

Exploration of Sustainable Agro-Pastoral Integration Development Models in the Qinghai-Tibet Plateau

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Abstract. The high-altitude geographical characteristics and unique climate types of the Qinghai-Tibet Plateau have dictated an agricultural and pastoral development path for the region, which, after a series of evolutionary developments, has culminated in the current model of agro-pastoral integration. However, the economic and ecological benefits brought by the development of agriculture and animal husbandry are accompanied by serious issues such as land degradation and overgrazing, making the exploration and practice of sustainable agro-pastoral integration models for the Qinghai-Tibet Plateau an urgent task. This article utilizes CiteSpace to review recent literature on agro-pastoral development models in the Qinghai-Tibet Plateau. Starting from the agro-pastoral processes, spatial layout, and economic development of the Qinghai-Tibet Plateau, this paper aims to provide a macroscopic understanding of the agro-pastoral integration model, propose new strategies and ideas for development, and offer scientific theoretical and practical guidance for sustainable development, achieving a win-win situation for economic growth and ecological protection.

Keywords: Qinghai-Tibet Plateau, Agro-pastoral Integration, Sustainable Development.

1. Introduction

The integration of agriculture and livestock varies by region and cultural background [1]. The "Agricultural Revolution" in England is a typical example of agro-pastoral integration, with the United States' sustainable composting technology in the Midwest, and Bangladesh's integrated dairy farming systems serving as successful cases of such integration [2-4]. Domestically, various models have developed, including the southern biogas ecological model, the "four-in-one" model, the northwest "five supports" ecological agriculture model, and the plain area's recycling chain model. In Tibet, the integration is typically at a low level within families, along with "company + farmer" and traditional types, but these models face challenges such as monoculture and insufficient resource recycling.

A rational agro-pastoral system can optimize agricultural resource allocation and improve production efficiency while addressing the growing food demand and resource shortages [5-6]. This model promotes resource recycling and sustainable agricultural economic development, and is key to driving rural modernization. Agro-pastoral integration benefits nutrient cycling in ecosystems and carbon emission reduction, improving soil quality through the return of crop residues and livestock manure to the fields, and enhancing soil carbon storage to combat global warming [7-8]. Economically, agro-pastoral systems reduce costs and improve overall efficiency through resource complementarity, fully utilizing land resources and increasing farmers' incomes [2]. Socially, agro-pastoral integration plays an important role in maintaining the religious beliefs and cultural traditions of the Qinghai-Tibet Plateau, providing more jobs and stable income with government support, which is crucial for social stability [9].

The fragile ecological environment of the Qinghai-Tibet Plateau is worsening due to land degradation and soil erosion caused by population growth. Traditional mindsets and the inability to adapt to change among herders hinder the sustainable development of agro-pastoral integration [10]. Challenges such as inadequate infrastructure, low industrialization, insufficient use of technology, weak carrying capacity of the cold grasslands, and extensive livestock management have led to inefficient and unprofitable grassland livestock farming [11]. Overexploitation in agro-pastoral transition areas causes grassland degradation, and the lack of leading enterprises and policy support impedes the development of the livestock industry [12-13].

2. Bibliometric Analysis

2.1. Data and Methods

This study conducted a bibliometric analysis of literature from 2000 to 2023 through the China National Knowledge Infrastructure (CNKI) database, focusing on keywords such as "Qinghai-Tibet Plateau", "Agro-pastoral Integration", and "Sustainable Development". A total of 314 related documents were selected from CNKI, considering the relatively fewer documents in the Web of Science (WOS) database. With the help of CiteSpace software, an in-depth analysis was performed to draw knowledge maps and explore research themes and trends.

2.2. Research Trends and Development Trajectory

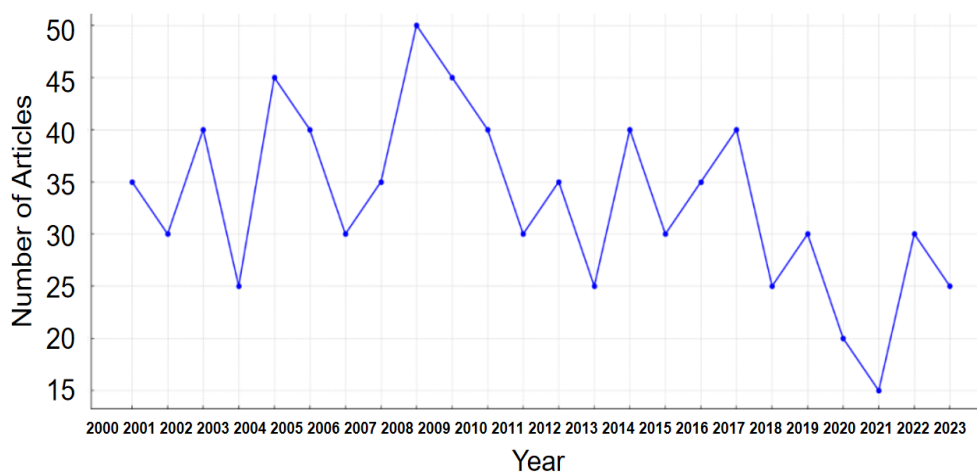


Figure 1. Annual Trends of Research on Sustainable Agriculture-Pastoral Integration in the Qinghai-Tibet Plateau

The research on agro-pastoral integration in the Qinghai-Tibet Plateau can be roughly divided into three developmental stages according to Figure 1:

(1) Initial Stage (2001-2004): Research in this period was relatively scarce, mainly focusing on basic surveys of agriculture and animal husbandry in the Qinghai-Tibet Plateau and the preliminary introduction of sustainable development concepts, with an emphasis on understanding the unique ecosystems and agro-pastoral production modes of the plateau.

(2) Development Stage (2005-2016): With growing recognition of the importance of the Qinghai-Tibet Plateau's ecological environment, research shifted towards integrating agricultural and pastoral production with ecological protection to ensure the region's sustainable development.

(3) Maturity Stage (2017 to present): Research in this period has become more in-depth and diversified, covering aspects such as adaptation to climate change, biodiversity conservation, and water resource management. There is also an increasing focus on empirical research and case studies.

2.3. Key Research Institutions

The research on sustainable agro-pastoral integration models in the Qinghai-Tibet Plateau is a complex topic involving multiple fields and institutions. We have compiled the key research institutions from the literature, and the results are shown in Table 1:

Table 1. Research Institutions on Agricultural and Pastoral Integration in the Qinghai-Tibet Plateau.

| Number of publications | Year of publications | Related institutions |
|------------------------|----------------------|--|
| 10 | 2008 | Lanzhou University |
| 9 | 2003 | Chinese Academy of Sciences |
| 5 | 2002 | Qinghai University for Nationalities |
| 3 | 2016 | Southwest University for Nationalities |

In the field of agro-pastoral integration and sustainable development in the Qinghai-Tibet Plateau, Lanzhou University has made contributions to water resources and environmental protection. The Chinese Academy of Sciences and its affiliated institutes play a central role in sustainable development research. Qinghai University for Nationalities has made progress in the practical application of sustainable agro-pastoral development models. The research outcomes of these institutions provide support for both theory and practice, and cooperation among them can lead to resource sharing and improved research quality.

2.4. Research Hotspots and Themes

We conducted a keyword clustering analysis on the 314 documents collected from CNKI, and the results are presented in Table 2.

Table 2. CNKI Qinghai-Tibet Plateau Agro-Pastoral Integration Related Literature Keyword Clustering List

| Number of Keyword Occurrences | Keyword Centrality | Year of First Occurrence | Keywords |
|-------------------------------|--------------------|--------------------------|---------------------------|
| 119 | 1.17 | 2000 | Qinghai-Tibet Plateau |
| 44 | 0.57 | 2001 | Agri-Pastoral Integration |
| 9 | 0.05 | 2000 | Animal Husbandry |
| 7 | 0.04 | 2002 | Ecological Environment |
| 6 | 0.03 | 2009 | Development Strategy |
| 6 | 0.02 | 2005 | Ecological Economy |
| 6 | 0.03 | 2000 | Grassland Resources |
| 5 | 0.02 | 2006 | Human-land Relationship |
| 5 | 0.01 | 2002 | Circular Economy |

The research hotspots mentioned above can be further summarized into three directions:

(1) **Ecosystem Management and Restoration:** Focuses on addressing issues such as grassland degradation, water resource management, vegetation and soil protection, and biodiversity. The goal is to develop practical management strategies and technologies to promote community self-governance, cross-sector cooperation, and ecosystem health.

(2) **Sustainable Agro-pastoral Production Models:** Pays attention to land planning, livestock management, and ecological balance, exploring the coordination between agriculture and pastoralism and environmental protection. It proposes strategies to promote rural economic development and alleviate poverty.

(3) **Ecological Compensation and Valuation of Ecosystem Services:** Investigates the health of grassland ecosystems, livestock development models, and water resource utilization to find sustainable livestock and water resource management solutions.

These research hotspots reflect the cutting-edge areas and key issues in the study of sustainable agro-pastoral integration models in the Qinghai-Tibet Plateau, providing important theoretical and practical support to address the sustainable development challenges of the region.

2.5. Establishing Knowledge Structure and Theoretical Framework

As illustrated in Figures 2-3, with the ongoing advancement of research, the development model of agro-pastoral integration in the Qinghai-Tibet Plateau increasingly involves interdisciplinary studies. This aligns with the current trend of cross-disciplinary research and is expected to further broaden and deepen the scope of research in the future.

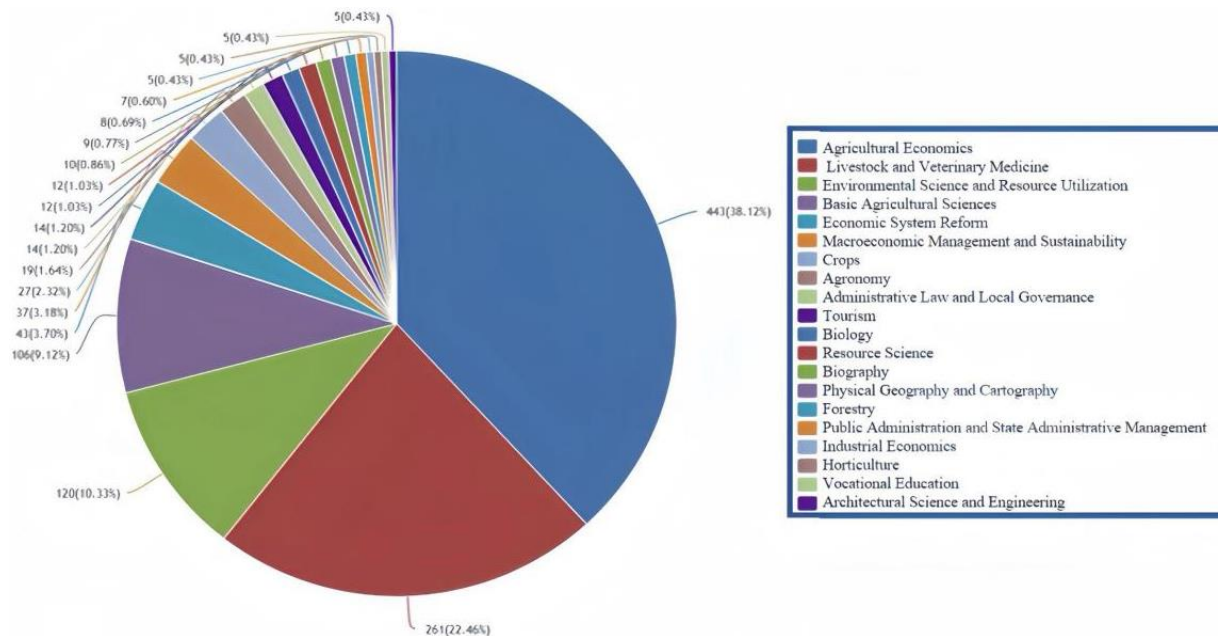


Figure 2. The Distribution of Disciplines Involved in the Direction of Agro-Pastoral Integration.

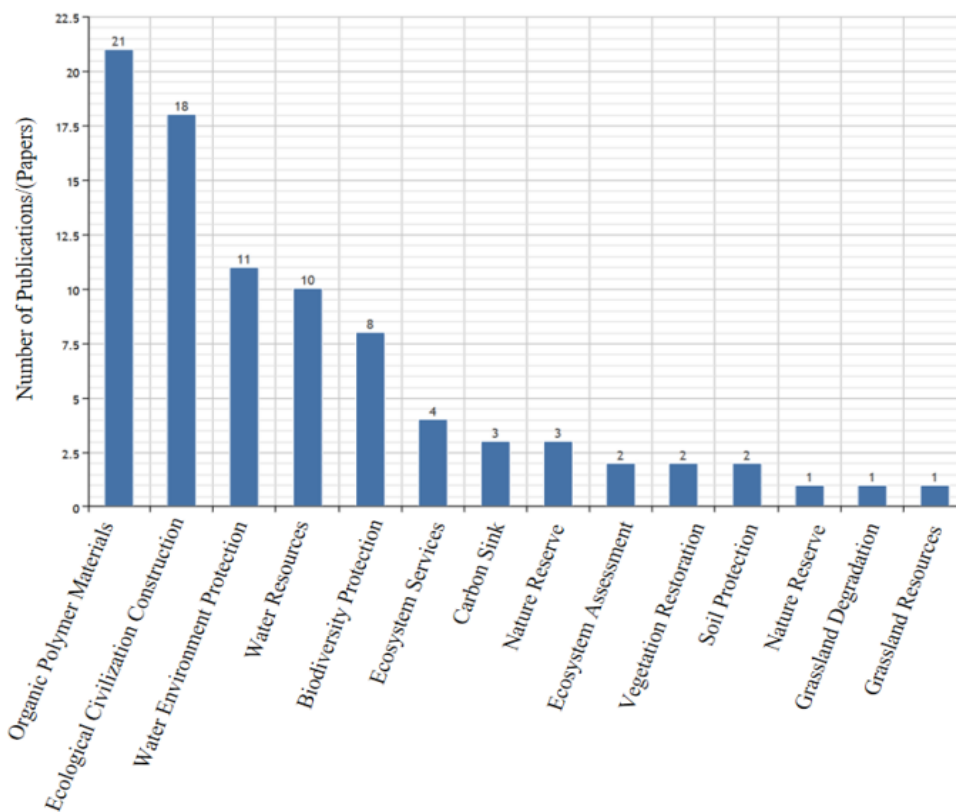


Figure 3. Research Levels in the Direction of Agri-Pastoral Integration.

Burst analysis of keywords allows for the identification of the start and end times of keywords, revealing shifts in research hotspots and themes. Figure 4 shows the changes in keywords from 2000

to 2023, transitioning from early-stage themes such as characteristic economy and ecological economy to mid-stage focuses on environmental protection and development models, and more recently to analyses of driving factors and the application of agro-pastoral integration models. Research on the sustainability of the Qinghai-Tibet Plateau has evolved from basic to in-depth, gradually showing a trend towards diversification.

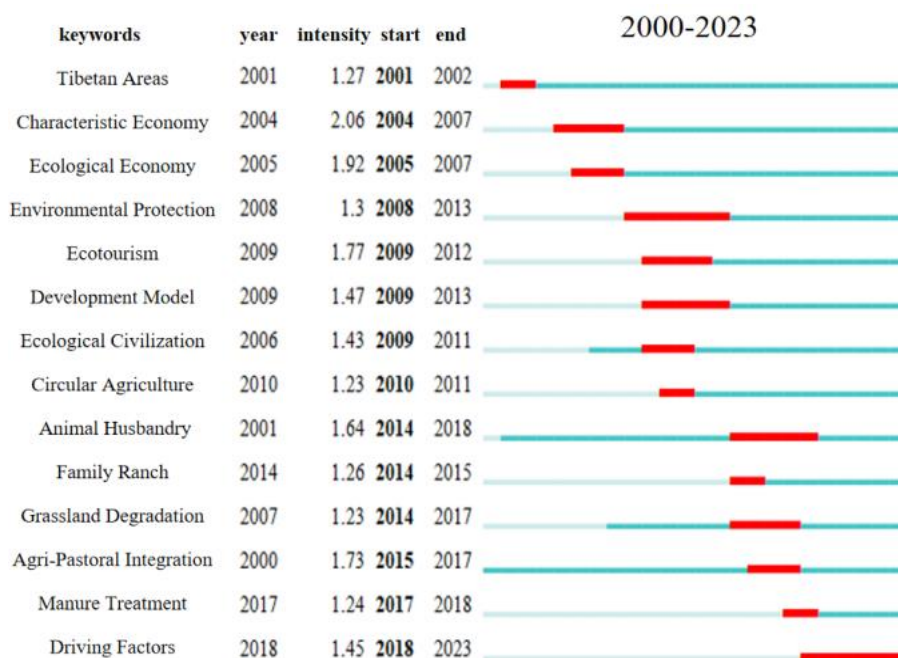


Figure 4. Changes in the Emergence Years of Keywords in Domestic Literature.

2.6. Identifying Research Gaps and Challenges

Agro-pastoral industries in the Qinghai-Tibet Plateau involve ecological environment, resource management, industrial development, and more, revealing a lack of comprehensive research that considers all these aspects together. There's a need to further explore how to achieve integrated management and promote coordinated development across all areas. The ecological environment of the Qinghai-Tibet Plateau is fragile, yet agriculture and animal husbandry are crucial for local economic development. Finding a balance between ecological protection and economic development requires further exploration of related policies and practices. The Qinghai-Tibet Plateau is sensitive to climate change, and research on how agriculture and animal husbandry can adapt is insufficient. It is necessary to adjust production methods and resource utilization, and to develop relevant technologies to mitigate the impact of climate change on agro-pastoral industries.

3. Exploration of Agro-pastoral Integration Models

The unique geographical climate and cultural background of the Qinghai-Tibet Plateau determine that simple agro-pastoral integration cannot achieve the expected economic benefits. Therefore, we have summarized the following four sustainable development paths for agro-pastoral integration in the Qinghai-Tibet Plateau:

3.1. Tailored Strategies - Coupling Models of Livestock Breeding and Crop Cultivation

In exploring agro-pastoral integration models for the Qinghai-Tibet Plateau, two innovative coupling models, livestock breeding and crop cultivation, and grassland-farming-pastoralism supplementation, were proposed to form a closed-loop sustainable development strategy. The livestock breeding and crop cultivation model transforms livestock excrement into crop nutrients, while the grassland-farming-pastoralism supplementation model uses the interdependence between

grassland and livestock to form an ecological chain. These models not only alleviate the pressure on pastoral areas but also optimize resource utilization in agricultural areas, improving regional ecological quality and economic benefits.

3.2. Adjusting Resource Allocation - Optimizing the Overall Layout

Agricultural resource input can be optimized, and the dosage of fertilizers and pesticides can be reduced through low-input sustainable models and resource cycling models to achieve the highest possible yield; the use of organic fertilizers instead of chemical fertilizers, biogas slurry instead of fuel, and straw as feed can reduce cost inputs and increase economic benefits[2]. Crop rotation can better utilize the nutrients in the soil while facilitating carbon and nitrogen cycling, thus increasing crop yields.

3.3. Expanding Operational Structure - Driving the Market Economy

The government can lead the optimization and segmentation of agricultural and pastoral operations, encouraging families to create unique brands. The Qinghai-Tibet Plateau's agricultural and pastoral products and derivatives are diverse, nutritionally valuable, and rich in taste, such as highland barley wine and yogurt fermented from highland barley, various dairy products fermented from sheep and yak milk, etc., which have a broad domestic and international market. In operational structure, market orientation should be emphasized to push the plateau's distinctive agricultural and pastoral products into a broader market. Based on the current overgrazing situation, a grassland ecological protection subsidy and reward mechanism should be applied to achieve grassland ecological protection through livestock reduction while ensuring that the income of pastoralists does not decrease by implementing ecological compensation based on the beneficiary-pays principle.

3.4. Developing Technology - Promoting Ecology and Technology Bilaterally

Building modern plateau-specialized agriculture and animal husbandry can enhance the economic benefits while maintaining the ecological environment of the plateau. Cost reduction through genetic breeding and seed bank construction, optimization of production factor allocation, and strengthening of plateau-specialized industry construction can promote the bilateral development of ecology and economy through technology[1]. Research on characteristic medicinal herbs in high-altitude areas and the development of Tibetan medicine are also key ways to enhance resource utilization and regional economy.

4. Conclusion

The following achievements have been made in the study and exploration of agro-pastoral integration models in the Qinghai-Tibet Plateau over the past two decades:

(1) Theoretical Contribution: A theoretical framework for the sustainable development of agro-pastoral integration in the Qinghai-Tibet Plateau has been established, clarifying key concepts and related fields.

(2) Practical Guidance: Sustainable management strategies and measures specific to the Qinghai-Tibet Plateau's unique conditions have been summarized, including coupling models of livestock breeding and crop cultivation, adjusting resource allocation, and expanding operational structures. This also provides a scientific basis for subsequent policy formulation.

Bibliometric analysis indicates that research on sustainable development models of agro-pastoral integration in the Qinghai-Tibet Plateau is a dynamically evolving field, with both its depth and breadth continually expanding. Future research needs to further explore strategies for adapting to climate change, strengthen interdisciplinary research, and enhance the pertinence and practicality of practical guidance and policy recommendations.

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