

Psychological Cognition and Environmental Regulation Impacts on Pollution Prevention and Control Behavior of Large-Scale Pig Farmers: Postprint

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Abstract

Clarifying the behavioral logic of pollution prevention and control among large-scale pig farmers at the micro level plays an important driving role in optimizing livestock and poultry breeding pollution governance at the macro level. To analyze the influencing factors of farmers' harmless treatment and resource utilization behaviors, this study takes 406 large-scale pig farmers in Fujian Province as research subjects, employs a structural equation model to analyze the impact of farmers' psychological cognition on their pollution prevention and control behaviors, and tests the moderating effect of environmental regulation on the psychological cognition-prevention behavior relationship through a hierarchical analysis model. The results indicate: 1) The pollution prevention and control behavior of large-scale pig farmers constitutes a rational choice formed under the significant positive influence of psychological cognition and the comprehensive moderation of environmental regulations; 2) Farmers' decision-making regarding pollution prevention and control behavior originates from their cognition of sense of responsibility, ecological rationality, self-assessment of pollution control capabilities, etc., represents a reference to other farmers and a positive response to the environmental demands of the government and non-farming stakeholders, and is also a rational choice for risk aversion. 3) Incentive and guiding measures serve as important supplements to mandatory environmental regulations, with mandatory regulatory measures exerting a more significant moderating effect on harmless treatment behavior, incentive regulations having a greater moderating effect on resource utilization behavior, and guiding regulations producing a comprehensive moderating effect on pollution prevention and control behavior. 4) Accordingly, this paper proposes strengthening the application of market-based incentive regulations and informal institutional means such as village regulations and agreements, fully considering farmers' dependence on pig farming and

their behavioral control ability in pollution prevention and control, and concurrently employing guidance for abandonment, industrial transfer support, and warning and punishment measures to promote pollution prevention and control in large-scale pig farming.

Full Text

Preamble

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Abstract: Clarifying the behavioral logic of pollution prevention and control among family-scale pig farmers at the micro level plays a crucial driving role in optimizing livestock pollution governance at the macro level. This study divides pig farmers' pollution prevention and control behaviors into two categories: harmless treatment and resource utilization behaviors. Using a sample of 406 pig-rearing households in Fujian Province, China, we conducted an empirical analysis of how farmers' psychological cognition influences pollution prevention and control behaviors through Structural Equation Modeling (SEM). The moderating effect of environmental regulation on the relationship between psychological cognition and pollution control behavior was examined using a Multi-Level Regression Model. Results indicate that farmers' pollution prevention and control behaviors are positively impacted by individual psychological cognition, with environmental regulations serving as a significant moderator. Farmers' decisions regarding pollution prevention and control behaviors stem from cognitions of responsibility, ecological rationality, and self-assessment of their pollution control capabilities. These decisions are also influenced by reference behaviors of other farmers, government regulations, and non-farmer groups, representing a rational choice to avoid risks. Incentive and guidance measures work in tandem with restrictive environmental regulation, where restrictive regulatory measures have a more significant effect on harmless treatment behaviors, incentive regulation has a more important effect on resource utilization behavior, and guidance regulation has significant regulatory effects on both harmless treatment and resource utilization behaviors. To promote pollution prevention and control in family-scale pig farming, this paper recommends strengthening the application of market incentive regulation and village social capital to regulate farmers' pollution prevention behaviors. Pollution control policies should fully consider farmers' dependence on pig rearing and their behavioral control ca-

pabilities. Additionally, guiding farmers to reasonably exit pig farming through strengthened industry transfer support and warning-punishment measures is advised.

Keywords: Psychological cognition; Environmental regulation; Family-oriented pig breeding; Pollution prevention and control behavior; Structural equation modeling

Livestock and poultry breeding pollution has become a critical challenge that urgently needs to be addressed for rural and agricultural development in China. Pig manure discharge constitutes one of the primary pollution sources in livestock breeding [1]. Family-scale pig farming, which relies mainly on family members as labor, represents one of the dominant models in China's pig industry. On one hand, the dispersed, public, and concealed characteristics of family-scale pig farming pollution significantly weaken the effectiveness of ex-post regulatory measures and policies [2]. On the other hand, existing policies and regulations for livestock pollution prevention and control typically apply only to intensive large-scale farms and breeding complexes, leaving family-scale pig farmers in a regulatory vacuum. Consequently, pollution from family-scale pig farming has become a major bottleneck constraining rural sustainable development. Pollution prevention and control at the source has emerged as the primary policy option [3]. Pig farmers face multiple interests and complex roles—they are both polluters, implementers of governance policies, and victims of non-point source pollution. Guiding them to voluntarily engage in pollution prevention and control has become a pressing practical issue.

In recent years, examining livestock pollution governance from the perspective of micro-level actors has become a distinctive feature of research in rural sustainable development. Researchers have focused on describing breeding entities' pollution prevention behaviors and exploring their influencing factors. Pollution prevention behaviors have been characterized as ecological behavior [4], environmental behavior [2,5], low-carbon breeding behavior [6], or specific manure treatment method choices [7]. However, pollution prevention and control in breeding is actually a multi-dimensional composite behavior that requires systematic and comprehensive characterization combining source control and end-of-pipe treatment. Summarizing existing research on influencing factors of breeding pollution prevention behavior: First, breeding entities' ecological cognition [4], environmental and health impact cognition [2,5], pollution perception [8], risk perception [2,9], and subjective norms [10] significantly influence various dimensions of pollution prevention behavior, with diverse theoretical connections and varying empirical results between different psychological cognitions and prevention behaviors. That is, no consistent conclusions have been reached regarding the direction and magnitude of influence of different psychological cognitions on farmers' pollution prevention behavior, and most literature lacks theoretical grounding when selecting and analyzing the effects of psychological cognition on breeding pollution prevention behavior, focusing instead on presenting data patterns. Second, existing studies show that environmental regulations

such as green subsidies, pollution discharge fees, and technology promotion and guidance can promote breeding entities' adoption of pollution prevention behaviors [11-13]. However, while confirming the significant positive effects of environmental regulation, questions remain about its specific role in the formation process of breeding entities' pollution prevention behavior. A closer examination reveals that breeding entities' psychological cognition and their environmental regulation context do not independently and parallelly influence their pollution prevention behavior; rather, there exists a certain interactive effect [1,5-7]. Therefore, this paper comprehensively characterizes pig farmers' pollution prevention and control behaviors based on the principle of combining source control and end-of-pipe treatment, seeking theoretical foundations to meticulously explore the influence mechanisms of psychological cognition, and revealing the moderating effect of environmental regulation on the relationship between farmers' psychological cognition and prevention behavior, thereby clarifying the behavioral patterns of breeding entities and opening new research pathways for improving livestock pollution governance.

1.1 Theoretical Framework

The Theory of Planned Behavior (TPB) is a widely applied cognitive-behavioral relationship theory in management and sociology that elucidates a complete framework for how cognition influences behavior, predicting and explaining actors' behaviors by weighing potential determinants [14]. According to TPB, farmers' pollution prevention and control behavior is determined by their behavioral intention, which is jointly determined by three factors: attitude toward the behavior, subjective norms, and perceived behavioral control. Accurate perceived behavioral control can partially substitute for actual control conditions and directly predict the likelihood of behavior occurrence. Additionally, risk perception is an important source directly shaping breeding pollution prevention behavior [15], with environmental risk perception significantly influencing environmental behavioral intention choices [2] and potentially directly predicting environmental behavior [10-11]. Therefore, this study incorporates environmental risk perception into the TPB theoretical model to comprehensively analyze the influence effects of psychological cognition on scale pig farmers' pollution prevention and control behavior. Livestock pollution problems mainly manifest in externalities and public environmental property rights. From the perspective of rational smallholders, farmers often lack environmental willingness in the absence of external monitoring. Environmental regulation serves as a supplement to the externalities of breeding pollution, unclear property rights, and farmers' lack of environmental motivation, representing an important facilitating factor for implementing pollution prevention and control behaviors [16]. Based on the nature of regulatory measures, environmental regulations can be categorized into three types: guidance, incentive, and binding [6,9,12]. In summary, farmers' pollution prevention and control behavior results from the combined effects of psychological cognition and environmental regulation. When pollution prevention and control behaviors are difficult to implement, farmers' reliance on psy-

chological variables weakens [17] while the influence of environmental regulation on prevention and control behavior strengthens [5,18]. Psychological cognition and environmental regulation are not parallel and independent influencing factors; theoretically, environmental regulation has a significant moderating effect on the relationship between farmers' psychological cognition and their pollution prevention and control behavior. Therefore, this study constructs a hypothetical model of the influence effects of psychological cognition and environmental regulation on scale pig farmers' pollution prevention and control behavior, as shown in [Figure 1: see original paper].

1.2.1 Data Sources and Sample Characteristics

The data used in this study were obtained from a sample survey conducted by the research team in Nanping, Longyan, and Sanming regions of Fujian Province from April to October 2016. Based on the relative concentration of pig breeding, five counties (cities, districts) were selected: Yanping, Shaowu, Xinluo, Shanghang, and Youxi. Farmer samples were selected using a combination of stratified hierarchical sampling and random sampling. Using the average breeding scale of each county (city, district) as the division criterion, 3-4 towns with scales above and below the average were randomly selected. Based on breeding density, 3-6 administrative villages with high, medium, and low densities were randomly and relatively selected. Then, 6-7 pig farmers were randomly and relatively selected from each village based on breeding scale for questionnaire surveys and interviews. A "one-on-one, face-to-face" interview method was adopted, with investigators filling out the questionnaires. A total of 451 questionnaires were distributed, with 406 valid questionnaires recovered, yielding an effective rate of 90.0%. The individual characteristics and breeding conditions of sample farmers are shown in . Statistics show that the sample is predominantly male, with ages concentrated between 41-60 years (69.71% of the total sample). Education levels are mainly junior high school and high school (56.65% of the total sample). Village cadres account for 14.75% of sample farmers. In terms of breeding characteristics, breeding scale is mainly concentrated at 100-500 heads, breeding years are mainly distributed between 10-20 years, and the average net family breeding income in 2015 was 193,300 RMB.

1.2.2 Variable Description and Descriptive Statistics

Following the principle of combining source control and end-of-pipe treatment, this study divides pig breeding pollution prevention and control behavior into harmless treatment and resource utilization based on expert opinions and interview results. According to interviews, dry manure removal before cleaning pig houses can effectively reduce pollutants. The pollutant reduction capacity of biogas digesters for livestock manure is mainly determined by the ratio of breeding volume to biogas digester capacity—pollutants can be ideally reduced only if biogas system facilities are constructed according to breeding scale (the optimal ratio is 1:7 to 1:8). Additionally, aerobic treatment technology is the

main measure for further reducing pollutants after anaerobic biogas processes. Therefore, harmless treatment behavior includes “adopting dry manure removal breeding methods,” “having biogas system facilities adapted to breeding scale,” and “whether pig urine and sewage undergo aerobic treatment.” Specifically, “adopting dry manure removal methods” is assigned values based on dry manure removal proportion (below 40%=1, 40%-50%=2, 50%-60%=3, 60%-70%=4, above 70%=5). “Biogas facility construction” is assigned values based on the ratio of biogas facilities to breeding scale (less than 1/10=1, 1/10-1/8=2, 1/8-1/7=3, 1/7-1/5=4, above 1/5=5). “Aerobic treatment behavior” is assigned values based on facility quantity and usage frequency (no facility or frequency below 30%=1, 30%-50%=2, 50%-60%=3, 60%-70%=4, above 70%=5). Resource utilization behavior includes three categories: fertilizer utilization, feed utilization, and energy utilization of breeding waste. To minimize subjective interference, measurements of farmers’ pollution prevention and control behaviors, psychological cognition, and environmental regulation variables were based on behavioral facts and employed the widely applied Likert five-point scale in management and psychology. Accordingly, the variable descriptions and statistical descriptions of sample farmers’ pollution prevention and control behaviors, psychological cognition, and environmental regulation are shown in .

1.2.3 Selection of Research Methods

Behavioral attitude, subjective norms, and perceived behavioral control belong to subjective cognition, which has the basic characteristics of being difficult to directly measure and having unavoidable subjective measurement errors. Structural Equation Modeling (SEM) is a measurement research technique that integrates measurement and analysis, providing an analytical tool that can observe and process latent variables that are difficult to directly observe while also estimating measurement errors in the variable measurement process [19]. Therefore, this study uses SEM to analyze the influence effects of psychological cognition on pig farmers’ pollution prevention and control behavior. Additionally, by calculating arithmetic mean values of farmers’ prevention and control behavior and intention, interaction terms between the comprehensive prevention intention score and various environmental regulation variables were constructed to test the moderating effect of environmental regulation on the relationship between farmers’ prevention intention and behavior using hierarchical regression models. To minimize potential multicollinearity problems, the “centering” method was used to process the interaction terms. The multicollinearity test results after processing showed that the maximum and average variance inflation factor values were both less than 10, indicating no multicollinearity among independent variables.

2.1 Reliability and Validity Tests of Farmers' Pollution Prevention Behavior and Psychological Cognition Variables

To ensure the credibility and validity of research conclusions, this study conducted reliability and validity tests on the scales, with results shown in . It should be noted that when conducting the corrected item-total correlation coefficient (CITC) and internal consistency coefficient tests, the observation variable RUB1 for resource utilization behavior and ATT4 for behavioral attitude were deleted according to the evaluation criterion that CITC should be less than 0.4. Reliability of sample data was tested through Cronbach's α values and composite reliability. The overall questionnaire Cronbach's α value was 0.845, with Cronbach's α values for prevention behavior, prevention intention, behavioral attitude, subjective norms, perceived behavioral control, and environmental risk perception ranging between 0.531-0.895, indicating good consistency among measurement indicators. Meanwhile, composite reliability values for each latent variable ranged between 0.695-0.890, exceeding the evaluation standard of 0.6. Except for the perceived behavioral control variable, all latent variables' extracted variance values were above the evaluation standard of 0.5, indicating good model reliability. Furthermore, factor analysis was conducted on sample data using SPSS 17.0, yielding a KMO value of 0.641 and a variance contribution rate of 71.667%. Overall, the model data are suitable for factor analysis, demonstrating strong construct validity [19].

2.2 Structural Equation Model Fit Test

The overall model fit test indices of the structural equation model show that the initial chi-square value was 425.2, with root mean square residual, goodness-of-fit, normed fit, relative fit, and Akaike information criterion indices not meeting evaluation standards. According to model path coefficients and modification indices, the model was revised by adding residual correlations between variables in descending order of modification indices, specifically between behavioral attitude and subjective norms, behavioral attitude and environmental risk perception, and between the harmless treatment latent variable and waste fertilizer utilization. After revision, the model's chi-square value significantly decreased (352.1). Except for root mean square residual and relative fit indices approaching evaluation standards, other fit indices met evaluation standards, indicating improved overall model fit. The regression results and path diagram obtained from the structural equation model are shown in and [Figure 2: see original paper].

2.3.1 Influence Effects of Behavioral Attitude on Prevention Intention and Behavior

As shown in , the influence path of behavioral attitude on farmers' pollution prevention intention passed significance tests. Furthermore, shows that the indirect effects of behavioral attitude on harmless treatment and resource utilization be-

aviors were 0.063 and 0.069, respectively, indicating that behavioral attitude has a significant positive influence on pollution prevention and control behavior. Additionally, observing the average path coefficients of ecological rationality and responsibility consciousness measurement variables on behavioral attitude (0.63 and 0.71, respectively, as shown in [Figure 2: see original paper]) reveals that responsibility consciousness has a stronger effect on farmers' pollution prevention intention and behavior than ecological rationality, largely benefiting from the "polluter pays" publicity and guidance policies implemented in the study area in recent years.

2.3.2 Influence Effects of Subjective Norms on Prevention Intention and Behavior

As shown in and , farmers' subjective norms have significant positive effects on their prevention intention and behavior, with indirect effects on harmless treatment and resource utilization behaviors of 0.142 and 0.156, respectively. Meanwhile, [Figure 2: see original paper] shows that among the observed variables of subjective norms, the explanatory power ranks from high to low as reference effect, policy pressure, and neighborhood pressure, all with explanatory power above 0.79. This indicates that farmers' pollution prevention and control behavior is not merely a rational choice based on cost-benefit evaluation but also a positive response to reference behaviors of similar actors and corresponding demands from other stakeholders, possessing attributes of altruism and collective action to some extent. As the government strengthens the demarcation and enforcement of no-construction and no-breeding zones, farmers become increasingly aware of corresponding breeding restriction policies, strengthening their perceived policy pressure. Moreover, as rural residents' environmental and health awareness increases, their sensitivity to environmental pollution in daily life also rises, forming specific group norms that become important constraints for farmers to adopt pollution prevention and control behaviors.

2.3.3 Influence Effects of Perceived Behavioral Control on Prevention Intention and Behavior

As shown in , the influence path of perceived behavioral control on farmers' resource utilization behavior did not pass significance tests, but it has significant positive effects on prevention intention and harmless treatment behavior, with total effects on prevention intention and harmless treatment behavior of 0.268 and 0.291, respectively (as shown in). Further examining the total effects in reveals that besides significantly influencing prevention and control behavior through the mediating effect of prevention intention, perceived behavioral control also directly and significantly influences prevention and control behavior, with direct and indirect effects of 0.157 and 0.134, respectively, indicating that the indirect effect through pollution prevention intention accounts for nearly half of the total effect, demonstrating good mediating effects. Turning to [Figure 2: see original paper], the three observed variables of perceived behavioral con-

trol—financial ability, technical skills, and self-efficacy—have explanatory powers of 0.757, 0.665, and 0.647, respectively, indicating that financial ability is the most important consideration for farmers when implementing pollution prevention and control behaviors. The non-significant influence of perceived behavioral control on resource utilization behavior may be because resource utilization behavior has lower requirements for economic and knowledge conditions and is less constrained by behavioral costs and conditions.

2.3.4 Influence Effects of Environmental Risk Perception on Prevention Intention and Behavior

As shown in , farmers' environmental risk perception has significant positive effects on their pollution prevention intention, harmless treatment behavior, and resource utilization behavior. further shows corresponding total effects of 0.307, 0.606, and 0.456, respectively, with risk perception' s effect on prevention intention being lower than on prevention behavior, indicating that farmers' self-perception of risk can largely directly explain the implementation of pollution prevention and control behavior, having significant direct effects. Meanwhile, decomposing the direct and indirect effects of risk perception on harmless treatment and resource utilization behaviors in shows that the indirect effects of this variable on both behaviors through prevention intention account for 62.7% and 68.4% of total effects, respectively, indicating good mediating effects of prevention intention. As shown in [Figure 2: see original paper], the explanatory coefficients of problem perception, loss perception, and policy perception observation variables on environmental risk perception are 0.715, 0.706, and 0.813, respectively, indicating that farmers' policy perception has the most significant effect on their pollution prevention and control behavior implementation, while loss risk perception has the smallest effect.

2.3.5 Influence Effects of Prevention Intention on the Psychological Cognition-Behavior Relationship

and jointly show that farmers' pollution prevention intention has significant positive effects on prevention and control behavior, with path coefficients of 0.501 and 0.549 on harmless treatment and resource utilization behaviors, respectively, and mediating effects between psychological cognition (behavioral attitude, subjective norms, perceived behavioral control, environmental risk perception) and prevention behavior. Meanwhile, as shown in [Figure 2: see original paper], among target intentions, the path coefficients for resource utilization and harmless treatment technology adoption intentions are 0.768 and 0.694, respectively, while among execution intentions, the path coefficients for time/effort investment, technology training participation, and capital investment intentions are 0.824, 0.828, and 0.815, respectively. This indicates that execution intention has greater explanatory power than target intention, possibly because farmers tend to view pollution prevention and control behavior as autonomous production and operation behavior, which to some extent contradicts the goal of reducing

public environmental pollution. In contrast, behavioral intention that treats pollution prevention and control as part of production and operation investment and participation has greater explanatory power for prevention behavior.

2.4 Model Testing and Results Analysis of Environmental Regulation Moderating Effects

As shown in , guidance environmental regulation has significant moderating effects on the relationship between prevention intention and behavior. First, publicity and education mainly promote farmers' pollution prevention and control behavior implementation by strengthening their responsibility consciousness and policy perception. Second, the effectiveness of government guidance for farmers to abandon breeding and change occupations has a significant negative moderating effect on the transformation of prevention intention. A possible explanation is that since farmers have been engaged in pig breeding for many years, they have developed strong dependence on the industry. Meanwhile, this group tends to have fixed mindsets with relatively weak cognition of the necessity of pollution control and their own responsibilities. Under circumstances where the effectiveness of government guidance for career change has not yet materialized, farmers are forced to adopt prevention and control behaviors due to survival and economic rationality, showing obvious inconsistency between intention and behavior.

As shown in , the theoretical assumptions about the moderating effects of incentive environmental regulation are largely confirmed. Specifically, the convenience of manure consumption and pollution prevention subsidies only have significant moderating effects on resource utilization behavior, while knowledge and technology promotion only have significant moderating effects on harmless treatment behavior. Convenient manure consumption and trading can not only bring certain economic benefits to farmers to compensate for pollution control costs but also solve site and secondary pollution problems from manure storage, prompting them to implement active resource utilization behaviors. Since the pollution prevention subsidies for pig farmers in the survey area mainly focus on household biogas digester construction subsidies, pollution control subsidies actually provide facility guarantees for energy utilization, thus only having moderating effects on resource utilization behavior. Furthermore, current grassroots animal husbandry department technology and knowledge promotion and guidance mainly focus on harmless treatment technologies and often carry certain compulsoriness in actual implementation, which may lead to inconsistencies between farmers' pollution prevention choices and harmless treatment behavior implementation, manifesting as significant moderating effects of knowledge and technology promotion.

According to the test results in , the theoretical assumptions about binding environmental regulation moderating effects are only partially supported. Specifically, village regulations and agreements have significant positive moderating effects on both pollution prevention behaviors, breeding quantity control only

has significant moderating effects on harmless treatment behavior, and the moderating effect of emission technology standards did not pass significance tests. First, village regulations and agreements are rooted in rural daily production, life, and unique customs [20], and this informal institution has strong binding force on farmers' pollution prevention and control behavior implementation. Second, breeding quantity control measures differentiate farmer groups who actively control pollution due to survival rationality and highlight the policy focus that treats harmless treatment as a prerequisite for breeding permission. Third, due to the concealed, random, and dispersed characteristics of family-scale pig farming pollution, the enforcement of emission technology standards not only requires high government regulatory intensity and means but also faces difficulties and high costs in supervision. Therefore, implementing supervision on a few key targets becomes an expedient choice for this regulatory measure, which weakens its moderating effect on farmers' pollution prevention and control behavior.

3 Conclusions and Policy Recommendations

Based on the above empirical research and model testing, the following conclusions are drawn:

- 1) Pig farmers' pollution prevention and control behavior is a comprehensive choice formed based on psychological cognition including behavioral attitude, subjective norms, perceived behavioral control, and environmental risk perception, under the moderating effects of government guidance, incentive, and binding environmental regulation policies.
- 2) Farmers' pollution prevention and control behavior decisions originate from cognition and judgment of responsibility consciousness, ecological rationality, and self-assessment of pollution control capabilities, representing reference to other farmers' behaviors and positive responses to perceived policy pressure and environmental demands from non-farmers, as well as rational choices to avoid breeding pollution environmental risks.
- 3) Formal binding measures that highly depend on government supervision have limitations, informal institutions are important means for effective breeding pollution regulation, and combined use of incentive regulation can increase the probability of implementing pollution prevention and control behavior.
- 4) Under circumstances of strong government regulation and favorable pig market conditions, farmers' pollution prevention and control behavior is often a reluctant choice under survival rationality, and the long-term sustainability of this behavioral decision still requires further guidance and internalization.

Accordingly, this paper offers the following policy implications:

- 1) To internalize breeding pollution prevention and control as farmers' autonomous behavior, both internal guidance and external incentive measures should be combined. Responsibility consciousness, subjective norm pressure, and risk perception should be enhanced through publicity, education, and public opinion means, while market measures such as subsidies and price protection should be strengthened to stimulate farmers' internal motivation.

- 2) The indispensability of informal institutions should be fully recognized, and the promotional effects of informal punitive supervision, value orientation, and transmission internalization functions on farmers' pollution prevention and control behavior should be emphasized and strengthened.
- 3) Given the important role of actual control conditions such as economy and technology in farmers' pollution prevention and control behavior, it is recommended to listen more to farmers' opinions when formulating pollution prevention subsidies and providing technical support, reaching reasonable and applicable ranges through consultation and dialogue channels to reduce their pollution prevention and control costs.
- 4) The moderating effects of breeding quantity control and career change regulation measures suggest that governments should scientifically and reasonably assess environmental carrying capacity while combining guidance and warning-punishment means, increasing industry transfer support, and reasonably controlling interference with farmers' livelihoods.

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