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How Does Agro-Tourism Integration Influence the Rebound Effect of China's Agricultural Eco-Efficiency? An Economic Development Perspective

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Agro-tourism integration is a breakthrough to flourish rural industries and fulfill rural revitalization. Also, agricultural eco-efficiency and agro-tourism integration are closely linked, so investigating the relationship between the two is significant for realizing high-quality agro-ecological development in China. However, existing studies have ignored the impact of agro-tourism integration on agricultural eco-efficiency. For this purpose, using a dataset of 30 provincial administrative regions in China from 2001 to 2019, this paper employs the Entropy weight approach and super efficient Slack-Based Measure (SBM) approach to measure the agro-tourism integration level and agricultural eco-efficiency, respectively. The system Generalized Method of Moments (SYS-GMM) approach is applied to investigate the effect of agro-tourism integration on agricultural eco-efficiency. The statistical results reveal that agro-tourism integration significantly contributes to agricultural eco-efficiency, which remains valid after the robustness checks are executed. There is also significant path-dependence of agro-tourism integration. Finally, agro-tourism integration significantly contributes to agricultural eco-efficiency in the eastern region, while it significantly inhibits agricultural eco-efficiency in the central-western region. Our findings suggest that policymakers not only reinforced the deep integration of agriculture and tourism to stimulate the overall rural revitalization, but also formulated agro-tourism integration policies in a differentiated and green manner to contribute to agricultural eco-efficiency growth.

Keywords: agro-tourism integration, agriculture, tourism, regional heterogeneity, agricultural ecoefficiency

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1 INTRODUCTION

Agriculture is the integration of natural reproduction and economic production (Chandio et al., 2021), which is not only an essential foundation for national economic development (Jinru et al., 2021), but also material support for human survival and development (Lane and Kastenholz, 2015; Shi et al., 2022). Since 1978, agricultural development in China has made considerable contributions, with a total agricultural grain production of nearly 669 million tons in 2020, which accounts for 24.2% of the world's total grain production (Yang and Wang, 2021)[1]. Agriculture has served as a powerful guarantee for the sustainable development of China's economy and society. However, there is also an imbalance in the supply of agricultural products with the unreasonable allocation of factors, weak competitiveness of agriculture, low-end locking of technology, and many varieties of agricultural products but not excellent. Simultaneously, to pursue high grain yield, Chinese chemical fertilizers, pesticides, and agricultural membranes have multiplied, while the excessive use of agricultural chemicals has brought about a grave problem of agricultural surface pollution (Qiu et al., 2021). The National Plan for Sustainable Agricultural Development (2015–2030) stipulates that the current utilization rate of chemical fertilizers and pesticides is less than 1/3, the recycling rate of agricultural films is less than 2/3, the effective treatment rate of livestock and poultry manure is less than half, and straw burning and marine eutrophication are severely affected (Yi et al., 2019)[2]. Just like that, agricultural pollution is a prominent problem seriously jeopardizing agricultural eco-efficiency (Irfan and Ahmad 2022). The 2015 Central Rural Work Conference specified a strategy for the sustainable and healthy development of agriculture. The Chinese government further emphasizes various initiatives to boost the green development of agriculture (Yu, 2011). Under such a background, it has emerged as an inevitable choice for the current and future development of agriculture to improve agricultural eco-efficiency, achieves resource conservation and environmental protection, and promote sustainable agricultural development.

Moreover, as China's economy has shifted from the high-speed growth stage to the stage of high-quality development (Hao et al., 2021; Rauf et al., 2021; Abbasi et al., 2022), agricultural development has also stepped into a new period from production-oriented to quality-oriented (Zhao et al., 2008). How to reverse the previous factor-driven economic development model and focus on promoting quality change, efficiency change, and power change in economic development have become an urgent issue for policymakers to tackle. To crack the industrial deficiencies, power deficiencies, competition deficiencies, and environmental degradation challenges facing the revitalization of the countryside, the Chinese government has successively proposed to prioritize the development of agriculture and rural areas and promote high-quality agricultural development, and other major guidelines and strategies (Iqbal et al., 2021; Irfan et al., 2021). Since then, the Chinese government has explicitly suggested that it is imperative to promote the revitalization of rural industries (Wang J. et al., 2021; Khan et al., 2021; Fang et al., 2022), enrich new rural industries (Wu et al., 2021a; Shao et al., 2021), expand the value chain of agricultural industries, and realize the integrated development of agriculture and adjacent industries to fulfill the comprehensive revitalization of rural areas. The integration of rural industries has broadened the boundary of agricultural production possibilities, which is a powerful grip and significant driving force for China to break through the constraints of agricultural resources and the environment and fully implement the rural revitalization strategy. Among them, the integration of agriculture and tourism (agro-tourism integration) is a significant way to integrate rural industries, which is not only beneficial to broadening farmers' income channels, promoting the transformation and upgrading of agriculture, and maintaining the prosperity and stability of rural areas but also helps to continuously enrich the tourism industry and lengthen the industrial chain. The Opinions on Accelerating the Modernization of Agriculture and Rural Areas by Comprehensively Promoting the Revitalization of the Countryside also clearly indicate that the synergistic development of agriculture and tourism is an essential element and the primary path to boost the "revitalization of the countryside" and deepen the structural reform on the supply side. Also, agro-tourism integration can develop power support for the agriculture and tourism industries, which not only significantly boosts the non-agricultural income of the rural population, but also has great practical significance for generating new rural industries and realizing ecological livability.

However, against such backgrounds as rising production costs, continuous deterioration of the ecological environment, and increasingly urgent resource constraints, the road to the development of the traditional crude agricultural tourism integration industry, relies on the original sparring resources, inputs, and ecology, which has been struggling. It is imperative to expeditiously facilitate the transformation and upgrading of agriculture, promote the coordinated development of new rural integration, and take the path of green and sustainable development of agriculture and enhancement of agricultural eco-efficiency. However, there are more researches on agricultural eco-efficiency that ignore the key factor of agro-tourism integration. Only some scholars have explored the development path of agro-tourism integration in terms of sustainable development (Tang and Yin, 2006; Rajović and Bulatović, 2015; Pan et al., 2018). For example, Rajović and Bulatović (2015) find that agritourism, as a form of selective tourism, is not only a possible way to retain residents in rural areas, but also to promote economic growth and sustainable development in rural areas. Alternatively, some scholars have only investigated the measures and influencing factors of agricultural eco-efficiency (Picazo-Tadeo et al., 2011; Deng, and Gibson, 2019; Liu et al., 2021). Agro-tourism integration is a major force to drive the development of the rural economy and realize the strategy of rural revitalization. So, what is the current status of agro-tourism integration and agricultural eco-efficiency? Can agro-tourism integration contribute to the improvement of agricultural eco-efficiency? What is the role of agro-tourism integration in influencing agricultural eco-efficiency under different regional distributions? Such questions deserve further exploration. Therefore, a fixed-effects and the system generalized method of moments (SYS-GMM) and an instrumental variables methods are employed to empirically examine the impact of agro-tourism integration on agricultural eco-efficiency on the basis of using a dataset of 30 provincial

[1]http://www.gov.cn/xinwen/2022-02/28/content_5676015.htm.
[2]http://www.moa.gov.cn/gk/tzgg_1/tz/201505/t20150527_4620018.htm.

administrative regions from 2001 to 2019. It is significant to facilitate the development of agro-tourism integration for the comprehensive revitalization of rural regions and accelerate the sustainable development of agricultural green carpets by providing decision-making references and intellectual support as well as the formulation of relevant policies.

As such, this paper aims to conduct additional research in the following three categories. This paper uses the entropy weight approach and the Slack-Based Measure (SBM) model with undesired super-efficiency to measure agro-tourism integration and agricultural eco-efficiency including agricultural carbon emissions, respectively, studying the impact of agro-tourism integration, with a view to providing evidence on whether agro-tourism integration can improve agricultural eco-efficiency and providing a reference for agricultural eco-environment improvement and industrial integration development. Furthermore, this paper identifies the impact of agro-tourism integration on agricultural eco-efficiency by categorizing the research sample into an eastern and central-western region based on regional heterogeneity, to broaden the research content of agro-tourism integration and agricultural eco-efficiency and propose deeper reference suggestions for how agro-tourism integration can differentially participate in environmental governance.

The remaining results of this paper are organized as follows. **Section 2** gives a literature review on agro-tourism integration and agricultural eco-efficiency. **Section 3** provides the variable measures, model selection, and data description. **Section 4** presents the empirical results and discusses it in detail. Finally, this paper concludes with precise policy implications and directions for future research based on the findings.

2 LITERATURE REVIEW

As the popularity of agro-tourism integration and agricultural eco-efficiency has been increasing, researchers have carried out numerous useful explorations on the relationship between agro-tourism integration and agricultural eco-efficiency from various dimensions, which also provides a rich research basis for this paper. Collectively, the research on agro-tourism integration and agro-ecological efficiency can be summarized in the following aspects.

2.1 Research on Agro-Tourism Integration

It is suggested that the research on agro-tourism integration has been conducted in the three primary dimensions as follows. First, it is the definition of agro-tourism integration and the study of cooperation mode (Koutsouris et al., 2014; Lifang, 2018; Meng, 2019). Han et al. (2020) argue that agro-tourism integration involves the development process in which agriculture and tourism interpenetrate and intersect, and eventually merge into one, gradually forming a new type of business. Li et al. (2021) identifies agro-tourism integration as an economic model that adheres to the concept of green, low-carbon, and environmental protection and integrates agriculture and tourism. Some scholars have analytically defined agro-tourism integration in terms of agro-tourism and agro-tourism (Torres, 2003; Ghadami et al., 2022). Hysa and Kruja (2022), for example, consider agro-tourism integration as the economic realization of the sharing of the agricultural and tourism sectors. Dernoi (1983) outlines the possibilities of farm tourism for the development of rural areas when agriculture and tourism are combined in Europe, which is the prototype of agro-tourism integration development. Next, some scholars have measured agro-tourism integration (Zhou et al., 2020; Uduji et al., 2021). Yi et al. (2019) used Yangjia town in Mianyang City as an example to gauge its level of agriculture-tourism integration through the AHP method and analyze the problems and solution measures in the process of its agriculture-tourism integration development. Qiu et al. (2021) explore the integration context of agriculture and tourism night from 2009 to 2018 by employing the entropy weight method and coupled coordination model in Henan Province. Yang and Wang (2021) measured the degree of agro-tourism integration based on the AHP-fuzzy integrated evaluation method considering the Enshu Gongshui grapefruit industry as an example. Finally, several scholars have undertaken profound analyses of the factors influencing agro-tourism integration (Goreta Ban, 2021). Salihoglu and Gezici (2021) first investigate the link between the tourist and agricultural sectors and analyze the impact of supplier networks and geographic economies on the integration of the agro-tourism sector. Using Tanzania as a case study, Jani and Nguni (2021) identify the nature of supply and demand, agricultural scale, tourism destination, hotel scale, and scenic area type as significant factors influencing agro-tourism integration. Fleischer and Tchetchik (2005) suggest that agro-tourism integration can stimulate agricultural development and promote the diversification of special agro-tourism products, which satisfies the diversified needs of tourists and in turn promotes the rapid development of the agricultural economy. Gruia et al. (2021) reveal that after the new crown epidemic Romania needs to guide village governance according to the spirit of rural communities is to develop new agro-tourism policies and strategies and align with Europe.

2.2 Research on Agricultural Eco-efficiency

Scholars have yielded abundant achievements on agricultural eco-efficiency, and up to now, the research on agricultural eco-efficiency is mainly covering the following aspects. First, there are the definitions and origins of agricultural eco-efficiency. Agricultural eco-efficiency was most initially originating from the broad definition of eco-efficiency. Eco-efficiency was introduced by Schaltegger and Sturm (1990), who interpreted it as the ratio of positive economic externalities to ecological load. Subsequently, the World Business Council for Sustainable Development (WBSCD) and other official bodies jointly developed a definition of eco-efficiency at different levels, and concluded that eco-efficiency is the gradual reduction of ecological impacts and resource intensity throughout the life cycle to a level acceptable to the ecological carrying capacity of the earth, while achieving the goal of environmental quality and social harmony. The concept of agricultural eco-efficiency is an extension of eco-efficiency in the field of agriculture. Currently, there is no clear definition of agricultural eco-efficiency, but scholars have defined it in accordance with their research focus, and its connotation can be summarized as obtaining the maximum agricultural economic benefits with the minimum input of environmental and resource factors. Many scholars have transferred the applied concept of eco-efficiency to agriculture, and thus agro-ecological efficiency was introduced. However, there are many differences among the interpretations of agroecological efficiency because of the different research objectives and samples selected by scholars. However, the present study defines agroecological efficiency as the maximum agricultural economic return with the minimum agricultural resource input and the minimum undesired output. Furthermore, scholars in various research scales have tested agricultural eco-efficiency and analyzed its influencing factors. Scholars usually employ the ratio method (Park et al., 2007), the indicator system method (Lauwers, 2009; Van Caneghem et al., 2010), and the input-output method (Akbar et al., 2021; Ji et al., 2021) to determine agricultural eco-efficiency (Liu, and Cheng, 2022). For example, using factor analysis methods, Guthman (2000) estimates the scale of agricultural development and operational efficiency in California, United States.

Moradi et al. (2018) construct a DEA approach to the CCR model to assess the agricultural cycle efficiency of farms. Taking different agricultural ecological zones from Ghana in 2010, Addai et al. (2014) assess the technical efficiency of maize growers. Akbar et al. (2021) calculate the agroecological efficiency of 30 provincial administrative regions in China in terms of agroecological efficiency using an SBM that includes undesired outputs. The super-efficient SBM model has gradually emerged as a prevailing model for measuring agricultural eco-efficiency because it combines the advantages of the super-efficient DEA model and SBM model, incorporates undesired outputs into the model, and effectively eliminates the slack phenomenon of inputs and outputs and the juxtaposition of ranking (Pang et al., 2016; Coluccia et al., 2020). In terms of the influencing factors of agricultural eco-efficiency, Yang et al. (2022) utilize a differential GMM model to quantify the influence mechanism between agricultural eco-efficiency and food security and the impact of different public investments in agriculture on them. Liu et al. (2020) suggest that agricultural infrastructure conditions, agricultural industry structure, agricultural development potential, and agricultural input intensity are the determinants of agricultural eco-efficiency. Liao et al. (2021) identify energy inputs, water inputs, and carbon emissions as the core drivers of spatial heterogeneity in agricultural eco-efficiency in China. Ma and Li (2021) examine digital inclusive finance and agricultural eco-efficiency and reveal that the effect of digital inclusive finance on agricultural eco-efficiency is non-linear with significant regional heterogeneity, which is dramatically reinforced by agricultural R&D investment.

Summarizing the above literature, it can be observed that agro-tourism integration and agricultural eco-efficiency have emerged as hotspots of academic attention, scholars have made meticulous and in-depth analyses of agricultural tourism integration and agricultural eco-efficiency on the basis of different research approaches and research objects (Chemnasiri, 2012; Zhou et al., 2021). Although scholars have separately examined the influencing factors of agricultural tourism integration and the influencing factors of agricultural eco-efficiency, few scholars have investigated the impact on agricultural eco-efficiency caused by agro-tourism integration (Wang and Zhou, 2021). Additionally, despite the fact that the measurement approaches, index systems, and analysis perspectives of agro-tourism integration and agricultural eco-efficiency have their distinctive features, there are some weaknesses (Yi et al., 2019; Hysa and Kruja, 2022). Because of this, this paper introduces agricultural carbon emissions into the eco-efficiency evaluation system, and utilizes a non-radial super-efficient SBM model and the Entropy weight method model to respectively gauge 2001–2019 agricultural eco-efficiency and agro-tourism integration levels. The systematic GMM model is employed to explore the heterogeneous characteristics of agro-tourism integration on agricultural eco-efficiency, so as to promote agricultural ecological protection and high-quality agricultural development.

3 MODEL SETTING, VARIABLES DEFINITION, AND DATA DESCRIPTION

3.1 Model Setting

To alleviate the endogeneity problem, referring to Wu et al. (2020), the generalized method of moments (GMM) is applied to assess the influence of agro-tourism integration on agricultural eco-efficiency. However, compared to differential GMM, systematic GMM (SYS-GMM) has fewer bias problems and improved efficiency in estimating results with limited samples, which not only alleviates the weak instrumental variables arising from the differential GMM estimation method, but also contributes to the robustness of the model estimation. Therefore, this paper opts for a systematic GMM to estimate the impact of agro-tourism integration on agricultural eco-efficiency. The specific form of the equation is set as follows.

$$AEE_{it} = \alpha_0 + \alpha_1 AEE_{it-1} + \alpha_2 ATI_{it} + \alpha_n X_{it} + \varepsilon_{it} \tag{1}$$

where the subscripts $i(t)$ and t denote provinces (years), respectively. AEE characterizes agricultural eco-efficiency. ATI characterizes agro-tourism integration. X denotes some other factors that may affect agro-ecological efficiency, including agricultural economic level (AEL), agricultural machinery density (AMD), industrialization level (INL), agricultural employment level (AET), financial support for agriculture (FSA), human capital (HUM), information level (INF), marketization level (MAR), and R&D investment (RDI). α_0, α_1, α_2, α_n denote the coefficient to be estimated. ε denotes the random perturbation term, which is subject to the white noise process.

3.2 Variables Selection

3.2.1 Explained Variables

Agricultural eco-efficiency (AEE). Data envelopment analysis (DEA) is the method frequently employed to evaluate agricultural eco-efficiency. DEA approach is a nonparametric statistical method based on the concept of relative efficiency and the relative effectiveness of the same type of units based on multi-indicator inputs and multi-indicator outputs (Hao et al., 2020; Yang et al., 2021a; Ren et al., 2022a). The principle of DEA lies in substituting the production function in microeconomics with an envelope and then mapping the inputs and outputs of all decision-making units (DMUs) into space. Then, the effective and ineffective points are divided by constructing a non-parametric envelope front line, with the effective points located on the frontier and the ineffective points located below the frontier (Cecchini et al., 2018; Ren et al., 2021; Su et al., 2021). However, the traditional DEA model is also classified as a radial model by some scholars, but the probability that the inputs and outputs change in the same proportion is very low or even 0. Moreover, the traditional radial DEA model has neglected the input and output slack variables (Li et al., 2021; Liu et al., 2021). Non-radial slack can often be found, with the possibility of improved slack non-proportionality as well as radial proportionality in the decision unit (Li and Shi, 2014). When the input (output) slack plays a significant role in the evaluation of the efficiency of a decision unit, the efficiency derived from the measurement of the model alone is inherently unreasonable (Hao et al., 2022). To fully capture the input (output) slack, Tone (2001) develops a super-efficient SBM model based on the SBM models. However, the SBM model, like the traditional DEA model, makes it difficult to further distinguish efficiency differences among efficient DMUs for DMUs that are all 1 efficient. Furthermore, the super-efficient SBM model can handle the “slack” problem better and provide a comparison for decision-making units (DMUs) with efficiency higher than or equal to 1. Therefore, the super-efficient SBM model is chosen for agricultural eco-efficiency measurement. The model construction is presented in the following form.

$$AEE = min\frac{(1/m)\sum_{i=1}^{m}\left(\bar{x}/x_{ik}\right)}{\frac{1}{r_1+r_2}\left(\sum_{s=1}^{r_1}\left(\overline{y^d}\Big/y_{sk}^d\right)+\sum_{q=1}^{r_2}\left(\overline{y^u}\Big/y_{qk}^u\right)\right)} \tag{2}$$

$$\begin{cases} \bar{x}\geq\sum_{j=1,j\neq k}^{n}x_{ij}\lambda_j;\ \overline{y^d}\leq\sum_{j=1,j\neq k}^{n}y_{sk}^d\lambda_j;\overline{y^d}\sum_{j=1,j\neq k}^{n}y_{qk}^u\lambda_j \\ \bar{x}\geq x_k;\quad \overline{y^d}\leq y_k^d;\quad \overline{y^u}\leq y_k^u \\ \lambda_j\geq 0, i=1,2,...m;\quad \bar{\lambda}_j\geq 0, j=1,2,...n, j\neq 0; \\ s=1,2,\cdots r_1;\quad q=1,2,\cdots r_2; \end{cases} \tag{3}$$

where AEE denotes the agricultural eco-efficiency value. There are n decision units, each of which includes m inputs, r_1 desired outputs, and r_2 undesired outputs. x denotes an element in the input matrix. y^d denotes an element in the desired output matrix. yu denotes an element in the undesired output matrix.

Agricultural eco-efficiency measurement system. Agriculture in a broad sense includes agriculture, livestock, and fishery, while agriculture in a narrow sense means plantation. This paper measures agricultural eco-efficiency with a narrow sense of agriculture as the focus of the survey. Based on the characteristics of plantation production, the input and output indicators are selected as follows.

3.2.1.1 Input Indicators

The inputs in agricultural production include fertilizer, irrigation, and mulch needed for crop growth, in addition to conventional labor and land inputs. This paper selects 8 input indicators that are associated with agricultural production, which basically cover the required inputs in the agricultural production cycle.

Labor input is quantified by the amount of labor input in agricultural production, which is the product of the number of people employed in the primary sector and the ratio of total agricultural output to total agricultural, forestry, animal husbandry, and fishery output. Land input, as one of the necessary elements of agricultural production, is denoted by the total sown area of crops. Fertilizers containing nitrogen, phosphorus, potassium, and other elements are usually applied in agricultural production, and fertilizer inputs are characterized by the amount of fertilizer applied after converting the sum of nitrogen, phosphorus, and compound fertilizers. Pesticide inputs are characterized by the number of pesticides used. The agricultural film, a breakthrough in modern agriculture, whose inputs significantly improve crop survival and growth, is characterized by the amount of agricultural film used. The input of machinery in modern agriculture has boosted labor efficiency and mechanization is an important feature of modern agriculture. The total power of agricultural machinery is denoted as agricultural machinery power input. The use of machinery in modern agriculture requires energy to power it. Energy inputs are denoted by the amount of agricultural diesel used. Water is an essential element in crop production. The effective irrigated area is used to express the irrigation input.

3.2.1.2 Desired Output

Following Liao et al. (2021) and Ma and Li (2021), the total agricultural output value is selected to denote the desired output of agriculture (to avoid the influence of price factors, this paper uses the price index of total agricultural, forestry, animal husbandry, and fishery output value, which is smoothed with the consumer price index in 2000 as the base period).

3.2.1.3 Undesired Output

Agricultural carbon emissions are characterized as non-desired outputs, which derive from 6 major direct or indirect sources such as fertilizers, pesticides, agricultural films, agricultural diesel, irrigation electricity and water consumption, and tillage loss. Referring to Shi et al. (2022) and Liao et al. (2021), the emission coefficients of 6 major carbon sources were 0.895 6 (kg/kg) for fertilizer, 4.934 1 (kg/kg) for pesticide, 5.18 (kg/kg) for agricultural film, 0.592 7 (kg/kg) for diesel, 20.476 (kg/km^2) for agricultural irrigation and 312.6 (kg/km^2) for agricultural tillage.

3.2.2 Core Explanatory Variables

Agro-tourism integration (ATI). Agro-tourism integration is a new business model based on the industrial connection between agriculture and tourism, which derives from the development of the rural tourism industry from rural agriculture, and the derivation of agrarian caravans, agricultural estates, melon and

TABLE 1 | Agro-tourism integration index system.

Guideline level	Indicator system
Industrial correlation degree	Agricultural added value Gross tourism revenue Gross tourist arrivals Domestic tourism revenue International foreign exchange tourism revenue
Tourism industry development	The added value of the accommodations and restaurants industry Travel agency business income Number of star-rated hotels Star-rated hotel business income Travel agency operating income
Integration benefits	Rural farming fixed-asset investment area of fruit orchards Number of employees in primary industry Value added in agriculture as a share of GDP Total tourism revenue as a share of GDP

fruit, and vegetable production bases (Astuti et al., 2019). Meanwhile, it fully utilizes rural natural resources, absorbs rural surplus labor, forms new economic growth points in rural areas, as well as realizes good economic and social benefits for the whole society. Thus, the degree of association between agriculture and tourism is the basis for evaluating agro-tourism integration, and the economic and social benefits of integration development serve as the outcome (Budiasa and Ambarawati, 2014) see (**Table 1**). Referring to Zhou et al. (2021), this paper establishes the following agro-tourism integration index system using the Entropy weight method.

Agro-tourism integration level measurement. For the synthesis of the agro-tourism integration index system, referring to Cao et al. (2021) and Cao et al. (2022), the more objective Entropy weight method is adopted to integrate each index. The specific steps are as follows.

Step 1. The indicators are normalized dimensionless using the extreme difference standardization method. Since the selected indicators all have a positive influence on agro-tourism integration, thus the indicators are processed as follows.

$$z_{ij} = \frac{x_{ij} - \min(x)}{max(x_j) - \min(x_j)} \tag{4}$$

Step 2. Calculating the relative share of the i_{th} region for the j_{th} indicator.

$$P_{ij} = z_{ij} \Big/ \sum_{i=1}^{m} z_{ij} \tag{5}$$

In **Eq. 5**, P_{ij} is the relative weight and m is the number of samples.

Step 3. Calculating the entropy value of the j_{th} indicator.

TABLE 2 | Descriptive statistics.

Variable	Obs	Mean	Std. Dev	Min	Max
AEE	540	0.8032	0.3122	0.2656	1.6627
ATI	540	0.1636	0.1190	0.0124	0.7269
AEL	540	21.2562	12.0365	3.3526	75.5372
AMD	540	5.5758	2.6520	1.3932	13.9378
AET	540	0.3883	0.1596	0.0296	0.8183
INL	540	0.3767	0.0873	0.1109	0.5924
FSA	540	0.1016	0.0352	2.0213	2.1897
MAR	540	6.3718	1.954437	2.3700	11.4000
INF	540	0.0908	0.1417	0.0013	1.6450
HUM	540	8.7099	1.0994	6.0400	12.9200
RDI	540	0.2139	0.6882	0.0015	6.3100

$$e_j = -\frac{1}{lnm} \sum P_{ij} lnP_{ij} \tag{6}$$

In **Eq. 6**, e_j is the entropy value of the j_{th} indicator.

Step 4. Calculating the weight (ω_j).

$$\omega_j = \left(1 - e_j\right) \Big/ \sum_{j=1}^{n} \left(1 - e_j\right) \tag{7}$$

In **Eq. 7**, $(1 - e_j)$ is the information utility value of j_{th}.

Step 5. Calculating the indicator of different years in each region.

$$ATI_{ij} = \sum_{i=1}^{n} \omega_j * z_{ij} \tag{8}$$

3.2.3 Control Variables

Referring to Shi et al. (2022), Wang J. et al. (2022), and Zhao et al. (2021), the variables of agricultural economic level (AEL), agricultural machinery density (AMD), industrialization level (INL), agricultural employment level

TABLE 3 | Baseline regression results.

Variables	(1)	(2)	(3)	(4)
L.AEE			0.6390***	0.6184***
			(0.019)	(0.078)
ATI	0.3726***	0.4971***	0.1480***	0.2632***
	(0.110)	(0.171)	(0.029)	(0.092)
AEL		0.0016		0.0006
		(0.001)		(0.001)
AMD		−0.0279***		−0.0136***
		(0.005)		(0.004)
AET		−0.9469***		−0.4235***
		(0.177)		(0.158)
INL		−1.3928***		−0.4213***
		(0.148)		(0.099)
FSA		−3.0293***		−1.1077***
		(0.509)		(0.354)
MAR		−0.0223*		−0.0138*
		(0.012)		(0.008)
INF		−0.0500		−0.0252
		(0.148)		(0.030)
HUM		−0.0645***		−0.0193
		(0.021)		(0.013)
RDI		−0.0474**		−0.0189**
		(0.024)		(0.008)
_cons	0.7440***	2.7647***	0.2500***	1.0206***
	(0.022)	(0.288)	(0.022)	(0.247)
AR(2)			−1.46	−1.42
			[0.145]	[0.156]
Hansen test			28.38	26.08
			[1.000]	[1.000]
N	570	570	540	540

*Standard errors in parentheses; *p < 0.1, **p < 0.05, ***p < 0.01. "[]" denotes the p-value.*

(AET), financial support for agriculture (FSA), human capital (HUM), Informatization level (INF), marketization level (MAR), and R&D investment (RDI) are considered to control for other factors affecting agricultural eco-efficiency. Agricultural economic level (AEL) is quantified using the ratio of total agricultural output to the resident population. Agricultural machinery density (AMD) is captured by the ratio of total agricultural machinery power to total crop sown area. Industrialization level (INL) is characterized by the ratio of industrial value-added to GDP. Agricultural employment level (AET) is characterized using the ratio of employment in the primary sector to the total number of employees. Financial support for agriculture (FSA) is summarized by the ratio of agricultural, forestry, and water expenditures to local general budget expenditures. The number of years of education per capita is selected to denote human capital (HUM). Informatization level (INF) is denoted by the volume of the postal and telecommunication business. Marketization level (MAR) is selected to measure the ratio of employees in private and individual enterprises to the resident population. R&D investment (RDI) is measured using R&D noted as a share of GDP.

3.3 Data Description

The study subjects are 30 provincial administrative regions in mainland China (limited to data availability and the special agricultural production conditions in Tibet and Hong Kong, Macao, and Taiwan, which are not included in the empirical study), and the time horizon is 2001–2019. The data involved in this paper are collected from "China Rural Statistical Yearbook", "China Agricultural Statistics", "Fifty Years of New China Agricultural Statistics", "China Tourism Statistical Yearbook", "China Statistical Yearbook" and provincial statistical yearbooks, the National Economic and Social Development Statistical Bulletin. Moreover, some of the missing data are supplemented by consulting the official websites of the relevant ministries and provincial statistical bureaus. The data measured in monetary units have been eliminated for inflation. Descriptive statistics are placed in **Table 2**.

4 RESULTS AND DISCUSSION

4.1 Baseline Regression Results and Discussion

For comparison, columns 1) and 2) of **Table 3** list the estimation results of the mixed least square method regression model. Columns 3) and 4) of **Table 3** show the estimation results of the SYS- GMM model. **Table 3**reports that the coefficients of AR (2) and the $Hansen\,test$ are not significant ($p-value > 0.1$), indicating that the disturbance terms do not have second-order serial autocorrelation as well as the validity of the instrumental variable selection, which confirms the rationality of employing the SYS- GMM to verify the effect of agro-tourism integration on agricultural eco-efficiency. Further, an interesting finding is that the coefficient of ATI is significantly positive ($p-value < 0.01$) with or without control variables introduced, i.e., agro-tourism integration can contribute to agricultural eco-efficiency. Our findings are in line with those of Liu et al. (2020) and Wang G. et al. (2022). One possible explanation is that agro-tourism integration converts the value of the agricultural ecological environment into economic benefits, which contributes to enhancing the agricultural producers' capital accumulation level (Wang J. et al., 2022). It allows them to have enough funds to purchase advanced and efficient agricultural equipment, thus diminishing factor inputs such as labor, arable land, and mechanical power and water, and ultimately improving agricultural production efficiency (Chemnasiri, 2012; Ana, 2017). Also, the development process of agro-tourism integration always adheres to scale, industrialization, intensification, and clean production and operation. Moreover, agro-tourism integration is mainly a direct regenerative use of natural and human resources, transforming them into scenic resources and attractive tourism products, which carry natural ecological attributes (Yi et al., 2019). During the process of agro-tourism integration development, the rural environment should be greened, purified, and beautified, which is conducive to the protection of the rural ecological environment (Budiasa and Ambarawati, 2014). Simultaneously, agro-tourism integration strengthens the economic base of the countryside and provides a financial guarantee for the maintenance and improvement of the rural

TABLE 4 | Regional heterogeneity results.

Variables	(1)	(2)	(3)	(4)
	Eastern region	Eastern region	Central-western region	Central-western region
L.AEE	0.5825***	0.5672***	0.5299***	0.6155***
	(0.010)	(0.076)	(0.017)	(0.084)
ATI	0.2663***	0.3598***	−0.3845***	−0.3095**
	(0.045)	(0.074)	(0.046)	(0.150)
AEL		0.0013		0.0014
		(0.001)		(0.001)
AMD		−0.0200***		−0.0139***
		(0.004)		(0.003)
AET		−0.4423**		−0.2751*
		(0.201)		(0.144)
INL		−0.5499***		−0.3726***
		(0.081)		(0.102)
FSA		−1.1403***		−1.0285**
		(0.424)		(0.454)
MAR		−0.0172***		−0.0046
		(0.006)		(0.008)
INF		−0.0206		0.0938***
		(0.022)		(0.034)
HUM		−0.0325*		0.0011
		(0.019)		(0.012)
RDI		−0.0182***		−0.0240***
		(0.005)		(0.009)
_cons	0.2977***	1.3022***	0.4029***	0.7340***
	(0.017)	(0.296)	(0.013)	(0.242)
AR(2)	−1.48	−1.47	−1.54	−1.37
	[0.138]	[0.142]	[0.125]	[0.170]
Hansen test	28.48	21.88	28.57	24.24
	[1.000]	[1.000]	[1.000]	[1.000]
N	540	540	540	540

*Standard errors in parentheses; *p < 0.1, **p < 0.05, ***p < 0.01. "[]" denotes the p-value.*

ecological environment (Qiu et al., 2021). During the process, agricultural producers gradually realize that ecological factors in the agricultural production process can create higher and more sustainable premiums. Therefore, to keep long-term sustainable economic returns, relevant practitioners will embrace the concept of low-carbon development and strengthen environmental awareness and behavior, such as reducing harmful environmental factors such as fertilizer and pesticide inputs and using low-carbon products, which minimize the negative impact of production and operation activities on the natural environment and thus contribute to the improvement of agricultural eco-efficiency (Rajović and Bulatović, 2015).

4.2 Heterogeneity Results and Discussion

Because of the influence of the economy, human history, and geographical environment, there are form differences among various regions in China (Yang et al., 2021b; Ren et al., 2022b; Wu et al., 2021b). The impact of agro-tourism integration on agro-ecological efficiency may yield significant variations in terms of different regions (Liu et al., 2020). Thus, this paper categorizes the research sample, which contains 30 provincial administrative divisions, into two regions (eastern and central-western). **Table 4** reports that a significant regional heterogeneity is found in the effect of agro-tourism integration on agricultural eco-efficiency, i.e., the coefficient of agro-tourism integration is significantly positive at the 1% level in the eastern region and significantly negative at the 5% level in the central-western region. It is not surprising that our findings correspond to the study of Wang and Zhou (2021). An underlying interpretation is that the eastern region has an advanced economy, sound agricultural infrastructure, and an interest in agricultural modernization (Xiao et al., 2022). Also, the eastern regions are highly exploited and experienced in developing tourism resources, with rich industrial advantages in transforming rural ecological resources into tourism resources (Wang Z. et al., 2021). Moreover, not only does the eastern region have more financial resources to align agricultural production, resource conservation, and environmental protection, but agro-tourism integration does not involve further sacrificing the rural environment as a cost (Nie, 2021). The development of agro-tourism integration can swiftly transform rural ecological values into economic benefits, and the enhancement of economic benefits further impels the improvement of the agricultural ecological environment, so that the integration of agro-tourism and agricultural eco-efficiency improvement is driven into a virtuous cycle (Wang and Zhou, 2021). However, although the rural ecological resources in the central and western regions are more abundant, the agricultural economic development mode is relatively rough and the agricultural technology level develops

TABLE 5 | Robustness checks.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	TSLS	TSLS	Removing outliers	Removing outliers	Excluding special years	Excluding special years
L.AEE			0.6456***	0.6169***	0.5917***	0.6727***
			(0.008)	(0.078)	(0.019)	(0.064)
ATI	0.4123***	0.4436**	0.1515***	0.2446**	0.1615***	0.2359**
	(0.115)	(0.179)	(0.025)	(0.100)	(0.030)	(0.097)
AEL		0.0030**		0.0007		0.0016
		(0.001)		(0.001)		(0.001)
AMD		−0.0262***		−0.0134***		−0.0098***
		(0.005)		(0.004)		(0.003)
AET		−0.9549***		−0.4342***		−0.3655***
		(0.184)		(0.155)		(0.109)
INL		−1.3165***		−0.4253***		−0.4503***
		(0.157)		(0.099)		(0.095)
FSA		−3.7554***		−1.1075***		−1.6541***
		(0.565)		(0.354)		(0.496)
MAR		−0.0267**		−0.0132*		−0.0126*
		(0.012)		(0.008)		(0.007)
INF		−0.0221		−0.0187		−0.0364
		(0.150)		(0.030)		(0.029)
HUM		−0.0617***		−0.0197		-0.0255**
		(0.022)		(0.013)		(0.010)
RDI		−0.0447*		−0.0193**		−0.0141**
		(0.024)		(0.008)		(0.006)
_cons	0.7290***	2.7773***	0.2462***	1.0252***	0.2947***	1.0216***
	(0.024)	(0.305)	(0.012)	(0.248)	(0.014)	(0.160)
AR(2)			−1.45	−1.41	−0.91	−0.75
			[0.146]	[0.157]	[0.362]	[0.452]
Hansen test			28.08	26.34	28.15	23.51
			[1.000]	[1.000]	[0.999]	[1.000]
N	510	510	540	540	480	480

*Standard errors in parentheses; *p < 0.1, **p < 0.05, ***p < 0.01. "[]" denotes the p-value.*

slowly (Hernández-Mogollón et al., 2011). Meanwhile, the agricultural production mode in the central and western regions is yet comparatively backward, with a lower degree of agricultural mechanization and insufficient market demand for agro-tourism integration, which is more driven by uncertain policies (Zhou et al., 2021). To fulfill agricultural tourism integration expeditiously, the central and western regions probably just emphasize economic benefits and forcefully graft on the agro-tourism integration model of the eastern regions, failing to apply strategies according to their local conditions and neglecting agro-ecological environmental protection, thus causing a reduction in agro-ecological efficiency.

4.3 Robustness Checks Results and Discussion

To ascertain that the benchmark regression results are robust, the following techniques are employed to perform robustness tests. First, aiming at the potential endogeneity problem, in addition to a dynamic panel model constructed by incorporating the lagged terms of the explanatory variables into the model, the instrumental variables approach can also be used to eliminate endogeneity. Following Wang J. et al. (2022), this paper performs two-stage least squares (TSLS) estimation by selecting the lagged second term of agro-tourism integration as the instrumental variable (Columns 1) and 2) of **Table 5**). Next, it is observed that, in general, the presence of outliers in the sample has a significant effect on the estimation of the results. Thus, this paper utilizes tailoring to remove the 1% outliers (Columns 3) and 4) of **Table 5**). Finally, the emergence of extreme events can also cause huge fluctuations in the sample data within a particular year. And the worldwide U.S. subprime mortgage crisis in 2008 will undoubtedly produce a tremendous shock to sample stability. Therefore, the 2008 years data were excluded to check the impact of agro-tourism integration on agricultural eco-efficiency (Columns 5) and 6) of **Table 5**). **Table 5** reports that the effect of agro-tourism integration on agricultural eco-efficiency remains significantly positive after using TSLS estimation, removing outliers, and excluding special years, implying that empirical results are robust and reliable.

5 CONCLUSIONS AND POLICY RECOMMENDATIONS

This paper evaluates the agro-tourism integration level utilizing the Entropy weight method on the basis of a dataset of 30 provincial administrative regions in China from 2001 to 2019. Also, considering the diverse factors of ecological environmental protection and green low-carbon development, agricultural carbon emissions are incorporated into the measurement system of agricultural eco-efficiency, and the super-efficient SBM approach is employed to measure agricultural eco-efficiency. Further, the SYS-GMM approach is applied to investigate the effect of agro-tourism integration on agricultural eco-efficiency. The major findings are as follows: Both static and dynamic panel models demonstrate a significant positive correlation between agro-tourism integration and agricultural eco-efficiency, i.e., agro-tourism integration can have a significant contribution to agricultural eco-efficiency. A significant positive effect of agro-tourism integration in the previous period on agro-tourism integration in the current period suggests that agro-tourism integration has strong inertia. Regional heterogeneity results report that agro-tourism integration significantly contributes to agricultural eco-efficiency in the eastern region, while it significantly inhibits agricultural eco-efficiency in the central-western region. Accordingly, this paper introduces the following two policy recommendations.

1) Policymakers should scientifically assess the development potential for both agriculture and tourism as well as the carrying capacity of the local ecological environment to determine the reasonableness and feasibility of agro-tourism integration development. Also, policymakers should actively explore a win-win model of total factor ecological protection and industrial development for mountains, water, forests, fields, and grasses, depending on local resource factor endowments. For example, policymakers should adhere to modernized green agriculture as a guide, broaden the depth and breadth of the agricultural industry chain, and strive to create a modern, green, and low-carbon agricultural industry system, thereby improving agricultural eco-efficiency.
2) Policymakers should dynamically adjust the development policy of agro-tourism integration in light of local conditions from the actual situation. In the specific implementation process of the policy, the significant regional heterogeneity that exists in the development of agro-tourism integration should be fully considered, and a dynamic, refined, and differentiated strategy of agro-tourism integration should be implemented to make agro-tourism integration development an effective tool to promote agricultural eco-efficiency. For example, given the sufficient market for agro-tourism integration in the eastern region and the perfect infrastructure construction of agriculture and tourism, policymakers should vigorously support the development of agro-tourism integration and improve the supervision function and institutional environment to actively guide consumer demand and broaden the scope of agro-tourism integration. In the central-western regions, due to their regional conditions, the foundation for developing agro-tourism integration is weak, and farmers' ecological awareness is insufficient. Policymakers need not only to give strong financial support to agro-tourism integration but also to strengthen agricultural ecological education and agricultural ecological management.

Although this paper has thoroughly analyzed the impact of agro-tourism integration on agricultural eco-efficiency, some significant issues still deserve attention. First, this paper only quantifies the direct effect of agro-tourism integration on agricultural eco-efficiency. However, agro-tourism integration may indirectly affect agro-ecological efficiency through the paths of human capital, resource allocation, and environmental regulation. Therefore, future scholars can explore the diversified paths of agro-tourism integration on agricultural eco-efficiency from the above perspectives.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

GJ: conceived the idea and contribute to the writing of the manuscript, performed the data collection, and statistical analysis, revised the manuscript, and gave guidance throughout the process of this study. All authors have read and agreed to the published version of the manuscript.

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REFERENCES

Abbasi, K. R., Shahbaz, M., Zhang, J., Irfan, M., and Alvarado, R. (2022). Analyze the Environmental Sustainability Factors of China: The Role of Fossil Fuel Energy and Renewable Energy. *Renew. Energy* 187, 390–402. doi:10.1016/j.renene.2022.01.066

Addai, K. N., Owusu, V., and Danso-Abbeam, G. (2014). Effects of Farmer–Based-Organization on the Technical Efficiency of Maize Farmers across Various Agro-Ecological Zones of Ghana. *J. Econ. Dev. Stud.* 2 (1), 141–161.

Akbar, U., Li, Q.-L., Akmal, M. A., Shakib, M., and Iqbal, W. (2021). Nexus between Agro-Ecological Efficiency and Carbon Emission Transfer: Evidence from China. *Environ. Sci. Pollut. Res.* 28 (15), 18995–19007. doi:10.1007/s11356-020-09614-2

Ana, M. I. (2017). Ecotourism, Agro-Tourism and Rural Tourism in the European Union. *Cactus Tour. J.* 15 (2), 6–14.

Astuti, N. N. S., Armoni, L. E., Ginaya, G., and Bagiastuti, N. K. (2019). Integrating Agro-Tourism and Trekking for Accelerated Yielding of Pelaga Rural Tourism Development. *nature* 30, 33. doi:10.2991/icastss-19.2019.14

Budiasa, I. W., and Ambarawati, I. G. A. A. (2014). Community Based Agro-Tourism as an Innovative Integrated Farming System Development Model towards Sustainable Agriculture and Tourism in Bali. *J. Int. Soc. Southeast Asian Agric. Sci.* 20 (1), 29–40.

Cao, J., Law, S. H., Samad, A. R. B. A., Mohamad, W. N. B. W., Wang, J., and Yang, X. (2021). Impact of Financial Development and Technological Innovation on the Volatility of Green Growth-Evidence from China. *Environ. Sci. Pollut. Res.* 28 (35), 48053–48069. doi:10.1007/s11356-021-13828-3

Cao, J., Law, S. H., Wu, D., Tang, X., and Yang, X. (2022). Effect of Digital Financial Inclusion on Dredging the Path of Green Growth-New Evidence from Front-End and Back-End Perspectives. *Front. Environ. Sci.* 10, 865229. doi:10.3389/fenvs.2022.865229

Cecchini, L., Venanzi, S., Pierri, A., and Chiorri, M. (2018). Environmental Efficiency Analysis and Estimation of CO2 Abatement Costs in Dairy Cattle Farms in Umbria (Italy): A SBM-DEA Model with Undesirable Output. *J. Clean. Prod.* 197, 895–907. doi:10.1016/j.jclepro.2018.06.165

Chandio, A. A., Jiang, Y., Akram, W., Adeel, S., Irfan, M., and Jan, I. (2021). Addressing the Effect of Climate Change in the Framework of Financial and Technological Development on Cereal Production in Pakistan. *J. Clean. Prod.* 288, 125637. doi:10.1016/j.jclepro.2020.125637

Chemnasiri, N. (2012). Community Potential Development for Sustainable Agro-Tourism: a Case in Daoruang Sub-district, Saraburi Province, Thailand. *Revista de turism-studii si cercetari turism* 14, 28–33.

Coluccia, B., Valente, D., Fusco, G., De Leo, F., and Porrini, D. (2020). Assessing Agricultural Eco-Efficiency in Italian Regions. *Ecol. Indic.* 116, 106483. doi:10.1016/j.ecolind.2020.106483

Deng, X., and Gibson, J. (2019). Improving Eco-Efficiency for the Sustainable Agricultural Production: A Case Study in Shandong, China. *Technol. Forecast. Soc. Change* 144, 394–400. doi:10.1016/j.techfore.2018.01.027

Dernoi, L. A. (1983). Farm Tourism in Europe. *Tour. Manag.* 4 (3), 155–166. doi:10.1016/0261-5177(83)90060-2

Fang, Z., Razzaq, A., Mohsin, M., and Irfan, M. (2022). Spatial Spillovers and Threshold Effects of Internet Development and Entrepreneurship on Green Innovation Efficiency in China. *Technol. Soc.* 68, 101844. doi:10.1016/j.techsoc.2021.101844

Fleischer, A., and Tchetchik, A. (2005). Does Rural Tourism Benefit from Agriculture? *Tour. Manag.* 26 (4), 493–501. doi:10.1016/j.tourman.2003.10.003

Ghadami, M., Dittmann, A., Pazhuhan, M., and Aligholizadeh Firouzjaie, N. (2022). Factors Affecting the Change of Agricultural Land Use to Tourism: A Case Study on the Southern Coasts of the Caspian Sea, Iran. *Agriculture* 12 (1), 90. doi:10.3390/agriculture12010090

Goreta Ban, S. (2021). Sustainable Development of Agriculture and Tourism in the Context of Climate Change. *Agric. Conspec. Sci.* 86 (3), 0.

Gruia, R., Gaceu, L., and Oprea, O. B. (2021). Post-pandemic Development Renewal of Romanian Agro-Tourism. *J. EcoAgriTourism* 17, 60–65.

Guthman, J. (2000). Raising Organic: An Agro-Ecological Assessment of Grower Practices in California. *Agric. Hum. values* 17 (3), 257–266. doi:10.1023/a:1007688216321

Han, H., Ding, T., Nie, L., and Hao, Z. (2020). Agricultural Eco-Efficiency Loss under Technology Heterogeneity Given Regional Differences in China. *J. Clean. Prod.* 250, 119511. doi:10.1016/j.jclepro.2019.119511

Hao, Y., Gai, Z., and Wu, H. (2020). How Do Resource Misallocation and Government Corruption Affect Green Total Factor Energy Efficiency? Evidence from China. *Energy Policy* 143, 111562. doi:10.1016/j.enpol.2020.111562

Hao, Y., Gai, Z., Yan, G., Wu, H., and Irfan, M. (2021). The Spatial Spillover Effect and Nonlinear Relationship Analysis between Environmental Decentralization, Government Corruption and Air Pollution: Evidence from China. *Sci. Total Environ.* 763, 144183. doi:10.1016/j.scitotenv.2020.144183

Hao, Y., Guo, Y., and Wu, H. (2022). The Role of Information and Communication Technology on Green Total Factor Energy Efficiency: Does Environmental Regulation Work? *Bus. Strat. Env.* 31 (1), 403–424. doi:10.1002/bse.2901

Hernández-Mogollón, J. M., Campón-Cerro, A. M., Leco-Berrocal, F., and Pérez-Díaz, A. (2011). Agricultural Diversification and the Sustainability of Agricultural Systems: Possibilities for the Development of Agrotourism. *Environ. Eng. Manag. J.* 10 (12), 1911–1921. doi:10.30638/eemj.2011.255

Hysa, E., and Kruja, A. D. (2022). "Advances of Sharing Economy in Agriculture and Tourism Sectors of Albania," in *The Sharing Economy in Europe* (Cham: Palgrave Macmillan), 365–383. doi:10.1007/978-3-030-86897-0_17

Iqbal, W., Tang, Y. M., Chau, K. Y., Irfan, M., and Mohsin, M. (2021). Nexus between Air Pollution and NCOV-2019 in China: Application of Negative Binomial Regression Analysis. *Process Saf. Environ. Prot.* 150, 557–565. doi:10.1016/j.psep.2021.04.039

Irfan, M., and Ahmad, M. (2022). Modeling Consumers' Information Acquisition and 5G Technology Utilization: Is Personality Relevant? *Personality Individ. Differ.* 188, 111450. doi:10.1016/j.paid.2021.111450

Irfan, M., Elavarasan, R. M., Hao, Y., Feng, M., and Sailan, D. (2021). An Assessment of Consumers' Willingness to Utilize Solar Energy in China: End-Users' Perspective. *J. Clean. Prod.* 292, 126008. doi:10.1016/j.jclepro.2021.126008

Jani, D., and Nguni, W. (2021). "Contextual Differences in Tourism-Agriculture Linkages in Selected Regions of Tanzania," in *Sustainable Tourism Development in Tanzania* (Cambridge Scholars Publisher).

Ji, T. G., Raza, A., Akbar, U., Ahmed, M., Popp, J., and Oláh, J. (2021). Marginal Trade-Offs for Improved Agro-Ecological Efficiency Using Data Envelopment Analysis. *Agronomy* 11 (2), 365. doi:10.3390/agronomy11020365

Jinru, L., Changbiao, Z., Ahmad, B., Irfan, M., and Nazir, R. (2021). How Do Green Financing and Green Logistics Affect the Circular Economy in the Pandemic Situation: Key Mediating Role of Sustainable Production. *Econ. Research-Ekonomska Istraživanja* 1, 21. doi:10.1080/1331677x.2021.2004437

Khan, I., Hou, F., Irfan, M., Zakari, A., and Le, H. P. (2021). Does Energy Trilemma a Driver of Economic Growth? the Roles of Energy Use, Population Growth, and Financial Development. *Renew. Sustain. Energy Rev.* 146, 111157. doi:10.1016/j.rser.2021.111157

Koutsouris, A., Gidarakou, I., Grava, F., and Michailidis, A. (2014). The Phantom of (Agri)tourism and Agriculture Symbiosis? A Greek Case Study. *Tour. Manag. Perspect.* 12, 94–103. doi:10.1016/j.tmp.2014.09.001

Lane, B., and Kastenholz, E. (2015). Rural Tourism: the Evolution of Practice and Research Approaches–Towards a New Generation Concept? *J. Sustain. Tour.* 23 (8-9), 1133–1156. doi:10.1080/09669582.2015.1083997

Lauwers, L. (2009). Justifying the Incorporation of the Materials Balance Principle into Frontier-Based Eco-Efficiency Models. *Ecol. Econ.* 68 (6), 1605–1614. doi:10.1016/j.ecolecon.2008.08.022

Li, H., and Shi, J.-f. (2014). Energy Efficiency Analysis on Chinese Industrial Sectors: an Improved Super-SBM Model with Undesirable Outputs. *J. Clean. Prod.* 65, 97–107. doi:10.1016/j.jclepro.2013.09.035

Li, Y., Zhang, J., Yang, X., Wang, W., Wu, H., Ran, Q., et al. (2021). The Impact of Innovative City Construction on Ecological Efficiency: a Quasi-Natural Experiment from China. *Sustain. Prod. Consum.* 28, 1724–1735. doi:10.1016/j.spc.2021.09.012

Liao, J., Yu, C., Feng, Z., Zhao, H., Wu, K., and Ma, X. (2021). Spatial Differentiation Characteristics and Driving Factors of Agricultural Eco-Efficiency in Chinese Provinces from the Perspective of Ecosystem Services. *J. Clean. Prod.* 288, 125466. doi:10.1016/j.jclepro.2020.125466

Lifang, W. A. N. G. (2018). The Dynamic Mechanism and Development Path for Integration of Agriculture and Tourism in Shanxi Province. *Agricult. Technol. Econ.* 04, 136–144. (in Chinese). doi:10.13246/j.cnki.jae.2018.04.012

Liu, L., Yang, X., Meng, Y., Ran, Q., and Liu, Z. (2021). Does the Construction of National Eco-Industrial Demonstration Parks Improve Green Total Factor Productivity? Evidence from Prefecture-Level Cities in China. *Sustainability* 14 (1), 26. doi:10.3390/su14010026

Liu, Y., and Cheng, X. (2022). Does Agro-Ecological Efficiency Contribute to Poverty Alleviation? an Empirical Study Based on Panel Data Regression. *Environ. Sci. Pollut. Res.* 1, 17. doi:10.1007/s11356-022-19408-3

Liu, Y., Zou, L., and Wang, Y. (2020). Spatial-temporal Characteristics and Influencing Factors of Agricultural Eco-Efficiency in China in Recent 40 Years. *Land Use Policy* 97, 104794. doi:10.1016/j.landusepol.2020.104794

Ma, J., and Li, Z. (2021). Does Digital Financial Inclusion Affect Agricultural Eco-Efficiency? A Case Study on China. *Agronomy* 11 (10), 1949. doi:10.3390/agronomy11101949

Meng, T. (2019). Study on Motivation Mechanism and Countermeasures of Integration of Agriculture and Tourism Industry Based on Value Chain. *Jiangsu Agric. Sci.* 47 (6), 320–324. doi:10.15889/j.issn.1002-1302.2019.06.067

Moradi, M., Nematollahi, M. A., Mousavi Khaneghah, A., Pishgar-Komleh, S. H., and Rajabi, M. R. (2018). Comparison of Energy Consumption of Wheat Production in Conservation and Conventional Agriculture Using DEA. *Environ. Sci. Pollut. Res.* 25 (35), 35200–35209. doi:10.1007/s11356-018-3424-x

Nie, S. (2021). Influence of Rural Infrastructure Construction on Agricultural Total Factor Productivity. *Agric. For. Econ. Manag.* 4 (1), 65–68. doi:10.23977/agrfem.2021.040112

Pan, S.-Y., Gao, M., Kim, H., Shah, K. J., Pei, S.-L., and Chiang, P.-C. (2018). Advances and Challenges in Sustainable Tourism toward a Green Economy. *Sci. Total Environ.* 635, 452–469. doi:10.1016/j.scitotenv.2018.04.134

Pang, J., Chen, X., Zhang, Z., and Li, H. (2016). Measuring Eco-Efficiency of Agriculture in China. *Sustainability* 8 (4), 398. doi:10.3390/su8040398

Park, P.-J., Tahara, K., and Inaba, A. (2007). Product Quality-Based Eco-Efficiency Applied to Digital Cameras. *J. Environ. Manag.* 83 (2), 158–170. doi:10.1016/j.jenvman.2006.02.006

Picazo-Tadeo, A. J., Gómez-Limón, J. A., and Reig-Martínez, E. (2011). Assessing Farming Eco-Efficiency: a Data Envelopment Analysis Approach. *J. Environ. Manag.* 92 (4), 1154–1164. doi:10.1016/j.jenvman.2010.11.025

Qiu, P., Zhou, Z., and Kim, D.-J. (2021). A New Path of Sustainable Development in Traditional Agricultural Areas from the Perspective of Open Innovation-A Coupling and Coordination Study on the Agricultural Industry and the Tourism Industry. *JOItmC* 7 (1), 16. doi:10.3390/joitmc7010016

Rajović, G., and Bulatović, J. (2015). Possibilities and Limitations Valorization of Mountain Katuns through Sustainable Development of Agro Tourism: Case of the Municipality Andrijevica. *Sochi J. Econ.* 4, 45–64.

Rauf, A., Ozturk, I., Ahmad, F., Shehzad, K., Chandiao, A. A., Irfan, M., et al. (2021). Do Tourism Development, Energy Consumption and Transportation Demolish Sustainable Environments? Evidence from Chinese Provinces. *Sustainability* 13 (22), 12361. doi:10.3390/su132212361

Ren, S., Hao, Y., and Wu, H. (2022b). How Does Green Investment Affect Environmental Pollution? Evidence from China. *Environ. Resour. Econ.* 81 (1), 25–51. doi:10.1007/s10640-021-00615-4

Ren, S., Hao, Y., and Wu, H. (2022a). The Role of Outward Foreign Direct Investment (OFDI) on Green Total Factor Energy Efficiency: Does Institutional Quality Matters? Evidence from China. *Resour. Policy* 76, 102587. doi:10.1016/j.resourpol.2022.102587

Ren, S., Hao, Y., Xu, L., Wu, H., and Ba, N. (2021). Digitalization and Energy: How Does Internet Development Affect China's Energy Consumption? *Energy Econ.* 98, 105220. doi:10.1016/j.eneco.2021.105220

Salihoglu, G., and Gezici, F. (2021). "Linkages between Tourism and Agriculture: The Case of Turkey," in *Regional Science Perspectives on Tourism and Hospitality* (Cham: Springer), 293–314.

Schaltegger, S., Sturm, A., and Kim, D.-J. (1990). Ŭkologische rationalitĘt: ansatzpunkte zur ausgestaltung von □kologieorientierten managementinstrumenten. die Unternehmung, 273–290. http://www.jstor.org/stable/24180467.

Shao, L., Zhang, H., and Irfan, M. (2021). How Public Expenditure in Recreational and Cultural Industry and Socioeconomic Status Caused Environmental Sustainability in OECD Countries? *Econ. Research-Ekonomska Istraživanja* 1, 18. doi:10.1080/1331677x.2021.2015614

Shi, R., Irfan, M., Liu, G., Yang, X., and Su, X. (2022). Analysis of the Impact of Livestock Structure on Carbon Emissions of Animal Husbandry: A Sustainable Way to Improving Public Health and Green Environment. *Front. Public Health* 145, 835210. doi:10.3389/fpubh.2022.835210

Su, X., Yang, X., Zhang, J., Yan, J., Zhao, J., Shen, J., et al. (2021). Analysis of the Impacts of Economic Growth Targets and Marketization on Energy Efficiency: Evidence from China. *Sustainability* 13 (8), 4393. doi:10.3390/su13084393

Tang, H., and Yin, C. (2006). "Models and Strategies for the Development of Circular Agriculture in China," in *Workshop on Environment, Resources, and Agricultural Policies in China*, 19–21. doi:10.1787/9789264028470-16-en

Tone, K. (2001). A Slacks-Based Measure of Efficiency in Data Envelopment Analysis. *Eur. J. operational Res.* 130 (3), 498–509. doi:10.1016/s0377-2217(99)00407-5

Torres, R. (2003). Linkages between Tourism and Agriculture in Mexico. *Ann. Tour. Res.* 30 (3), 546–566. doi:10.1016/s0160-7383(02)00103-2

Uduji, J. I., Okolo-Obasi, E. N., Onodugo, V. A., Nnabuko, J. O., and Adedibu, B. A. (2021). Corporate Social Responsibility and the Role of Rural Women in Strengthening Agriculture-Tourism Linkages in Nigeria's Oil Producing Communities. *J. Tour. Cult. Change* 19 (6), 754–780. doi:10.1080/14766825.2020.1826500

Van Caneghem, J., Block, C., Cramm, P., Mortier, R., and Vandecasteele, C. (2010). Improving Eco-Efficiency in the Steel Industry: the ArcelorMittal Gent Case. *J. Clean. Prod.* 18 (8), 807–814. doi:10.1016/j.jclepro.2009.12.016

Wang, G., Shi, R., Mi, L., and Hu, J. (2022b). Agricultural Eco-Efficiency: Challenges and Progress. *Sustainability* 14 (3), 1051. doi:10.3390/su14031051

Wang, J., and Zhou, I. (2021). The Effect of the Integrated Development of Agriculture and Tourism on Agricultural Ecological Efficiency. *J. Hunan Agric. Univ. Soc. Sci. Ed.* 2, 50–56. doi:10.13331/j.cnki.jhau.(ss).2021.02.007

Wang, J., Wang, W., Ran, Q., Irfan, M., Ren, S., Yang, X., et al. (2021a). Analysis of the Mechanism of the Impact of Internet Development on Green Economic Growth: Evidence from 269 Prefecture Cities in China. *Environ. Sci. Pollut. Res.* 29, 1–15. doi:10.1007/s11356-021-16381-1

Wang, J., Wang, W., Ran, Q., Irfan, M., Ren, S., Yang, X., et al. (2022a). Analysis of the Mechanism of the Impact of Internet Development on Green Economic Growth: Evidence from 269 Prefecture Cities in China. *Environ. Sci. Pollut. Res.* 29 (7), 9990–10004. doi:10.1007/s11356-021-16381-1

Wang, Z., Wang, J., Zhang, G., and Wang, Z. (2021b). Evaluation of Agricultural Extension Service for Sustainable Agricultural Development Using a Hybrid Entropy and TOPSIS Method. *Sustainability* 13 (1), 347. doi:10.3390/su13010347

Wu, H., Ba, N., Ren, S., Xu, L., Chai, J., Irfan, M., and Lu, Z. N. (2021a). The Impact of Internet Development on the Health of Chinese Residents: Transmission Mechanisms and Empirical Tests. *Socio-Economic Plan. Sci.* 81, 101178. doi:10.1016/j.seps.2021.101178

Wu, H., Hao, Y., and Ren, S. (2020). How Do Environmental Regulation and Environmental Decentralization Affect Green Total Factor Energy Efficiency: Evidence from China. *Energy Econ.* 91, 104880. doi:10.1016/j.eneco.2020.104880

Wu, H., Hao, Y., Ren, S., Yang, X., and Xie, G. (2021b). Does Internet Development Improve Green Total Factor Energy Efficiency? Evidence from China. *Energy Policy* 153, 112247. doi:10.1016/j.enpol.2021.112247

Xiao, H., Zheng, X., and Xie, L. (2022). Promoting Pro-poor Growth through Infrastructure Investment: Evidence from the Targeted Poverty Alleviation Program in China. *China Econ. Rev.* 71, 101729. doi:10.1016/j.chieco.2021.101729

Yang, K., and Wang, C. (2021). Analysis of Integration Degree of Agriculture and Tourism Based on AHP- Fuzzy Comprehensive Evaluation Method-- Taking Enshi Gongshui White Pomelo Industry as an Example. *Agric. Resour. Region. China* 1, 220–230. (in Chinese).

Yang, X., Su, X., Ran, Q., Ren, S., Chen, B., Wang, W., et al. (2022). Assessing the Impact of Energy Internet and Energy Misallocation on Carbon Emissions: New Insights from China. *Environ. Sci. Pollut. Res.* 29 (16), 23436–23460. doi:10.1007/s11356-021-17217-8

Yang, X., Wang, J., Cao, J., Ren, S., Ran, Q., and Wu, H. (2021b). The Spatial Spillover Effect of Urban Sprawl and Fiscal Decentralization on Air Pollution: Evidence from 269 Cities in China. *Empir. Econ.* 1, 29. doi:10.1007/s00181-021-02151-y

Yang, X., Wang, W., Wu, H., Wang, J., Ran, Q., and Ren, S. (2021a). The Impact of the New Energy Demonstration City Policy on the Green Total Factor Productivity of Resource-Based Cities: Empirical Evidence from a Quasi-Natural Experiment in China. *J. Environ. Plan. Manag.* 1, 34. doi:10.1080/09640568.2021.1988529

Yi, Y., Zhao, C., and Fu, J. (2019). Research on the Integration and Development of Modern Agriculture and Rural Tourism Based on AHP—Take Yangjia Town in Mianyang City as an Example. *Open J. Soc. Sci.* 7 (7), 76–87. doi:10.4236/jss.2019.77008

Yu, C. (2011). China's Water Crisis Needs More Than Words. *Nature* 470 (7334), 307. doi:10.1038/470307a

Zhao, J., Luo, Q., Deng, H., and Yan, Y. (2008). Opportunities and Challenges of Sustainable Agricultural Development in China. *Phil. Trans. R. Soc. B* 363 (1492), 893–904. doi:10.1098/rstb.2007.2190

Zhao, J., Shen, J., Yan, J., Yang, X., Hao, Y., and Ran, Q. (2021). Corruption, Market Segmentation and Haze Pollution: Empirical Evidence from China. *J. Environ. Plan. Manag.* 1, 23. doi:10.1080/09640568.2021.2001316

Zhou, P., Shen, Y., and Li, A. (2021). Can the Integration of Agriculture and Tourism Promote the High-Quality Development of Agriculture?-- an Empirical Test Based on Provincial Panel Data. *Macroecon. Res.* 10, 117–130. doi:10.16304/j.cnki.11-3952/f.2021.10.008

Zhou, Z., Yang, Q., and Kim, D.-J. (2020). An Empirical Study on Coupling Coordination between the Cultural Industry and Tourism Industry in Ethnic Minority Areas. *JOItmC* 6 (3), 65. doi:10.3390/joitmc6030065

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