberated upon in detail below.

Table 1. The links between DPs and the constituent elements of grassland collective governance.

Ostrom's DPs	Questionnaire Items in Grassland Collective Governance in Qinghai, China
DP1	(1) Is the pasture in the village contracted to individual households or joint households, or made available to the public (cooperative members)? (2) Must herdsman without contracted pastures rent grassland for use? And does the process of renting require prior consent from the local authority? (3) Do clear boundaries exist within the contracted pastures? And do fences exist within households, groups, or villages?
DP2	(1) Are there regulations that allow herders or cooperatives to utilize the pasture in a manner that is congruent with local conditions? What exactly are the rules? (2) Will these regulations be modified in response to actual specific circumstances?
DP3	(1) Are users (usually referring to villagers or members of local cooperatives) permitted to propose amendments to regulations and are they invited to participate in collective meetings? (2) What strategies are employed to achieve consensus during the rule modification process? Are the results of villagers' votes respected by village officials?
DP4	(1) What is the established monitoring mechanism for implementing the aforementioned rules? (2) Who or which organization typically assumes the responsibility for supervision?
DP5	(1) Will there be consequences for individuals who vandalize grassland or violate regulations? (2) Will the penalties align with the severity of the infractions, ranging from mild to severe based on the extent and gravity of the misconduct?
DP6	(1) Are disputes regarding boundaries, grazing rights, and expropriation frequent? (2) Can these disputes be typically resolved in an efficient and effective manner? (3) Is there a cost-effective platform available for resolving these issues among herdsmen or between herdsmen and administrative officials?
DP7	Should the operative rules formulated by village-level cooperatives be subject to the consent and approval of the county-level government or its superior authorities?
DP8	What is the operation mode of village ecological husbandry cooperatives? Are there strong vertical and horizontal management mechanisms in place?

3. Methodology

3.1. Cases and Data

This study focuses on the pastoral regions of Qinghai Province. Since 2008, ecological husbandry, which leverages regional unique attributes, has developed in Qinghai, with a concerted effort to achieve a mutually beneficial outcome encompassing ecological preservation, economic development, and increased income for herders. Ecological husbandry necessitates the transformation of traditional grassland husbandry into a new model emphasizing intensification, organization, and collaboration. This approach centers on the upgrading of the husbandry industry and the development of high-quality husbandry products. The yak and Tibetan sheep industry, bearing distinct local characteristics and advantages, have demonstrated evidently comprehensive development and persistent expansion in scale throughout the ongoing endeavor to promote ecological husbandry. Previous reports indicate that the number of cattle was 6.42 million in Qinghai in 2021, with the growth rate surpassing the national average level by 2.6%, and the production of Tibetan sheep similarly demonstrated consistent increases, with an average annual growth rate of 1.2%. An important facet of promoting ecological husbandry in Qinghai involves the establishment of village-level ecological husbandry cooperatives to facilitate coordinated grassland management. As of August 2018, there had been 961 cooperatives, with a membership rate of 72.5% among herders and integration rates of resources exceeding 65%, such as both livestock and pastures.

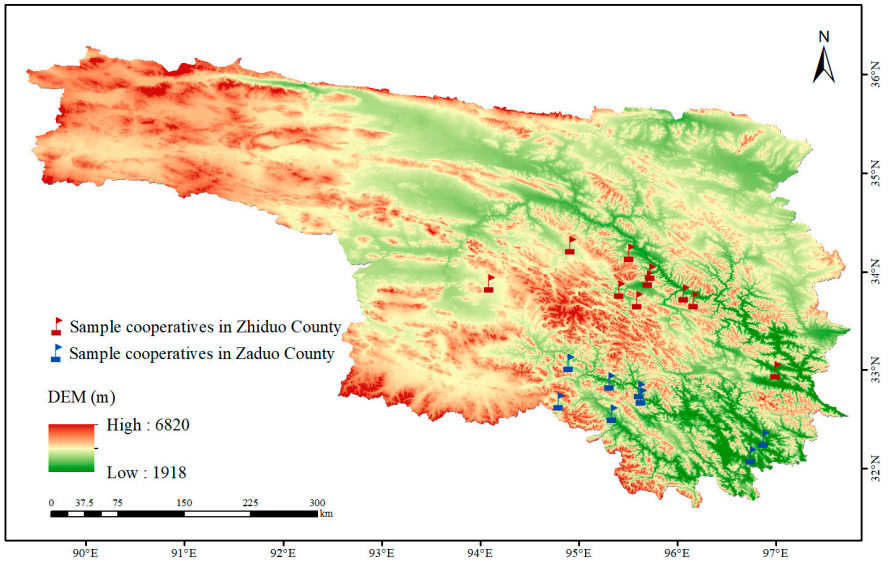

Figure 1. Locations of husbandry cooperatives in Yushu Prefecture.

Yushu Prefecture, situated in the Sanjiangyuan region, is the core production center of Qinghai yaks. Given its well-developed ecological animal husbandry industry, it can offer more typical cases of ecological husbandry cooperatives for this study. Hence, Yushu Prefecture is selected as the main data collection area. The local government upholds the principles of ecological governance and sustainable development and is dedicated to enhancing the quality and efficiency of the husbandry industry. It strives to establish a center for the export of organic agricultural and livestock products, as well as cultivating a regional public brand for "Yushu Yak", attaining benefits stemming from the development of ecological husbandry becoming increasingly evident with each passing year. There had been a total of 206 village-level ecological husbandry cooperatives encompassing over 40,000 herders in Yushu as of October 2022, with 36 cooperatives having successfully transitioned to a joint-stock system.

The data in this study were collected through a field survey in Zhiduo and Zaduo County of Yushu Prefecture during July and August of 2022. Our approach involved filling out the questionnaires during one-on-one interviews between the surveyors and local herders. Based on the preliminary survey, it was evident that the majority of local herders are Tibetans as they had limited proficiency in both understanding and articulating Chinese language. Therefore, the research team issued a recruitment note for surveyors via a WeChat public account in advance and selected 14 native university students who are proficient in both Tibetan and Chinese languages and are more familiar with the investigation area through joint collaboration among the research team, local government and social publicity. Thorough training was conducted prior to the formal survey to equip the surveyors with the necessary skills and knowledge. The training ensured the accurate transmission of questionnaire content to some extent, facilitating the collection of authentic and meaningful feedback from the herders. The survey questionnaires consisted of herdsmen-level and village-level parts with lengths of 24 and 9 pages, respectively, and the interview duration for each questionnaire was approximately 1.5 to 2 h. A stratified random sampling approach was adopted based on some key factors such as natural conditions, economic development characteristics, and other fundamental information. With villages as the sampling units, an average of 10 to 15 households of herders were interviewed in each village, resulting in a total of 241 valid herder samples from 18 villages spanning 10 townships.

Locations of ecological husbandry cooperatives can be seen in Figure 1. Among the 18 village-level ecological husbandry cooperatives, 1 was established as early as 2011, while the majority of them were subsequently established between 2015 and 2017. These cooperatives have taken a systematic approach in integrating livestock and pasture resources,

implementing rotational grazing, and optimizing livestock structures, and gradually promoted the shareholding reform. Four of them were recognized as national or provincial models, exerting a pioneering role in the subsequent progression of ecological husbandry.

3.2. Fuzzy-Set Qualitative Comparative Analysis (fsQCA)

Qualitative Comparative Analysis (QCA) was employed in this study, which is a technique designed for the comparative explanations of multiple cases [38,39]. QCA offers dual merits: firstly, it integrates both qualitative and quantitative comparative techniques [40]; secondly, it proves particularly pertinent for small-N analyses, typically for studies with case numbers ranging from 10 to 50. This methodological selection aligns with our research objective of rigorously investigating the intricate relationships within the case dataset, leveraging the nuanced capabilities of QCA to provide a comprehensive analytical approach.

Fuzzy-Set Qualitative Comparative Analysis (fsQCA), a methodological approach derived from QCA, entails systematic examination of fuzzy-set combinations of antecedent conditions, employing Boolean logic to mirror causal relationships between those conditions and specific outcomes. Fuzzy sets allow for the representation of social phenomena and real-world situations with imprecise boundaries between membership and non-membership—namely graded sets—which is necessary for social research [41]. In contrast to crisp sets, which dichotomously classify conditions as either present or absent, fuzzy sets introduce the notion of a membership score to signify the degree of inclusion. A membership score of 1 or 0 indicates full membership or non-membership, while a score approaching 1 denotes strong but not absolute membership and a score between 0 and 0.5 represents weak but not total non-membership. This approach provides valuable opportunities to capture and analyze inherent intricacies and uncertainties of social phenomenon, consistent with the exigencies of contemporary social research methodologies.

Raw data for both antecedent conditions and outcomes must be transformed into fuzzy-set values ranging from 0 (indicating non-membership) to 1 (indicating full membership) before fsQCA analysis, adhering to the methodology outlined by Ragin [42]. This conversion serves to capture qualitative nuances inherent among cases. The contribution of fsQCA lies in its capacity to discern single conditions or configurations necessary or sufficient to attain a final outcome. A condition is deemed necessary if it appears in all combinations leading to a specific outcome, and it is considered sufficient if the outcome occurs whenever this condition is present [43]. There are two pivotal indicators to assess the fuzzy-set relations, consistency and coverage [40]. Consistency gauges the degree of set relation, while coverage evaluates the significance of a condition in elucidating an outcome.

The rationale behind our determination to adopt fsQCA in lieu of conventional methods in this study is threefold. In the first place, we posit that the relationship between condition sets is asymmetric. Secondly, various combinations of antecedent conditions may culminate in the same outcome, illustrating equifinality. What is more, there exists a potential for causal complexity between antecedent conditions and outcomes. FsQCA, with its inherent capabilities, proves adept at addressing these intricacies more effectively.

3.3. Measurement

3.3.1. The Outcome: Performance of Grassland Collective Governance

This study identifies nine indicators structured across three subordinated layers related to provision, appropriation, and resource dependency, representing the overall outcomes, in accordance with the CPR theory, which address dual challenges involving provision and appropriation [44]. “Facility” and “Sustainability” are secondary levels of “Provision” and “Dependency”, respectively, while “Quantity”, “Quality”, and “Equity” are all relevant to “Appropriation”. Indicators were set with reference to prior research on irrigation management [45,46] and expressed in the form of survey questions. A five-point scale ranging from ‘Absolutely Disagree’ to ‘Totally Agree’, scored from 1 to 5, was used to evaluate these indicators, and descriptive statistics are detailed in Table 2. Further, we employed the

entropy weight method (EWM) to combine these figures into a comprehensive value, with the specific procedure explained in subsequent sections.

Table 2. Measurements of outcomes.

Dimension	Layer	Survey Questions (5 Points: 1 = Absolutely Disagree; 5 = Totally Agree)	Mean	S.D.
Provision	Facility	The husbandry infrastructure, such as greenhouse and grass sheds, is good	4	0.907
		The annual maintenance burden on these facilities is minimal	3.111	1.023
Appropriation	Quantity	There has been an ample supply of grass for livestock in the last years	3.555	1.294
		The initial allocation of the pastures to herdsmen was fair	4	0.970
	Quality	The quality of the pastures has improved over the past years in the village	3.222	0.943
		The grassland is in good condition currently	3.778	1.060
	Equity	Disputes related to pasture utilization are infrequent	4.111	0.900
		Disputes can be effectively and efficiently resolved when they do arise	3.889	1.410
Dependency	Sustainability	Grassland degradation exerts only a marginal impact on income and living standards	2.222	1.114

3.3.2. The Antecedent Conditions: Design Principles (DPs)

We adopt a nuanced perspective in this study by treating design principles (DPs) as fuzzy sets [47]. This approach attempts to more accurately capture the distinctions among cases by quantifying the degree of membership rather than relying on a simplistic binary characterization of presence or absence. Drawing on prior categorizations of DPs [48], our assignment and elucidation of these principles are detailed in the following content and summarized in Table 3.

Table 3. Measurement of antecedent conditions (4 points: 0 = completely absent; 1 = totally present).

Category	DPs	Mean	S.D.
Rules	DP1: Clearly defined boundaries	0.612	0.309
	DP2: Congruence with local conditions	0.407	0.315
Rule enforcement	DP4: Monitoring	0.314	0.313
	DP5: Graduated sanctions	0.167	0.348
	DP6: Conflict resolution mechanisms	0.611	0.349
Rule-making arenas	DP3: Collective choice arrangements	0.369	0.301
	DP7: Minimal recognition of rights to organize	0.519	0.287
	DP8: Nested governance	0.371	0.427

Rules encompass DP1 and DP2. The users (DP1A) and resource boundaries (DP1B), initially delineated by the household registration system (HRS) and grassland contract system (GCS), were universally acknowledged by villages, while nuanced dynamics were introduced with the establishment and development of ecological husbandry cooperatives. On the one hand, the demarcation of DP1A and DP1B became somewhat ambiguous from a herdsmen-level perspective, as fences between households were intentionally dismantled to integrate resources including pastures and livestock. This integration can promote shared usage and co-management, thereby optimizing governance. Yet, the lack of uniformity in cooperative operations led to an unclear membership status, making it challenging to exclude non-users. On the other hand, DP1A and DP1B remained constant at a broader village-level, only with internal allocation and utilization undergoing some alterations. Consequently, the perceived ambiguity of DP1, primarily reflecting internal changes in this study, does not universally undermine the local context. Rules matching the local conditions (DP2A) and parity of costs and benefits (DP2B) assume greater importance in this case, serving as evaluative criteria for processes and outcomes of both grassland collective governance and cooperative management. It seems that the adoption of strategies that are relevant to local realities emerges as a foundational element for achieving success in a multifaceted context.

Rule enforcement encompasses DP4, DP5, and DP6. Monitoring (DP4) entails (i) regular assessment of grassland conditions to enable adaptive grazing measures and (ii) oversight to ensure herders adhere to existing rules and judiciously utilize pastures. The implementation of graded sanctions (DP5) serves to deter speculative behaviors, aligning benefits with associated costs, as violations are often linked to deviations from the prescribed grass–stock balance standard (one sheep per hectare in Yushu Prefecture). The incorporation of conflict resolution mechanisms (DP6) contributes to a reduction in the overall cost of supervision and sanctions, thereby enhancing management efficiency. A decrease in conflicts correlates with more normative behaviors among herdsmen, highlighting the important impact of effective rule enforcement mechanisms on shaping desired norms within the system.

Rule-making arenas encompass DP3, DP7, and DP8. Collective choice arrangements (DP3) play a pivotal role in representing the decision-making processes and the degree of participation of herdsmen within ecological husbandry cooperatives. Minimal recognition of rights to organize (DP7) signifies the extent to which higher-level authorities acknowledge and support these collective choices. Additionally, the nested governance (DP8) functions as an evaluative framework, assessing the capacity and quality of ecological husbandry cooperatives in this study. It aims to elucidate the contributions of these cooperatives to sustainable development and local resource management.

3.4. Data Processing and Calibration

Utilizing the survey data, we employed the entropy weight method (EWM) to compute the comprehensive performance score of collective grassland governance for each cooperative. This objective weighting technique allocates weights based on the observed degree of variation in each indicator, effectively minimizing potential biases introduced by human factors. After standardizing the data according to Equation (1), the subsequent procedures outlined in Equations (2)–(5) were implemented to determine the weights for the nine previously mentioned indicators. The score of each case was subsequently obtained by multiplying the calculated weights with the original data. The specific process is as follows:

First, the data were standardized. In Equation (1), X generally refers to the nine indicators employed to measure performance, detailed in Table 2. i indicates the number of samples, while j indicates the number of indicators, with j = 1, 2, . . ., 9.

$$X'_{ij} = \frac{X_{ij} - min\{X_j\}}{max\{X_j\} - min\{X_j\}} \quad (1)$$

Then, we calculated the proportion of the sample (i) under the indicator (j), and P represents the calculated result.

$$P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{n} X_{ij}} \quad (2)$$

We calculated the information entropy value (e) for the indicator (j):

$$e_j = -k \times \sum_{i=1}^{n} P_{ij} log(P_{ij}) \quad (3)$$

Setting $k = \frac{1}{lnm}$, the value ranges from 0 to 1. The redundancy of information entropy for the indicator (j) can be expressed as $d_j = 1 - e_j$, where a higher redundancy value signifies a more crucial indicator.

The weight (W) for the indicator (j) is calculated as follows:

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (4)$$

The performance score of grassland collective governance (referred to as *GP*) is calculated as follows:

$$GP = \sum_{i=1}^{n} W_i X_i (i = 1, 2, 3, \ldots, n) \quad (5)$$

It is imperative to calibrate the data with respect to anchor points before fsQCA, necessitating careful selection of the reference scale. Diverse calibration methods were employed, contingent upon the nature of the data. Upon evaluating different value thresholds, we determined three anchor points—0.95, 0.5, and 0.05—to calibrate the governance performance, treated as a continuous variable or a fuzzy set [39]. This approach ensures that the nuances among cases are meaningfully and comprehensively represented [49].

For DPs, four anchor points were determined as calibration references to convert raw records into a fuzzy set, steering clear of the fuzzy point 0.5 [50]. The calibration points are as follows: 0 (completely not affiliated), 0.33 (partially not affiliated), 0.67 (partially affiliated), and 1 (completely affiliated) [51,52]. This step has already been completed in the part of variable explanation, and specific meanings associated with each point were elucidated previously.

Subsequent to data processing and calibration, a data fuzzy-set matrix required for fsQCA was generated. This comprehensive approach covers various combinations, thereby providing an expansive observation space for both presence and absence configurations in the ensuing analysis.

4. Results

4.1. Necessary Condition Analysis

The initial phase of our analysis involves testing the necessary conditions to ascertain whether a single antecedent condition (DP1 to DP8) is imperative for the outcome (governance performance, GP for short). A single antecedent condition is deemed necessary if its consistency exceeds 0.9 and the coverage coefficient is above 0.5 [53]. The results, as outlined in Table 4, reveal that the consistency and coverage coefficients of DP6 for GP, as well as those of ~DP4, ~DP5, and ~DP8 for ~GP, meet both threshold requirements, suggesting they may be potentially necessary conditions for the corresponding outcomes.

Table 4. Necessary analysis of single condition.

Conditions	GP		~GP	
	Consistency	Coverage	Consistency	Coverage
DP1	0.8249	0.6497	0.6781	0.5735
~DP1	0.4585	0.5702	0.5858	0.7822
DP2	0.7350	0.8716	0.3820	0.4863
~DP2	0.5668	0.4607	0.8991	0.7846
DP3	0.5518	0.7214	0.4474	0.6280
~DP3	0.7154	0.5467	0.8015	0.6576
DP4	0.5634	0.8640	0.3047	0.5018
~DP4	0.6751	0.4749	0.9174	0.6929
DP5	0.2926	0.8467	0.1127	0.3500
~DP5	0.7753	0.4487	0.9506	0.5907
DP6	0.9136	0.7209	0.5579	0.4727
~DP6	0.3318	0.4114	0.6706	0.8929
DP7	0.8065	0.7495	0.5933	0.5921
~DP7	0.5611	0.5624	0.7489	0.8060
DP8	0.6682	0.8696	0.2049	0.2864
~DP8	0.4516	0.3460	0.9067	0.7458

Note: the "~" indicates "absent" in the configuration.

Furthermore, to qualify as necessary conditions, they must also satisfy two criteria in an XY plot [54]. One is that the scatters distributed above the diagonal line should be less than one-third of the total samples [55], and the other is that all scatters are encouraged to

approach the right area of the graph. Then, only ~DP5 and ~DP8 pass the test for ~GP in this regard.

Given that the necessary condition analysis results fall below the established criterion, a more in-depth configuration analysis is warranted.

4.2. Configuration Analysis

4.2.1. Presence Configuration

The truth table for configuration analysis can be generated with fsQCA 3.0 [56], utilizing the fuzzy-set matrix comprising eight antecedent conditions and the outcomes. Setting the frequency and consistency thresholds at 1 and 0.8, respectively, the subsequent path analysis explores the results. As delineated in Table 5, configurations linked to high-level governance performance are plotted according to the intermediate and parsimonious solutions.

Table 5. Configurations for high-level governance performance.

Condition	GP		
	1a	**1b**	**1c**
DP1	•	•	
DP2	●	●	●
DP3			
DP4			•
DP5	•		
DP6	•	•	•
DP7		•	•
DP8	•	•	•
Number of observations	2	4	4
Raw coverage	0.2177	0.4608	0.3825
Unique coverage	0.0645	0.0772	0.0369
Consistency	0.9450	1	0.9940
Solution coverage		0.5622	
Solution consistency		0.9741	

Note: "●" means that the core causal condition is present and "•" means that the peripheral causal condition is present; a blank cell indicates that the condition, present or absent, does not affect the result.

Table 5 shows various configurations conducive to generating high-level grassland collective governance performance, suggesting a causal equivalence among antecedent configurations for successful outcomes, all exhibiting high consistency above 0.9. Three configurations, embodying five DPs, are identified. Each of them encompasses at least one principle from rules (DP1 and DP2), rule enforcement (DP4, DP5, and DP6), and rule-making arenas (DP3, DP7, and DP8).

Upon closer examination of their similarities, the three configurations consistently include DP2, DP6, and DP8, with DP2 emerging as a core condition. The congruence between appropriation and provision rules with local conditions (DP2) is a pivotal prerequisite and a key factor in grassland collective governance, consistent with findings from other research endeavors [57]. It provides a crucial foundation for subsequent implementation, emphasizing that effective performance hinges on actions harmonizing with local realities. In this context, an absolute clear boundary for users and resources (DP1) is relatively less crucial in the rules category (as seen in configuration 1c), and rotational grazing, as perceived and told by herdsmen, seems to be ecologically beneficial [58].

A standardized village-level ecological husbandry cooperative (DP8) is present in all three configurations. Cooperatives serve to unify scattered herdsmen and integrate resources, achieving economies of scale, thereby contributing significantly to improving grassland governance performance. This aligns with the evidence supporting the efficacy

of community-based management [59]. Despite variations in specific guidelines (presence or absence of DP4, DP5, and DP6), positive effects are consistently observed.

Notably, collective choice arrangement (DP3) does not exist in the three configurations. This may be related to the presence of DP8 within our research design, namely that the establishment of village-level ecological husbandry cooperatives to foster CPR governance has been viewed as the outcome of herdsmen's collective choice. And certain regulations remain relatively unchanged during the exploratory and developmental phase of ecological husbandry, compared to the original determination upon initiating cooperatives.

4.2.2. Absence Configuration

Following the examination of the presence configuration, it is necessary to concurrently investigate the absence configuration, aiming to draw a more comprehensive and cautious conclusion. The two primary reasons are as follows. First, one of the assumptions of fsQCA is that antecedent conditions exhibit an asymmetrical causality with the outcomes. In other words, the factors contributing to "success" are typically not identical to those causing "failure", indicating that the presence configuration fostering positive results is not entirely equivalent to the absence configuration yielding negative consequences (i.e., non-high-level governance performance). Second, conducting a simultaneous configuration analysis for both high and non-high levels can provide valuable insights, enhancing our theoretical and practical understanding. Therefore, we also explored the "failed process", reducing the bias of disproportionately focusing on successful cases to the detriment of failed ones.

Likewise accompanied with the truth table of DPs and ~GP, the intermediate and parsimonious solutions for non-high-level governance performance are output by fsQCA 3.0 with the frequency and consistency thresholds at 1 and 0.8, respectively. The culmination of results is presented in Table 6.

Table 6. Configurations for non-high-level governance performance.

Condition	~GP		
	2a	**2b**	**2c**
DP1			⊗
DP2	⊗	⊗	⊗
DP3	⊗	⊗	
DP4	⊗	⊗	⊗
DP5	⊗	⊗	⊗
DP6		⊗	⊗
DP7	⊗		⊗
DP8	⊗	⊗	⊗
Number of observations	5	6	2
Raw coverage	0.5697	0.5708	0.4345
Unique coverage	0.0719	0.0730	0.0225
Consistency	0.9382	0.9383	0.9397
Solution coverage		0.6652	
Solution consistency		0.9281	

Note: "⊗" means that the core causal condition is absent and "⊗" means that the peripheral causal condition is absent; a blank cell indicates that the condition, present or absent, does not affect the result.

Various absent combinations of the eight DPs can be identified as causative factors leading to non-high-level grassland collective governance performance. Notably, the three configurations in Table 6 share a commonality—they lack all items from one or two categories mentioned earlier, such as rule-making arenas for 2a, rule enforcement for 2b, and rules and rule enforcement for 2c. This suggests that commendable performance is unattainable without any one of rules, rule enforcement, and rule-making arenas.

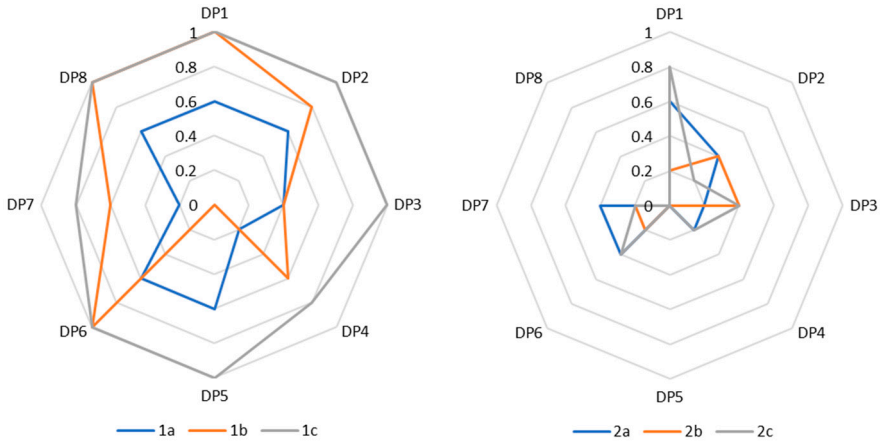

Figure 2. The institutional rules of a typical configuration.

The institutional rules of typical configurations are showed in Figure 2, and a comparative analysis of configurations for GP and ~GP reveals two key findings: (i) the necessity for satisfying most DPs for successful CPR governance is validated in the context of grassland governance in China, in line with the logic widely accepted of governing the commons; (ii) configurations for high and non-high levels of governance performance are not completely symmetrical, demonstrating the asymmetric causality in the relationship between institutional regulations and governance performance and illustrating the rationality of the fsQCA method.

4.3. Robustness of Findings

Evaluating the robustness of QCA results typically involves modifying relevant parameters. We opted to assess robustness by adjusting the consistency from 0.8 to 0.9 and excluding cases with a PRI below 0.85 in this study (PRI, Proportional Reduction in Inconsistency, is recommended to be maintained above 0.75 to mitigate the occurrence of "different outcomes with the same conditions" [60].

The analytical results, including consistency, convergence, and configurations, remain essentially unchanged under these parameter adjustments, reinforcing the reliability of the results [49]. And we computed the average values across the three categories and analyzed them again to further validate our findings; the results remained consistent with those obtained previously (seen in Table 7).

Table 7. Robustness of categories of DPs.

Condition	GP	~GP
Rules	•	⊗
Rule enforcement	●	⊗
Rule-making arenas	●	⊗
Number of observations	3	6
Raw coverage	0.5814	0.7344
Unique coverage	0.5814	0.7344
Consistency	0.9288	0.9208
Solution coverage	0.5814	0.7344
Solution consistency	0.9288	0.9208

Note: "●" means that the core causal condition is present and "•" means that the peripheral causal condition is present; "⊗" means that the core causal condition is absent and "⊗" means that the peripheral causal condition is absent.

5. Discussion

5.1. Existence of DPs

This study identified that congruence with local conditions (DP2), conflict resolution mechanisms (DP6), and nested governance (DP8) were predominant in the examined case study sites. Specifically, it is found that DP2 is indeed the primary factor for successful rangeland management [57]. While DP6 cannot be neglected, its absence may not be prohibitive, as alternative mechanisms can partially compensate, marking a vital stage in co-management [61]. But participants must face high costs occasionally in such a situation [62]. Moreover, the efficacy of grassland governance extends beyond simple community-based approaches, meaning that it necessitates multi-level measures (DP8) fortifying hierarchical communication and lateral flexibility [63].

In particular, clearly defined boundaries (DP1) is absent in configuration 1c, which is consistent with some findings in other pastures [64]. Although undefined or implicit boundaries may escalate conflicts, the influence of conflict resolution mechanisms (DP6) mitigates these concerns, emphasizing the meaningful and reasonable co-occurrence of these two principles [65], corresponding to configuration 1a and 1b in this study. The violation of collective choice arrangements (DP3) is often a downfall in failed CPR governance [66]. However, The disappearance of DP3 in this study may stem from the fact that cases with positive outcomes often exhibit well-functioning organizations, and the establishment of cooperatives signifies collective choices in action, embodying the logic of DP3.

5.2. Reasons for Good Governance

The establishment of ecological husbandry cooperatives is in line with local realities and can help achieve high grassland governance performance. Based on the analysis of typical cases, we determine that the key lies in the enhancement of ecological, economic, and social benefits brought about by the joint-stock cooperative operation model characterized by "livestock shares in grasslands, collective unified operation, remuneration based on labor for employment, and distribution of earnings according to shares". This model can stimulate herders to actively engage in grassland governance.

In terms of ecological benefits, cooperatives can achieve a larger-scale grass–livestock balance, preserve and enhance grassland ecology, and increase the carrying capacity of grasslands, thereby creating favorable conditions for the development of grassland animal husbandry. They integrate grassland and livestock resources, conduct joint grazing, implement rotational grazing by dividing pastures into zones and sections, and raise livestock through grouping and categorization. This not only enables rational utilization of grassland resources but also effectively optimizes the livestock structure. Cooperatives based on an acquaintance society make the contractual relationship between cooperatives and members public and transparent in the form of cooperative conventions, providing a basis for supervising and punishing irregular behaviors such as grassland resource abuse in pastoral governance. The reduction in uncertainty in the cooperation process enhances the stability and continuity of cooperation, effectively addressing the free-rider problem in the governance of common pool resources [24].

Regarding economic benefits, cooperatives can guarantee stable operating incomes and drive the continuous growth of herdsmen's earnings. The collective is more motivated and capable of enhancing the construction and maintenance of infrastructure like warm sheds and grass storage sheds. It consciously increases the improved variety rate and female livestock rate, changes the traditional reluctance to slaughter and sell, and raises the slaughter rate to obtain operating income. Through joint-stock reform, cooperatives convert herders' livestock, grasslands, and other resources into shares, enabling members to obtain dividend incomes according to shares and enjoy the collective operating benefits. Initially, to address the shareholding problem for households with few or no livestock and poor households, some cooperatives allowed accurately targeted poor households to invest in cooperatives at one time with industrial assistance funds. The diversified shareholding

methods essentially provide multiple ways to obtain membership, benefiting as many herdsmen as possible. Reasonable quantification of shares guarantees members' earning rights and strengthens herdsmen's centripetal force toward cooperatives. Additionally, cooperatives change the single industrial model, accelerate the development of secondary and tertiary industries, and enhance the industrial resilience of pastoral areas [67].

As for social benefits, cooperatives strengthen the connections among herdsmen, enhance the effective participation of herders, and solidify the foundation of rural governance in pastoral areas. Cooperatives can boost the cultural identity and collective sense of belonging of members. The role of cultural homogeneity in achieving collective action cannot be overlooked [68]. To fully mobilize and utilize the talents of herdsmen, cooperatives offer a series of jobs and employment opportunities, such as full-time herders and milkers. The remuneration system combines basic remuneration with performance incentives, which not only heightens the sense of responsibility of workers but also reduces supervision costs. Herdsmen who wish to continue engaging in animal husbandry can select appropriate positions to assist in the production and operation of cooperatives and obtain additional labor remuneration. Other herdsmen can choose to enter other industries and be liberated from pastoral grasslands to expand their livelihood channels. Reducing the number of people involved in animal husbandry and promoting the effective participation of herdsmen are in line with the goal directions of the sustainable use of grasslands and the high-quality development of animal husbandry. Village-level cooperatives are more capable of arranging matters related to animal husbandry according to actual changes in circumstances. This flexibility can reduce potential cooperation obstacles caused by contract rigidity, gather cooperation momentum, ensure standardized operation, and form a virtuous circle.

5.3. Case Analysis

YM Village is a typical case of configuration 1b with promising development prospects, achieved by developing ecological animal husbandry cooperatives to drive herders to participate in collective governance. The village consists of 320 households and 1,518 people. The contracted available grassland is approximately 180.6 square kilometers, averaging 0.56 square kilometers per household. In 2009, with the support and guidance of the local government, YM Village began to explore the cooperative operation model for animal husbandry. Due to the influence of traditional thoughts and grazing habits, only 35 herder households joined the cooperative at its inception. The establishment of the cooperative has enhanced the efficiency of livestock breeding and optimized the industrial development chain. Given the relatively insufficient grassland resource endowment of this village, the village collective rents grassland from neighboring villages to meet the needs of livestock management activities. Similar to existing research findings, the expansion of the grassland scale is conducive to achieving collective action [69]. Over the past decade or more, through measures such as resource integration, zoned rotational grazing, reasonable stocking, and unified management, the potential of the ecological animal husbandry cooperative in YM Village has been gradually tapped into. The development scale has continuously expanded, and more and more herders have participated in collective grassland governance. By the end of 2021, 263 households had joined the cooperative. The operating income of animal husbandry was substantial, and more than half was used for member dividends. The cooperative formulates reasonable and feasible rules for grassland use and animal husbandry development based on local conditions. It sets up five grazing points within the grassland area of the cooperative and hires 16 full-time herders to assist in grazing management. The cooperative management personnel also earnestly listen to the opinions of the vast number of herdsmen and timely adjust and optimize relevant institutional rules. Institutional rules adapted to local conditions and friendly and harmonious relations between cadres and the masses can stimulate the willingness of herders to participate in collective governance. The effective participation of herders and positive interaction with cooperatives or village collectives are important factors for realizing the sustainable

development of pastoral areas [70]. Due to its excellent benefits, the ecological animal husbandry cooperative in YM Village has been rated as a provincial-level demonstration cooperative, and its specific operation model has also been promoted and publicized as a typical example. Cooperatives can leverage the advantage of "concentrating strength to do big things." More and more herdsmen are paying attention to this cooperation benefit and actively taking actions to join in collective governance.

6. Conclusions

This paper explored the conditions conducive to successful grassland governance using Ostrom's design principles (DPs), building a bridge between theory and reality in the context of Chinese pastures. The insights presented in this paper contribute novel perspectives to understanding the importance of applying institutional regulations in grassland collective governance. The key findings include the following:

(i) Diverse combinations of institutional rules can form favorable collective governance outcomes, and attaining good outcomes necessitates a comprehensive approach encompassing rules, rule enforcement, and rule-making arenas. (ii) Congruence with local conditions (DP2) emerges as a pivotal and foundational condition in collective grassland governance. Thus, it is paramount to formulate strategic governance rules that adapt to local realities and capitalize on regional advantages for ensuring long-term success. (iii) The establishment of ecological husbandry cooperatives is in line with local realities and can help achieve high grassland governance performance. The improvement in ecological, economic, and social benefits brought about by cooperatives constitutes a crucial factor for promoting herders' active involvement in the collective management of grasslands.

However, it is essential to acknowledge the limitations of this study, given the practical constraints that we only collected data from the representative Qinghai Province. Case studies in other pastoral regions in China can either validate our findings or identify new mechanisms for achieving excellent grassland governance performance.

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