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INTEGRATING AGRICULTURAL TECHNOLOGY WITH ENVIRONMENTAL SUSTAINABILITY: INSIGHTS FROM YUNNAN PROVINCE

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Abstract: Yunnan's exceptional ecological environment, shaped by its diverse topography and climatic conditions, provides a unique advantage. The region's complex ecosystem serves as a habitat for a wide array of plant and animal species, culminating in the selection of Kunming as the host city for the COP15 conference in October 2021. Given the integral role of modern technology in agricultural development, this study explores the pivotal question of how to harmonize agricultural technology promotion with the ecological environment, mitigating its potential adverse impact. It also seeks to identify a path forward for agricultural technology promotion reform in Yunnan Province. This research addresses the critical need for aligning agricultural advancements with the preservation of Yunnan's distinctive ecological heritage.

Keywords: Ecological Environment, Agricultural Technology Promotion, Sustainable Development, Yunnan Province, Agricultural Technology Reform

1. Introduction

Good ecological environment is Yunnan's greatest advantage. Yunnan has a complex and diverse topography, crisscrossed by mountains, different climatic conditions have created a complex ecosystem, where a variety of plants and animals gather, and the COP15 conference in October 2021 is chosen to be held in Kunming. Based on the premise that the current development of agriculture cannot be separated from the application of modern technology promotion, how to make agricultural technology promotion and ecological environment coordination, reduce the damage of agricultural technology promotion to the ecological environment, as well as what is the way forward for the reform of agricultural technology promotion in Yunnan Province? Becomes the question that this study tries to answer.

The United States was the first country to carry out agricultural technology extension, beginning in the 1830s, but the concept of agricultural technology extension was first proposed by Earlofclarendon, an Englishman. China's agricultural technology promotion began in the 1960s, but the early promotion of the conversion rate of only about 30%[1], to the 80s, China's agricultural technology promotion has been rapid development, to the current agricultural technology promotion and "Internet+" approach, but in general, China's agricultural technology promotion and developed countries there is still a certain gap. Throughout the existing research results, the academic community is still stuck in the agricultural technology promotion and ecological environment protection and agro-ecological environment construction [2] and other levels. Of course, there are scholars on agricultural technology promotion, ecological protection and high-quality agriculture three coordination [3], agricultural technology promotion in different ecological zones to promote the effect [4] and so on more in-depth discussion. However, there are few studies on the coupled development of agricultural technology extension and ecological environment, especially in specific regions. Existing research for the development of agricultural technology

promotion and ecological environmental protection to provide ideas, and for the two coupled and coordinated development provides a method. How to realize the coordinated development of the two, and through what kind of coupled coordination mechanism? Solve the lack of in-depth exploration. Based on this, it becomes the problem that this paper tries to explain.

2. Research area

Located in the southwest of China, Yunnan Province has eight cities and eight minority states under its jurisdiction, neighboring Guangxi, Guizhou, Sichuan and Tibet, and bordering the South Asian countries of Myanmar, Vietnam and Laos, making it an important southwestern trade port between China and South Asian countries. Yunnan is also the province with the largest number of ethnic minorities, according to the main data bulletin of the seventh national population census of Yunnan Province in 2021, the total population of the province is 47.21 million people, of which 15.64 million people are ethnic minorities, accounting for 33.12% of the total population.The GDP of the province in 2020 will be 245.2190 billion yuan, with the proportion of the three major industries as follows: 14.7: 33.8: 51.5 respectively, and the urban and rural residents' The per capita net income will be 37,500 yuan and 12,842 yuan respectively. There is a large gap in the level of economic development within Yunnan Province, with the exception of Kunming and a few neighboring prefectures, other prefectures have a relatively low level of development and are extremely unbalanced in their development. Yunnan's territory is dominated by highland mountains, which account for more than 90% of the province's total area, showing a vertical climate distribution, with a forest coverage of 64%, which also provides conditions for the habitats of many kinds of plants and animals, and thus Yunnan is also known as the "Kingdom of Animals", "Kingdom of Plants Therefore, Yunnan is also known as "Animal Kingdom", "Plant Kingdom" and "Natural Oxygen Bar", which makes ecological environmental protection become one of the important tasks in Yunnan, and also provides a better case for this paper on the coupled and coordinated development of agricultural technology promotion and ecological environment.

3. Measurement of Agricultural Technology Extension and Ecological Environment Level in Yunnan Province

Understanding the difference of agricultural technology popularization level and ecological environmental protection intensity in Yunnan Province is the premise of agricultural technology popularization and ecological environmental protection improvement in the next step.

3.1 Indicator Selection and Data Acquisition

3.1.1 Construction of the indicator system

Table 1 Two index systems of agricultural technology extension and ecological environment

target level	Secondary indicators	Tertiary indicators	target level	Secondary indicators	Tertiary indicators
Bio Ecology Environment Environment	Environmental level	Forest cover (%, +)	Agricultural technology promotion	Extension and application of agricultural science and technology	Fertilizer application (million tons, +)
		Air excellence (%,+)			Pesticide use (tons, +)
		Water quality excellence (%,+)			Agricultural film (10,000 tons, +)

Original Article

		Natural reserves (number, +)			Total machinery power (10,000 kW, +)
	Environmental protection	Domestic sewage treatment rate (%, +)			Tractors (units, +)
		Rate of non-hazardous treatment of domestic waste (%, +)			Level of crop mechanization (%, +)
		Afforestation area (ha,+)		Farmland construction management	Reservoirs (stand，+)
		Rural latrine reform (%, +)			High-standard farmland (10,000 mu, +)
	Environmental pressure	Industrial wastewater discharge (billion tons,-)			Highly water-efficient irrigation area (million acres, +)
		Industrial emissions (billion cubic meters, -)		Agricultural human resource development	Agriculture-related institutions (number, +)
		Generation of general industrial solid waste (tons, -)			Provincial agricultural leading enterprises (households, +)

Note: "+" and "-" in () indicate that the indicator is positive and negative, respectively.

Agricultural technology promotion and the ecological environment have broader connotations. According to the Agricultural Technology Extension Act, it encompasses all kinds of technologies and facilities needed for agricultural production; while the ecological environment is more difficult to measure and define than agricultural technology extension, so it is impossible to evaluate the two concepts with a simple indicator. From the viewpoint of existing research results, agricultural technology promotion and ecological environment cover a wider system of indicators, which can better evaluate the relationship between the two. Here, we refer to the evaluation indexes of agricultural technology promotion, ecological environment evaluation indexes and the relevant indexes referred to in the Law on Agricultural Technology Promotion to construct the two index systems of agricultural

technology promotion and ecological environment (Table 1), which will be used to evaluate the comprehensive level of agricultural technology promotion and ecological environment in each prefecture of Yunnan Province, and calculate the degree of coupling and coordination on this basis.

3.1.2 Data acquisition

The main sources of data for this paper are Yunnan Statistical Yearbook 2020, the 2019 National Economic and Social Development Statistical Bulletin of each state, the 2019 State of the Environment Bulletin of each state, and the 2020 Statistical Yearbook of each state.

3.2 Evaluation methodology

3.2.1 Data normalization

Due to the existence of a scale in the selected data, the data were normalized in order to make them comparable, which was done as follows:

(1) If b is extremely large (positive indicator):

$$b'_{ij} = \left[\frac{b_{ij} - \min(b_{1j}, b_{2j,\cdots}, b_{nj})}{\max(b_{1j}, b_{2j,\cdots}, b_{nj}) - \min(b_{1j}, b_{2j,\cdots}, b_{nj})}\right] \quad (1)$$

(2) If b is extremely small (negative indicator):

$$b'_{ij} = \left[\frac{\max(b_{1j}, b_{2j,\cdots}, b_{nj}) - b_{ij}}{\max(b_{1j}, b_{2j,\cdots}, b_{nj}) - \min(b_{1j}, b_{2j,\cdots}, b_{nj})}\right] \quad (2)$$

In the expression (1)(2), $b'_{ij}$is the standardized value of indicator i of the jth geographical unit, j=1,2...n is the total number of geographical units, b_ij is the original value of indicator i of the jth geographical unit, max($b_{1j}, b_{2j,\cdots}, b_{nj}$) is the maximum value of the indicator i, and min($b_{1j}, b_{2j,\cdots}, b_{nj}$)is the minimum value of the indicator i.

3.2.2 Model for measuring the level of agricultural extension and ecosystem development

After the normalization process to determine the comprehensive score through the weight of the indicators, using the entropy value method to determine the weight of each indicator, its comprehensive indicator score calculation model is:

$$C_r = C_e = \sum_{j=1}^{m} w_j \times p_{ij} \quad (3)$$

In equation (3), Cr is the agricultural technology promotion score, Ce is the ecological environment score, $w_j$is the weight of each indicator system of entropy value method, and $p_{ij}$is the normalized indicator value.

3.2.3 Model for Measuring Agricultural Technology Extension and Ecosystem Coupling

The coupling reflects the relationship between agricultural technology extension and ecological coordination, which is structurally modeled [5] as:

$$T = [C_r \cdot C_e/(C_r + C_e)]^{1/2} \quad (4)$$

In (4), T is the coupling degree, Cr is the comprehensive level of agricultural technology promotion, and Ce is the comprehensive level of ecological environment. In order to better reflect the coordination effect of the two, the coupling coordination degree model is introduced, and the structural formula is:

$$H = (T \cdot S)^{1/2} \quad (5)$$

$$S = aC_r + fC_e \quad (6)$$

In formula (5) and (6), H is the coupling coordination degree and its interval is [0,1], and S is the comprehensive index of agricultural technology extension and ecological environment; a and f are undetermined parameters, where a+f=1. Based on relevant research, the weights are given as a=0.6 and f=0.4. The degree of coupling coordination reflects the strength of the coupling between agricultural technology extension and ecological environment, and the degree of coupling coordination is divided into 6 levels (Table 2).

Table 2 Degree of coupling coordination between agricultural technology extension and ecological environment

Coupling coordination degree level	Coupling coordination value	Coupling coordination feature
Severe disorder	0-0.1	Disorder between systems or elements
Moderate dysregulation	0.1-0.3	Low level of agricultural extension and high ecological carrying capacity
resist	0.3-0.5	Accelerated agro-technology diffusion and declining ecological carrying capacity
running-in	0.5-0.7	Agricultural extension and ecology are beginning to have a positive interaction
Good coordination	0.7-0.9	Mutual promotion of agricultural extension and ecology
Quality coordination	0.9-1	Optimization of coupling coordination towards new orderliness

3.3 Evaluation of results

According to the above comprehensive evaluation method, the data of 16 prefectures in Yunnan Province in 2019 were applied to weight the comprehensive score of agricultural technology promotion and ecological environment using entropy value method and the coupling coordination model was used to get the degree of coupling coordination, as shown in the following table (Table 3) evaluation results.

Table 3 Evaluation of coupling coordinated development of agricultural technology extension and eco-environment in Yunnan Province in 2019

prefecture	Coordinate coupling degree	Coordination level
Kunming	0.708	good coordination
Qujing	0.749	good coordination
Yuxi	0.671	running-in
Baoshan	0.707	good coordination
Zhaotong	0.475	resist
Lijiang	0.585	running-in
Puer	0.510	running-in
Lincang	0.677	running-in
Chuxiong	0.733	good coordination
Honghe	0.579	running-in
Wenshan	0.495	resist
Xishuangbanna	0.602	running-in
Dali	0.905	Quality coordination
Dehong	0.257	Moderate dysregulation
Nujiang	0.181	Moderate dysregulation
Diqing	0.199	Moderate dysregulation

Table (3) shows that the effect of coupling coordination degree between agricultural technology extension and ecological environment in Yunnan Province is not very satisfactory, among the 16 prefectures in the province, moderate dissonance (3), resistance (2), abrasion (6), good coordination (4), and quality coordination (1). The best coupling coordination is Dali, with a coupling coordination degree of 0.905, the only high-quality

coordination in the province, in the first echelon, reflecting the fact that Dali does not neglect the protection of the ecological environment in the process of agricultural technology promotion and improvement of the level of agricultural modernization, and that agricultural technology promotion and the ecological environment promote each other and develop in an orderly manner. The well-coordinated (4 prefectures) in the second echelon, i.e., Kunming, Qujing, Baoshan, and Chuxiong, belong to the middle and above level of Yunnan's economic development status, indicating that the ecological environment protection is also better in these prefectures in the process of carrying out agricultural technology promotion. The third echelon of the abrasion (6 prefectures), i.e. Yuxi, Lijiang, Pu'er, Lincang, Honghe, Xishuangbanna, except for Yuxi and Honghe, which have a better overall development level, the other 4 prefectures have an overall development of a medium to low level in the province, and the level of their agricultural technology promotion is not very high, but there is already a good interaction between the promotion of agricultural technology and the ecological environment. In the fourth echelon of resistance (2 prefectures), namely Zhaotong and Wenshan, their economic development in the province as a whole belongs to the medium level, the level of agricultural technology promotion is relatively low, but the situation of accelerating the speed of promotion has already appeared, and should pay attention to ecological environmental protection at the same time of accelerating the speed of promotion. In the fifth echelon of moderate dislocation (3 prefectures), namely, Dehong, Nujiang and Diqing, which is affected by the natural conditions, these 3 places are located in the Hengduan Mountain, Gaoligong Mountain and other deep and large rupture and longitudinal valleys, most of which are unsuitable for the production and living areas, and it is extremely difficult to promote agricultural technology, and the ecological environment has a high carrying capacity, so that the protection of the ecological environment in these prefectures is more of a first priority.

4. Roadmap for the Coordinated Development of Agricultural Technology Extension and Ecological Environment in Yunnan Province

To harmonize the relationship between agricultural technology promotion and ecological environment is to deal with the logical relationship between economic development and ecological environment protection. Against the backdrop of increasing efforts to protect the ecological environment, it is particularly important to promote local economic development and increase the income of the population without destroying the ecological environment or crossing the ecological red line, especially in ecologically fragile areas such as Yunnan.

4.1 Closely follow local constraints and implement differentiated development paths

From the evaluation results, the degree of coupled coordination of agricultural technology extension and ecological environment in Yunnan Province is not ideal, and it is a long way to coordinate and promote the coordinated development of agricultural technology extension and ecological environment in the province. From the point of view of the actual situation in the province, further subdivided, the coordination of agricultural technology promotion and ecological environment is divided into three kinds of relationships: the first kind, the high level of agricultural technology promotion, ecological environment is good, such as Dali, Kunming, Qujing, etc.; the second kind, agricultural technology promotion is faster, the quality of ecological environment is declining, such as Wenshan, Zhaotong, Honghe, etc., and most of the prefectures belong to this kind of situation; the third kind, agricultural technology promotion is low, the ecological environment quality is good, such as Dehong, Nujiang, Diqing. For the first, should continue to accelerate the momentum of agricultural technology promotion, improve agricultural production efficiency, reduce their production costs; at the same time, but also focus on the protection of the ecological environment, in the process of promoting economic growth, ecological and environmental quality does not fall for the bottom line. For the second kind, under the accelerated promotion of agricultural technology, the ecological environment protection should not be neglected, and strict rules for ecological environment protection should be formulated, not to take the old road of destroying and then governing, and for the ecological zones that have already been destroyed, they should be repaired in a timely manner. The

third kind, due to natural conditions, agricultural technology promotion is difficult to carry out, its focus should be placed on ecological environmental protection, at the same time, public finance and other resources should be tilted to them, to make up for the short board of economic development of these prefectures, which also reflects the principle of public economics on the who benefits who pays principle, the good ecological environment as a kind of public goods, and ultimately by the whole population to share, and should not only let the people who protect it to pay the bill.

4.2 Optimize the mode of agricultural extension and improve the targeting of agricultural extension

Improving agricultural production efficiency is the purpose of agricultural technology promotion. At this stage, there is still an obvious gap between the efficiency of agricultural technology promotion in Yunnan Province and that of the economically developed provinces in China, and the promotion model must be optimized. But no matter what promotion mode, the key is to ensure that farmers get the agricultural technology they need, focusing on the needs of farmers. Gao Qijie believes that Yunnan and other western regions of the vast area, fragile natural ecological conditions, weak agricultural base, economic level is not high, agricultural technology promotion model should be used in a full range of integrated consulting services, in the form of pro bono services, to strengthen the demonstration effect. In Yunnan, the agricultural technology promotion mode more use of public welfare demonstration mode and quasi-public welfare association promotion mode, which is in line with the characteristics of the current economic development of Yunnan, these two modes are more conducive to the acceptance of the agricultural technology promotion service object farmers, to facilitate to pass the agricultural technology promotion into the village of the "last kilometer". However, in some prefectures, the farmers' technical level is not very high under the real conditions, small farmers experience mode is the agricultural technology promotion in the use of the process of the first encountered obstacles, mainly in the farmers in the learning and application of modern agricultural technology, not to follow the modern scientific and technological rationality, more simple empiricism color, which led to the emergence of the so-called agricultural technology promotion, "low level of balance". This has led to the so-called "low-level equilibrium" phenomenon of agricultural technology promotion. Therefore, in the process of agricultural technology promotion, it is crucial to improve the level of production organization and management level of farmers, which is related to the transformation efficiency of agricultural technology promotion and the issue of increasing the income of farmers. It is important to actively explore the agricultural technology promotion model of new agricultural management subjects and to give full play to their demonstration and leading role.

4.3 Highlight the advantages of natural resources by focusing on eco-agriculture

As a typical agricultural mountainous province, the mountainous terrain has become a limiting condition for agricultural technology promotion. Currently, agricultural development is balanced with the double pressure of efficiency and ecological protection, and how to improve agricultural efficiency without destroying the ecology has become the pursuit of agricultural development in various countries. Eco-agriculture is under the guidance of ecological economics, a way of agricultural development that improves the ecological environment and makes full use of all kinds of natural resources to obtain the maximum economic benefits. "Eco-agriculture" was firstly proposed by Albrecthe W. in 1970, which he interpreted as "a self-sustaining, low energy-consuming, profitable and acceptable small-scale agriculture". According to the statistics of the Department of Ecology and Environment of Yunnan Province, Yunnan has made good achievements in the construction of eco-agriculture, and formed four models: the agriculture model of "forest fruits + forage + animal husbandry + biogas", the model of "Yuanyang terraces", the mountainous model of "land-based rice as an entry point, food security as a foundation", and the rural model of "rural rice as a base for food security". "Mountain mode, rural" Nongjia "ecological tourism mode, these models are fully integrated with the natural characteristics of Yunnan, under the premise of protecting the ecological environment, but also to promote farmers to increase income, reflecting the

combination of economic and ecological benefits. Should also be combined with ecological agriculture and the characteristics of Yunnan terrain, research and development of ecological agricultural development of agricultural technology, and actively carry out the plateau agricultural products of good seeds, good animals, good law test, to overcome the natural conditions of the limitations of the formation of ecological agriculture of the plateau characteristics of the industrial clusters, the formation of Yunnan's own ecological agricultural characteristics of the brand.

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