Research on the Production Methods of Yunnan Plateau Characteristic Agriculture and Food Safety under the Ecological Economic Model

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Abstract: The Yunnan Plateau, rich in agricultural resources and featuring a favorable ecological environment, is pivotal for rural industrial revitalization and ecological progress. This study applies circular economy principles to systematically examine the theoretical characteristics and significance of Yunnan's plateau-specific eco-agricultural model. It focuses on key components like crop-livestock recycling systems, clean production, and deep processing of agricultural products to explore innovative approaches. The research also proposes a dynamic coordination mechanism between economic development and ecological carrying capacity. Findings reveal that extensive practices have degraded soil quality and caused non-point source pollution, threatening regional food safety. However, adopting ecological technologies, biological controls, and organic fertilizer substitution can significantly enhance agricultural ecological benefits and food safety. By analyzing Yunnan Plateau's innovative agricultural practices, the study identifies multi-dimensional development models, including integrated ecological technologies, cooperative joint operations, agritourism, and e-commerce empowerment. It also highlights integrating traditional farming wisdom with ethnic cultural elements. The study concludes that synergizing traditional knowledge with modern technology, enhancing ecological standards, strengthening digital traceability platforms, and developing region-specific sustainable strategies are critical pathways to achieving greater agricultural efficiency, ecological sustainability, and food safety.

Keywords: Ecological Economy; Food Safety; Yunnan Plateau Agriculture; Production Methods; Sustainable Agriculture

1. Introduction

Under the strategic goals of 'Dual Carbon,' plateau agriculture characterized by Yunnan is demonstrating a trend towards green, low-carbon, and circular development. It innovatively leverages resource endowments, thoroughly investigates ecological recycling models, and is guided by the integration of the 'Three Industries' to enhance the recycling of agricultural resources and the integrated development of industries. This approach not only extends the agricultural industry chain but also increases the added value of the sector. However, soil degradation and non-point source pollution resulting from traditional extensive production methods have significantly threatened the foundation of regional food safety [1]. The excessive application of chemical fertilizers and pesticides in current agricultural production not only leads to a continuous decline in the quality of arable land but also poses potential health risks through food chain transmission. This paper adopts the eco-economic model as a novel approach, emphasizing the internalization of ecological protection as an essential element of agricultural production. It aims to achieve efficient resource utilization by reconstructing the crop-livestock recycling system, particularly in ecologically fragile plateau regions, to establish a dynamic balance mechanism between economic output and ecological carrying capacity. From the perspective of the integrated concept of sustainable development's three aspects-production, ecology, and livelihood-it reveals the intrinsic correlation mechanism between the eco-economic model and food safety assurance. By analyzing the material and energy circulation pathways of the transformation in agricultural production methods, it establishes a synergistic development framework for ecological protection and food safety. The article

focuses on transforming the resource endowment of plateau-specific agriculture into a quality and safety advantage, providing theoretical support for building a comprehensive risk prevention and control system from 'field to table' and developing a replicable transformation pathway. This aims to achieve the triple objectives of enhancing agricultural efficiency, improving ecological conditions, and ensuring food safety. In the context of the new era, it is essential to keep pace with the times, leverage local resource endowments, promote the high-quality development of Yunnan Plateau agriculture, and construct an agricultural industry upgrade path that is market-led and ecology-first.

2. Analysis of Ecological Economic Theory and the Theoretical Characteristics of Yunnan Plateau's Distinctive Agriculture

2.1 Agricultural Application of Circular Economy Theory

In The essence of "circular economy" is "ecological economy". From an academic research perspective, guided by national policies, a large number of scholars have engaged in theoretical discussions on the circular economy, continuously exploring various conditions and mechanisms for implementing the circular economy in China in terms of specific practical objectives. This breakthrough is not confined to the field of economics but also extends to interdisciplinary areas such as agricultural science. The theory of circular economy emphasizes the restructuring of production systems through the principles of "reduce, reuse, and recycle," which manifests in the agricultural sector as an ecological process of closed-loop material flow and multi-level energy utilization. This theory goes beyond the traditional linear economic model, converting agricultural waste into renewable resources and forming a circular chain of "resources - products - renewable resources". In the context of a set agrarian economy, how people perceive, utilize, and reuse crop straw in daily life has diverse features. It has long been a cyclical resource utilization model. The main aim of growing straw-based economic crops is to harvest their fruits and seeds. But if we just look at it from this one perspective, we're really underestimating its cultural value. Within the framework of a set agrarian economy, straw-based economic crops can be seen as 'treasures in themselves' and might even break free from the limits of this economy. Crop straw is a crucial source of fodder for livestock in nomadic economic systems. It's also a key part of the fuel for daily needs, especially in the vast areas north of the Yellow River basin in China [2]. Besides, straw is an important source for fertilizing farmland and can even be used as an additive in building materials. Straw has never been in a state of 'waste'; instead, it has always been a 'resource', fitting into both sedentary agricultural and nomadic economies. This process not only shows how ethnic cultures can adapt to their ecological environments and what capabilities they have, but also reflects how thoroughly resources are utilized within these cultures. The cultural goal is simple and clear: to make the use of resources as diverse as possible, so that we can really achieve the principle of making the best use of everything and cut down costs in the process of social construction and operation. From this perspective, whether in the nomadic economic system or the settled agricultural economic system, crop straw has never been regarded as waste. It is actually a genuine resource. In the practice of plateau agriculture in Yunnan, the theory of circular economy is really important for guiding three key transformation directions of agricultural production methods on the plateau.

2.1.1 Construction of a Closed-loop Cultivation and Breeding System

Spatially coupled planting and breeding industries can establish an internal cycling mechanism for organic matter [3]. Specifically, corn stalks can be processed into animal feed, while the excreta from livestock and poultry can be converted into organic fertilizer for farmland through harmless treatment. This material cycling chain not only reduces the demand for external inputs but also effectively minimizes waste generation. In regions with pronounced vertical climatic characteristics, utilizing different altitude gradients can create a tiered development model of integrated planting and breeding, thereby significantly enhancing resource utilization efficiency.

2.1.2 The Clean Transformation of Agricultural Production Processes

To address the excessive application of chemical fertilizers and pesticides in conventional agriculture, an alternative technical framework based on the principles of the circular economy has been established. This framework implements a green manure rotation model that

enhances soil nutrients through the nitrogen-fixing functions of leguminous crops. Simultaneously, a biological control strategy has been promoted, which replaces chemical pesticides with natural enemies and microbial agents. These measures not only significantly reduce the potential threat of agricultural non-point source pollution but also help maintain the stability of biodiversity in farmland ecosystems [4].

2.1.3 Value-added utilization in the agricultural product processing stage

By systematically developing agricultural by-products, we can turn fruit peel residues into renewable fuels. Meanwhile, with the help of microbial technology, straw can be broken down into cultivation substrates. This extended industrial chain model doesn't just boost economic benefits. It also makes the best use of materials and energy [5]. In specialized agricultural product processing areas, a zero-waste process system has been set up. It covers everything from raw material production to in-depth processing, so as to achieve efficient resource recycling. Facing the twofold pressures of ecological preservation and economic growth, the Yunnan Plateau region has innovatively combined the planting, breeding, and processing sectors to build an agricultural ecological cycle system that can regulate itself. This model fully conforms to the characteristics of the carrying capacity of the karst geological environment. It effectively improves soil quality and lessens the dependence on outside resources. The material circulation monitoring system, which is developed by using modern information technology, allows for precise control of the energy and material flows. This ensures the quality and safety of agricultural products right from the start. What's more, the application of digital technologies like blockchain has made it easier to create and strengthen a resource circulation traceability system throughout the whole agricultural production process.

2.2 Analysis of the Current Status of Yunnan Plateau Characteristic Agriculture

Yunnan, a prominent province in southwestern China, features a wide array of climatic conditions attributed to its distinctive geographical setting. These conditions vary from the temperate plateau monsoon in the north to the classic tropical monsoon climate. The province spans an approximate area of 394,100 square kilometers, with over one-fifth classified as tropical regions, resulting in a climate that consistently resembles summer and spring throughout the entire year. Although the region is largely mountainous, its soil exhibits excellent natural fertility, which supports diverse plant growth and fosters rich biodiversity. Nonetheless, Yunnan encounters several developmental hurdles, including deficiencies in infrastructure development, a relative lag in the advanced processing technologies for agricultural goods, inadequate focus on brand development and market outreach, as well as a necessity for enhancements in agricultural tech innovation and policy support systems [6].

2.2.1 Vertical zonation law of agricultural production in plateau regions

The gradient differentiation traits of mountain ecosystems give a boost to the vertical zonality seen in agricultural production. In the Yunnan Plateau region specifically, this shows up as a systematic shift in the agricultural structure in line with altitude changes. To get agricultural production to fit better with the topographic traits, it's key to set up a three-dimensional farming system that's well-suited to these circumstances [7]. In the typical study area, the obvious variations in altitude gradients bring about distinct combinations of water availability, heat, and soil properties at different heights. These elements all work together to limit the distribution of crops and their growth cycles. When it comes to practical uses, the low-heat valley areas that are under 1,500 meters in altitude focus on growing tropical cash crops.[8] They take advantage of the year-round high temperatures to keep crops like mangoes and bananas being cultivated continuously. In the mid-mountain areas, which are between 1,500 and 2,500 meters in altitude, the attention turns to developing economic crops such as tea and walnuts that do well in low-temperature settings. At the same time, they also boost land output efficiency by using intercropping methods. In the alpine regions that are above 2,500 meters in altitude, the emphasis is on cultivating high-mountain medicinal herbs and pushing forward ecological animal husbandry. This makes use of the benefits of low temperatures to grow special medicinal plants like Angelica sinensis and Paris polyphylla. The three-dimensional agricultural layout that's built based on altitude differences doesn't just ease the ecological pressures from traditional farming

methods. It also does a great job of optimizing the efficiency of land resource allocation. Looking at it from the angle of vertical zonality theory, the agricultural technology system has a clear gradient distribution. In low-altitude areas, the main thing is to use water-saving irrigation techniques to deal with water shortages during dry spells. In mid-altitude regions, they use biological shading steps to lessen the bad effects of strong sunlight on crops. And in high-altitude zones, they apply plastic film mulching technology to make the effective temperature needed for crop growth better. This layered technical system has clearly upped the ability of agricultural systems to handle climate change, giving crucial technological backing for making sure there's food security. As research keeps moving forward, the use of vertical zonality theory has gone from just passively adapting to actively regulating. By coming up with a three-dimensional agricultural zoning model, it becomes possible to accurately figure out the production potential and ecological carrying capacity of different elevation units. This then offers a scientific reason for marking out the good areas for specialty agricultural products. In karst landform areas, this more detailed zoning way has effectively balanced the connection between controlling rocky desertification and agricultural production, bringing about a two-way boost in ecological and economic benefits.

2.2.2 Yunnan Plateau's Mechanism for Conserving Biodiversity

The effective upkeep of biodiversity holds a decisive part in the sustainable growth of characteristic agriculture on the Yunnan Plateau. Its essence is about setting up a composite ecological mechanism where multiple species coexist and collaborate in a symbiotic way, which brings about a positive interaction between agricultural production and environmental protection [9]. In mountainous settings marked by significant vertical zonality, this mechanism, which is based on safeguarding crop genetic resources, creates a multi-dimensional protection setup that includes species arrangement, ecological regulation, and technological application. Through the rational optimization of planting arrangements, the biodiversity of the agricultural ecosystem has been substantially enhanced. In practical applications, the intercropping of traditional varieties with improved ones not only contributes to the effective conservation of genetic resources but also strengthens the disease and pest resistance of crops [10]. The southwestern Yunnan tea region, recognized as the primary production zone for Pu'er tea in China, has historically struggled with ecological degradation linked to the use of chemical pesticides. A mechanism characterized by "plant volatiles - pest behavior modulation - preservation of natural enemies" is present, where camphor terpenoids mitigate the risk of pests developing resistance by inhibiting cytochrome P450 enzyme activity. In comparison to tea monocultures, the composite system has shown an annual increase in carbon storage of 0.82 Mg per hectare, highlighting the potential associated with carbon sequestration in agricultural practices. This shift has resulted in an enhanced biodiversity index [11].

2.2.3 The integration of ethnic culture and agricultural wisdom

As a multi-ethnic gathering place, the steady advancement of plateau agriculture in Yunnan Province arises from the high integration of farming traditions and ethnic cultures. Faced with complex terrain conditions, various ethnic groups have gradually developed unique regional agricultural production systems throughout history. These agricultural practices, passed down through generations, provide significant cultural support and technical references for modern ecological agriculture. In the evolution of crop cultivation systems, the traditional practices of ethnic minorities exhibit remarkable ecological adaptability [12]. For instance, the agroforestry cultivation method employed by the Naxi people in the "Three Parallel Rivers" area involves planting shade-tolerant crops beneath the forest canopy, establishing a three-dimensional planting model that not only enhances land utilization but also effectively controls soil erosion. The traditional "rotational fallow farming" system of the Yi ethnic group employs a strategy that combines periodic fallowing with forage cultivation to promote the natural recovery of soil nutrients, a method that is highly consistent with modern green manure crop rotation theory. Through scientific transformation, these traditional farming practices have become effective means of controlling agricultural non-point source pollution. In terms of ecological protection technologies, ethnic wisdom and modern science have demonstrated significant synergistic effects. The traditional "rice-fish-duck" symbiotic system in the Dai

region of Jinghong City, Xishuangbanna, has been optimized and developed into an ecological recycling farming model, which not only reduces the use of chemical fertilizers but also achieves ecological control of pests and diseases. Moreover, the ancient variety resources preserved in the courtyard economy of the Bai Autonomous Prefecture of Dali provide precious genetic materials for modern breeding research, with the local varieties demonstrating particularly notable stress resistance in response to extreme climate conditions, thereby highlighting their special value. By utilizing intelligent monitoring equipment to conduct quantitative analysis of these traditional techniques, a standardized operational system suitable for promotion has been established.

To speed up the agricultural modernization process, it's really necessary to set up a systematic integration framework for traditional knowledge [13]. By building a resource library of ethnic farming wisdom, those scattered folk experiences can be turned into specific technical parameters. This way, it can push forward the innovative use of traditional architectural techniques in agricultural facilities. For example, we can make use of the ancient rammed earth technology to build energy-efficient storage facilities. At the same time, it's very important to move forward with the digital processing of oral farming proverbs to form an ecological planting knowledge network that covers major crops. In the area of cultural heritage, we need to dig into the guiding meaning of traditional ecological ethics for modern agricultural producers. We shouldn't just apply traditional elements in a superficial way. Especially when we are working on improving the quality and safety management system, it would be a good idea to draw on the risk prevention concepts that come from the dietary taboos of ethnic minorities. Then we can work out safety production regulations that match cultural identity more closely.

3. Plateau-specific Agricultural Production Methods

3.1 Modernization Transformation of Traditional Farming Techniques in Yunnan Plateau

During the transition from conventional to contemporary agricultural practices in the Yunnan Plateau area, the fundamental aspects of ecological knowledge have been maintained. The introduction of technology has significantly enhanced the efficiency of agricultural production. This change does not completely discard traditional farming techniques; rather, it employs technological advancements to tackle challenges such as inefficiency and resource wastage that are characteristic of conventional systems [14]. At the same time, it draws upon wisdom that is suitable for mountainous terrains. Regarding the implementation of technology, smart devices are progressively being incorporated into traditional agricultural methodologies. Soil moisture sensors installed in fields are capable of monitoring soil moisture levels in real time. When combined with the practical experiences of farmers, this allows for precise control of irrigation practices. Compact tillage machines that utilize Beidou navigation technology efficiently fulfill the operational requirements of fragmented plots in hilly regions, The hallmark of intensive farming practices has been maintained, yet there has been a notable reduction in labor intensity. The implementation of digital simulation and the optimization of traditional intercropping techniques have led to a crop configuration strategy that is more scientifically based. In the conventional corn-bean intercropping system found in central Yunnan, optimizing the row spacing ratio to 1:2.4 with an advanced particle swarm algorithm resulted in a canopy light interception rate that increased to 89.7%. In the southern region, animal husbandry practices are comparatively sophisticated. At the yak breeding facility in Diqing Prefecture, the introduction of a microbial inoculant technology specifically tailored for high-altitude environments during the composting of farmyard manure has decreased the breakdown period from 60 days to just 20 days, all while effectively eradicating harmful pathogens. A gradient fog collection net array, designed from the traditional fog and dew collection methods used in the Hani terraces of Ailao Mountain, has been combined with local water management practices and innovative materials, achieving nearly a 30% increase in water collection efficiency. In the renovation of the Bai people's traditional slate granary in Dali, standard storage structures have evolved into ecological storage spaces augmented with automatic ventilation and dehumidification capabilities. This adaptation takes full advantage of the temperature variations between day and night in mountainous regions for energy-efficient

preservation, thereby fulfilling food safety standards while maintaining the original taste. This gradual transformation is redefining the agricultural development model on the Yunnan Plateau [15].

3.2 Innovation in Highland-Specific Crop Cultivation Models

Agricultural producers in the Yunnan Plateau have established a diversified system of cultivation technology that takes advantage of the region's distinct topographical and landform characteristics. These technological advancements have successfully met ecological protection objectives while also improving the quality of agricultural products, thus bolstering the stability and safety of the food supply chain [16]. In regions that rise to around 2000 meters in elevation, the plateau's vertical climate zones allow farmers to create a three-dimensional agricultural ecosystem [17]. Within the principal dwarf dense apple production area of the Sayu River Basin in Zhaotong City, Yunnan, where elevations range from 2000 to 2200 meters, traditional Yi families grow konjac under the protective canopy of apple trees, making effective use of the area's distinctive light, temperature, and water resources. The shading effect of the apple trees fosters ideal growth conditions for shade-preferring konjac, thus improving land resource efficiency and enhancing both the ecological and economic value of agriculture on the plateau. In the Yuxi flue-cured tobacco planting zone, tobacco farmers practice intercropping with marigolds in their fields; the brightly colored marigold flowers serve as a natural deterrent to pests while also being harvestable for natural pigments, which contributes to supplementary income. Additionally, cultivators of medicinal herbs utilize a mixed planting approach with Panax notoginseng and Paris polyphylla, leveraging the height disparity of the two herbs to form a natural shading system, thereby cutting down on expenses related to building shade shelters and effectively curbing the spread of diseases.

3.3 Optimization Pathways for Agro-pastoral Integrated Systems

The integrated farming and animal husbandry system in the Yunnan Plateau region is progressing significantly through the integration of planting and breeding along with the efficient recycling of resources [18]. Farmers have effectively combined livestock and poultry rearing with crop cultivation, establishing an ecological recycling chain characterized by the sequence of 'breeding-biogas-farmland.' In this system, livestock and poultry excreta undergo anaerobic fermentation to produce renewable energy and bio-fertilizers. The fermentation liquid is then precisely applied to farmland using irrigation systems, which not only reduces the reliance on chemical fertilizers but also enhances soil quality. Regarding spatial layout optimization, mountainous pastures and arable land are arranged in a three-dimensional distribution. A rotational grazing system is implemented in areas above 2,500 meters in altitude, standardized breeding bases are established in mid-altitude zones, and the utilization of straw as feed is promoted in low-altitude agricultural areas. Based on the assessment of grassland carrying capacity, it is to make sure there's enough feed supply while also preventing the degradation of the grassland. In the karst geological regions, the understory forage planting model makes good use of the resources in the rock crevices. This enables goats to carry out ecological restoration while they're feeding on shrub shoots. Also, by using the idle farmland in winter to plant high-quality forages like ryegrass and alfalfa, it promotes an adjustment in the 'grain - economy - forage' planting structure. By pushing forward the silage technology, the surplus forage produced during the rainy season can be stored for a long time. And when it's combined with the total mixed ration formulation technology, it greatly boosts the utilization of the feed. In recent years, Yunnan has been actively making use of its local natural conditions and industrial foundations. It has adopted a cooperative-based organizational model that features 'unified seed supply, decentralized breeding, and centralized processing'. The pastures that integrate agricultural tourism increase the added value of the products through visitor experiences. And the on-site dairy product production experiences can raise the profit margins by around 40% [19]. This model not only maintains the vitality of the nomadic tradition, but also creates new ways to earn economic income.

4. Innovative Practices in Production Methods

4.1 Integrated Eco-Agricultural Technology

4.1.1 Current Application Status of Biological

Control Technology

The unique agriculture of the Yunnan Plateau has seen biological control technology emerge as a groundbreaking substitute for chemical pesticides, initiating a transformative change in conventional plant protection frameworks. The ecological prevention and control system, based on the concepts of "biological regulation of pests" and "microbial antagonism," plays a crucial role in ensuring the safety and quality of agricultural products while establishing a dynamic balance within farmland ecology [20]. To address significant crop pest issues, a regional system has been implemented for conserving natural enemy resources, organized on a large scale. In the tea-producing region of Menghai in Xishuangbanna, targeted release technology for Trichogramma-utilizing parasitic natural enemies for precise application-has led to a reduction of 43.6% in the population density of tea green leafhoppers. In the area of botanical pesticide development, a new neurotoxic compound has been extracted from Moringa seeds in Ruili City's Moringa planting region, with a created botanical nanoemulsion exhibiting a knockdown rate exceeding 95% against aphids. Furthermore, in Tonghai County's facility vegetable region of Yuxi City, a three-dimensional arrangement of volatile repellent plants has been set up, leveraging a spatial arrangement of Artemisia-Pyrethrum composite hay bundles to create an ecological barrier that disrupts pest activity. These cutting-edge initiatives merge traditional ecological knowledge with contemporary biotechnology, systematically transforming the plant protection framework of the Yunnan Plateau's distinctive agriculture [21].

4.1.2 Organic Fertilizer Substitution Technology Pathway

Based on the distinct characteristics of regional resource endowments, the plateau areas of Yunnan Province have established a multi-tiered organic fertilizer production system [22]. Researchers have developed three fertilizer preparation schemes tailored to local conditions, reflecting the ecological variations across different altitude zones. In the higher altitude cold regions, livestock manure and forest humus are utilized as raw materials to produce basic organic fertilizer through traditional composting techniques. In the mid-altitude agricultural areas, a combination of returning crop straw to the field and cultivating green manure has been implemented, effectively promoting nutrient cycling. In the lower altitude flatland areas, technicians have concentrated on developing functional organic fertilizers using raw materials such as fruit processing residues and edible fungus culture media. This series of innovative measures exemplifies the concept of synergistic development between optimized resource utilization and ecological environmental protection.

4.1.3 Agricultural Waste Resource Utilization Model

In the plateau regions of Yunnan, the resource utilization of agricultural waste has established a localized recycling system [23]. Tailored to the production characteristics of different altitude zones, four main conversion models have been developed: in high-altitude cold areas, the focus is on transforming straw into feed; in temperate basin areas, biogas energy is promoted; in dry-hot valley areas, the emphasis is on using waste as raw material for substrates; and in traditional farming areas, composting for returning to fields is encouraged. Through these four conversion models, waste that could potentially pollute the environment is transformed into productive resources, thus creating a closed-loop system of "resource-product-renewable resource".

4.2 Exploration of Business Model Innovation

4.2.1 Cooperative Joint Operation Mechanism

To tackle the issues caused by disjointed activities among small-scale farmers, the cooperative has successfully integrated resources and fostered coordinated growth through a collaborative operational framework, forming a consortium that leverages market strengths. This approach is based on a platform for resource sharing and utilizes centralized purchasing strategies to considerably lower expenses related to agricultural equipment and supplies. By adopting the "Five Unifications" management criteria, it guarantees that the quality of products meets market expectations closely. The collaborative establishment of cold chain transfer stations has improved the storage and logistics network, facilitating staggered sales of agricultural products and significantly boosting their added value. Regarding the distribution of profits, a system has been implemented that comprises a "guaranteed minimum return plus a secondary dividend," which facilitates risk-sharing while ensuring equitable profit allocation. This approach has considerably enhanced the motivation for farmers to engage.

To tackle the problem of inadequate capital, the cooperative has partnered with financial institutions to launch a joint guarantee loan, thereby offering substantial financial assistance to farmers. These initiatives have generated a synergistic impact, boosting market competitiveness and advancing the sustainable growth of the distinctive agriculture in the Yunnan Plateau. Furthermore, the cooperative has co-registered a regional public brand and increased its market presence through comprehensive marketing strategies. On e-commerce platforms, various cooperatives have come together to establish specialty exhibition halls, giving a collective platform for plateau ecological agricultural products [24]. In terms of offline efforts, the cooperative alliance has formed direct supply relationships with chain supermarkets, implementing an order-based agricultural model to synchronize production with consumer demands. For products that embody ethnic traits, the cooperatives have collaboratively developed cultural tourism integration initiatives, enabling consumers to engage in the production process via reservations, which enhances product value and fosters the preservation of traditional culture. With respect to the technical service framework, the cooperatives have jointly employed agricultural professionals to consistently offer on-site technical support.

4.2.2 Value-added Path of Agricultural and Tourism Integration

The plateau-specific agriculture in Yunnan has achieved significant industrial chain extension and value innovation through a strategic development approach that integrates agriculture with tourism [25]. During this transformative process, traditional agricultural production spaces have been transformed into interactive experiential venues, thereby creating a novel industrial model characterized by 'landscape farmlands, tourist homestays, and agricultural experience activities.' The optimization of spatial layouts, combined with the systematic development of experiential content, has effectively driven the deepening of this transformation. For instance, the Hani Terraces in Yuanyang County exemplify this trend through the launch of the 'Four Seasons Farming' experience project and the establishment of an integrated tea-picking and processing experience center in the tea region of Menghai County. These initiatives demonstrate the successful integration of ecological features with interactive functions, providing visitors with practical opportunities for an in-depth understanding of agricultural production. Culturally, ethnic villages have achieved a win-win scenario for cultural inheritance and industrial development by organically integrating traditional festivals with agricultural product marketing [26].

The innovative value-added pathways are primarily evident in three key domains. First, value enhancement of primary agricultural products is realized through experiential consumption models, as showcased by the distinctive service initiative "Coffee Tree Adoption + Roasting Experience" recently introduced in Yunnan. Second, the melding of traditional craftsmanship with contemporary educational frameworks has resulted in unique cultural education offerings. For example, Zhoucheng Village within Xizhou Ancient Town has creatively established a research course named "Ecological Dye Plant Cognition and Tie-Dye Craft Practice" at its tie-dye experience center. This course incorporates immersive teaching approaches, allowing participants to engage with traditional tie-dye techniques while thoroughly understanding the cultivation methods, ecological aspects, and cultural significances of natural dyes such as sappanwood, indigo, gardenia, tea, and safflower. This effectively fosters a profound integration of traditional craft preservation and ecological education. Lastly, Yunnan's cultural tourism aims for transformation and innovation, transitioning from "residential tourism brands" to "enhanced consumption." Tengchong City in Baoshan leverages the ecological benefits and biodiversity of Gaoligong Mountain, actively pursuing the development of the ecological wellness sector and exploring novel development models that broaden the wellness capabilities of agricultural environments. By capitalizing on the region's rich plant resources, a high-quality negative ion atmosphere, and geothermal hot springs, we offer visitors various wellness experience options, including forest bathing trails, botanical science education zones, medicinal and edible plant cultivation gardens, hot spring therapy centers, and specialized farms.

4.2.3 Analysis of the Empowerment Effect of E-commerce Platforms

The Yunnan plateau's characteristic agricultural products have undergone a digital transformation through the innovative use of e-commerce

platforms, effectively addressing the challenges of inadequate information flow and lengthy intermediaries in traditional marketing systems. A solution for supply chain innovation, termed "cloud trading+direct delivery from the origin," was introduced by researchers [27, 28], allowing high-quality agricultural products from remote mountainous regions to overcome geographic barriers and swiftly penetrate the national consumer market. Regarding marketing strategies, e-commerce platforms have created specialized sections for these unique agricultural products and leveraged big data technology to facilitate effective supply and demand matching. Merchants, following detailed analysis of browsing data from Pu'er tea consumers, have adopted varied marketing approaches: they are offering portable packaging to appeal to younger buyers while providing customization options for ancient tree tea to cater to experienced tea aficionados. The use of live-streaming as a marketing model has revealed distinct ecological benefits in the sales of agricultural products. Presenters highlight real-time tea picking experiences in plantations and detail organic farming methods, fostering direct engagement with viewers and offering a comprehensive insight into the entire production journey. This engaging format has notably improved the rate of product transactions. The improvement of supply chain efficiency mainly concentrates on three key areas: During the phase of acquiring raw materials, the platform effectively links individual farmers with substantial market demands through a focused procurement approach, consolidating dispersed wild mushroom harvesting regions into a streamlined supply network. Regarding transportation and distribution, the platform has formed strategic alliances with cold chain logistics specialists, creating dedicated routes for specialty products from plateau regions, while implementing a comprehensive traceability packaging solution to maintain the quality stability of fresh items like Matsutake mushrooms. In the aspect of after-sales service, a specialized compensation system tailored for agricultural products has been set up, accompanied by a quick replenishment response mechanism aimed at addressing losses encountered during the logistics phase. These innovative strategies have led to a significant enhancement in the circulation efficiency of agricultural products, exceeding 40%, while greatly minimizing the product loss rate. Digital technology is essential in the brand development process, as the platform equips farmers with visual design tools to help them craft product display interfaces enriched with elements of ethnic culture.

5. Research Conclusions and Prospects

The operational mechanism for the coordinated development of Yunnan Plateau characteristic agriculture and food safety has been elucidated through systematic research. The findings reveal that the ecological economic model significantly contributes to harmonizing economic gains with environmental sustainability, with its core focus on establishing a labor division mechanism tailored to local conditions and a diversified cooperative framework. Current research necessitates further deepening regarding technology promotion mechanisms and the formulation of long-term policies. Future efforts should emphasize exploring three key areas. Firstly, enhancing the adaptive improvement of ecological technologies by developing lightweight equipment and simplified management solutions suitable for smallholder farmers. Secondly, improving the dynamic adjustment mechanism of ecological compensation standards by establishing a differentiated subsidy system linked to product quality. Thirdly, advancing research driven by consumer demand to construct a big data-based demand feedback system that achieves precise alignment between production layout and market changes. Lastly, strengthening the integration of ethnic culture with modern agriculture involves continuing to explore and organize the traditional farming wisdom of ethnic minorities, merging it with modern technology to create a standardized operational system that can be promoted, particularly in the preservation of genetic resources and the cultivation of stress-resistant varieties. This approach aims to further enhance the competitiveness of Yunnan Plateau agriculture and propel the ecological economy of Yunnan Plateau agriculture towards higher quality and safer development.

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References

[1] Huan Hongyan. Extraction and Spatial Differences of Agricultural Production Efficiency in China - Measurement Based on Panel Data from 31 Provinces from 1996 to 2013. Jianghan Forum, 2019, (01): 33-42.

[2] Yang Zenghui. Research on the Circular Economy of "Waste" in Traditional Livelihood Structures. Journal of Original Ecological National Culture, 2020, 12(02): 8-17.

[3] Ping Weiying, Zhang Biaobiao, Wang Jia, et al. The Income-Increasing Effect of Farmers' Scale Operation: Internal Mechanism and Empirical Test. Journal of Management, 1-19 [2025-03-20].

[4] Chen Jiping, Liu Yuying, Fu Xinhong. Can Cooperative Social Services Promote Farmers' Adoption of Integrated Pest Management Techniques? - Empirical Evidence from Sichuan. Journal of China Agricultural University, 2022, 27(06): 264-277.

[5] Zhu Meixi, Luo Yi, Wu Laping. The Theoretical Logic and Practical Path of High-Quality Development of Agricultural Product Supply Chains - Based on the Analysis of Agricultural Product Price Formation Mechanisms. Price: Theory & Practice, 1-6 [2025-03-20].

[6] Wang W, Liu H, Zhao P, et al. Research on the Influence Factors of Sustainable Development of Plateau Characteristic Agriculture Based on DEMATEL and AISM Combined Model. PloS One, 2024, 19(2): e0297684-e0297684.

[7] Fu Wei, Zhao Junquan, Du Guozhen. Ecological Analysis of Mountainous Three-dimensional Agriculture. China Population, Resources and Environment, 2013, 23(S2): 62-65.

[8] Liu Huan, Xiong Wei, Li Yingchun, et al. Research Progress on the Impact of Climate Change on China's Crop Rotation Systems. Chinese Journal of Agrometeorology, 2017, 38(10): 613-631.

[9] Malézieux E, Crozat Y, Dupraz C, et al. Mixing Plant Species in Cropping Systems: Concepts, Tools and Models. A Review. Agronomy for Sustainable Development, 2009, 29(1): 43-62.

[10] Jarvis I D, Hodgkin T, Sthapit R B, et al. An Heuristic Framework for Identifying Multiple Ways of Supporting the Conservation and Use of Traditional Crop Varieties within the Agricultural Production System. Critical Reviews in Plant Sciences, 2011, 30(1-2): 125-176.

[11] Zhou Wuyang. Ecological Revitalization: A Green Path for Ethnic Regions to Consolidate and Expand the Achievements of Poverty Alleviation. Journal of Yunnan Minzu University (Philosophy and Social Sciences Edition), 2021, 38(05): 72-77.

[12] Shicai S, Gaofeng X, Diyu L, et al. Agrobiodiversity and in situ conservation in ethnic minority communities of Xishuangbanna in Yunnan Province, Southwest China. Journal of ethnobiology and ethnomedicine, 2017, 13(1):28.

[13] Zhou Yuting, Zhao Jinhui. Disruption and Integration: Reflecting on the Farmers' Knowledge System in the Context of Agricultural Modernization. Rural Economy, 2015, (04): 88-92.

[14] Li Jingsuo, Wan Qun. The Impact of Agricultural Technological Innovation on Agricultural Economic Resilience: A Threshold Effect Analysis Based on Fiscal Support for Agriculture Policies. Journal of Agrotechnical Economics, 1-14 [2025-03-21].

[15] Wang Yahong, Wei Yueli. The Impact of New Quality Productivity on Farmers' Income Growth. Journal of Agricultural and Forestry Economic Management, 2024, 23(04): 446-455.

[16] Xu Yachun, Wei Yaqi. Research on the Impact of New Quality Productivity on the Resilience of the Grain Supply Chain: Based on Panel Data from 30 Provinces in China. Journal of Yunnan Agricultural University (Social Sciences), 1-9 [2025-03-21].

[17] Pu Jicun, Huang Zhongyan, Gao Min. The Relationship between Climate Characteristics in Yunnan and the Suitability of Major Economic Crop Cultivation. Journal of Meteorological Research and Application, 2021, 42(01): 53-57.

[18] Li Zhigang, Zheng Yi, Liang Qibin, et al.

Analysis of Nitrogen Flow Characteristics in Different Agricultural and Livestock Systems in the Erhai Lake Basin Based on the NUFER-village Model. Journal of Agro-Environment Science, 1-16[2025-03-23].

[19]Li Jiesong, Li Jianjiang. Research on the High-Quality Development of Characteristic Industries in Ethnic Regions from the Perspective of Rural Revitalization. Academic Exchange, 2021, (09): 96-109.

[20]Duan Qinggang, Wang Falong. Research on the Development Path of Pesticide-Free Agriculture in China under the Background of Building a Strong Agricultural Country. Agricultural Economy, 2025, (02): 29-31.

[21]Jiangnan L, Jie Z, Xionghui L, et al. Long-term returning agricultural residues increases soil microbe-nematode network complexity and ecosystem multifunctionality. Geoderma, 2023, 430.

[22]Deng Yaqin, Wang Yuyun, Li Lan, et al. Evaluation of the land absorption capacity of livestock and poultry manure and the prospects for its fertilizer development in Yunnan Province. Journal of Agro-Environment Science, 2021, 40(11): 2419-2427.

[23]Zhu Siji, Sun Jun, Wu Yingmei, et al. Research on the near and remote coupling of agricultural eco-economic systems and sustainable development: A case study of plateau characteristic agriculture in Yunnan Province. Chinese Journal of Agricultural Resources and Regional Planning, 2024, 45(04): 222-234.

[24]Yue Ya, Wang Guoxian. Suggestions on e-commerce poverty alleviation in rural areas of Yunnan. Macroeconomic Management, 2018, (07): 73-78.

[25]Wan Zhiqiong, Zou Hua. Exploration of sustainable development paths for industrial integration and innovation in ethnic regions: A case study of Linxiang District, Lincang City, Yunnan Province. Journal of Yunnan Minzu University (Philosophy and Social Sciences Edition), 2021, 38(03): 136-143.

[26]Dong Rong. Exploration of green marketing models for agricultural products in western China. Reform & Strategy, 2016, 32(01): 105-108.

[27]Feng Chaorui, Zhang Nan. Research on the measurement of green development efficiency and influencing factors of agricultural product circulation industry in Yunnan Province. Inquiry into Economic Issues, 2024, (04): 124-135.

[28]Zhang Xinjie. Exploration of the development of e-commerce for characteristic agricultural products in ethnic minority areas: A case study of Yunnan. Guizhou Ethnic Studies, 2018, 39(07): 161-165.

