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Disentangling the heterogeneous effects of different support policies on livestock and poultry farmers' willingness to utilize manure resources: Evidence from central China

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China's livestock and poultry industries have undergone massive transformations, with far-reaching implications for resource consumption and environmental issues. Utilizing waste resources from livestock and poultry, which requires increased farmer participation, is critical for China to meet its goal of lowering carbon emissions while also advancing high-quality animal husbandry. To this end, this study develops a model based on stimulus-organism-response (SOR) theory to explore the impact of different policy instruments on farmers' willingness to utilize resources, as well as the mediating effect of farmers' perception and the moderating effect of farmers' attitude toward risk. Using OLS and Bootstrap estimation on survey data from 607 farmers from 11 counties in China's Hunan province, this study reaches the following main results. First, incentive policies have a significant positive effect on farmers' willingness to utilize resources. The service policy has the greatest positive impact among the various incentive policies considered, followed by the subsidy policy, while the impact of the propaganda policy is insignificant. Second, farmers' perceptions mediate the effect of incentive policies on their willingness to utilize resources. Finally, risk attitude negatively impacts farmers' willingness to utilize resources, indicating that the more conservative a farmer's risk preference, the greater the impact of farmers' perception on willingness to utilize resources, and *vice versa*. To achieve sustainable livestock production, policymakers should prioritize measures that can improve and strengthen regulatory control, encourage education and technology adoption related to resource utilization, and offer subsidies for manure treatment and utilization.

KEYWORDS

utilization of manure resources, support policies, farmers' perception, risk attitude, livestock and poultry manure

1 Introduction

China's livestock sector has undergone significant transformation in recent decades since the country's opening up, making it the world's largest producer and consumer of livestock products. Such transformations result from a variety of sources. Market-oriented rural reform began with a number of policies that changed the organizational structure of the agriculture sector and ended the government's monopoly on livestock production, allowing farmers to increase animal breeding and subsequently granting them access to agricultural markets (Huang, et al., 2016). Furthermore, increased *per capita* income and purchasing power of Chinese consumers, as well as the crucial role of livestock production in increasing rural household income and reducing rural-urban disparities, have significantly contributed to the rapid transformation of the Chinese livestock industry (Bluemling and Hu, 2011). In addition, China's WTO membership released a tremendous increase in demand for Chinese livestock products on international markets. As a consequence, China's animal husbandry output exceeded four trillion yuan in total in 2020, which is more than 39 times the output's value in 1978.

Despite the fact that China's intensive livestock sector has profound effects on domestic and global food provision, the sector's growth is accompanied by increased resource consumption and massive manure production, which has environmental and climate change implications (Bai et al., 2018; Vrieze et al., 2019). Livestock production systems consume a sizeable portion of the world's essential resources, including land and water (Herrero and Thornton, 2013), and are a significant driver of non-CO2 GHG emissions, ammonia in the atmosphere, and nitrogen and phosphorus in surface waters (Bouwman et al., 2013). The country is the largest producer of livestock manure globally, with a share of 18.22% in the global market in 2017 (FAO, 2019). According to the Ministry of Agriculture, China produced four billion tons of animal and poultry manure annually (Xu et al., 2020). A portion of this production was released untreated directly into the environment, which increased China's overall carbon emissions and added to rural non-point source pollution. Improper handled manure poses serious health risks (Huong et al., 2014), contributes to air and water pollution, and has a devastating effect on the environment (Vu et al., 2015).

Livestock farmers are responsible for properly managing manure from their own farm under China's current environmental regulation regime. Utilizing manure as a resource as opposed to a waste product can be advantageous for livestock farmers (Mathias, 2014) and its biogas potential is double that of current biogas production (Roubík et al., 2018). However, the externalities associated with recycling, as well as land, capital cost, and technological constraints, severely restrict farmers' ability to recycle manure (Dong et al., 2021). Because manure recycling resources are primarily used to control pollution from livestock and poultry farming, management agencies must take immediate action to prevent pollution caused by improper manure disposal (Li et al., 2020). Since 2014, China has implemented a number of policies to encourage manure recycling. The Chinese government has prioritized environmental improvement since the 18th National Congress of the CPC. Additionally, local governments and functional organizations at various levels have released a number of policies for the resource utilization of livestock and poultry waste (Gu and Du, 2020; Jiang et al., 2022), which have significantly contributed to enhancing the ecological environment and conserving resources.

Given China's market-oriented channels for resource utilization of livestock and poultry waste are still in the exploratory stage, and resource utilization policies have not yet fully recognized farmers' behavior-inducing role (Li et al., 2020). Farmers' willingness to respond and their response to waste resource utilization policies is unclear. While it is anticipated that China's demand for animal products will rise even further (Bai et al., 2018), this could have a significant negative impact on the environment and raise questions about the sustainability of global livestock production. In this light, increasing farmers' willingness to utilize livestock and poultry manure is a crucial issue for both government departments and academia in order to meet China's carbon goal and to develop its agriculture in a way that is both high-quality and environmentally friendly.

To this end, this study has three main objectives. First, it aims to evaluate the impact of different policies on farmers' willingness to utilize resources. Second, it determines how farmers' perception plays an intermediary role between the policy instruments and their willingness to utilize resources. Finally, it assesses the role of risk attitude in regulating the relationship between different policies and farmers' willingness to utilize resources.

The theory of externalities provides policymakers with a rationale for regulating livestock and poultry farming with environmental policies. There are two types of fundamental regulatory instruments: command-and-control and economic incentives (Li et al., 2020). The traditional approach to environmental protection is command-and-control (examples include technology-based and performance-based measures), in which regulators specify the steps that individual polluters must take, and are frequently accompanied by substantial fines for non-compliance (Yuan and Zhu, 2015; Cao et al., 2022). Incentive-based policies, which include taxes, subsidies, and permits, are utilized more frequently than traditional measures on a global scale because economic instruments offer a more adaptable and cost-effective form of regulation. China is currently using both instruments to control pollution from its livestock sector. Existing theoretical studies demonstrate that both of China's regulatory environmental instruments are capable of incentivizing farmer compliance with environmental regulations, but they also reveal policy flaws (Li et al., 2015; Lyu et al., 2020). For example, farmer lack of knowledge relevant to national policies and regulations impedes policy implementation (Yang, 2013).

Farmers' willingness is an important aspect of fecal management research. Many studies have demonstrated that willingness is a prerequisite and psychological precursor of farmer behavior (Gong, 2020). Scholars have argued that farmer's decisions are affected by factors internal and external to farm operations, and it is crucial to take into account both the farmers' willingness and ability to manage manure (Zhang and Jiang, 2016). Numerous empirical studies have been conducted to examine the factors affecting farmers' livestock manure management practices. These factors, among others, include individual traits such as cognitive status (Obubuafo et al., 2008; Afroz et al., 2009), family traits such as population scale and land size (Waithaka et al., 2009), business traits

such as breeding scale as well as organizational resources (Kassie et al., 2013), and policy conditions such as government supervision and subsidy (Xu et al., 2020). Other studies looked at how different environmental policies, such as incentive-based policies (Zhang and Jiang, 2016) and command-and-control regulations (Zhang et al., 2014), influenced farmers' manure management behavior (Li, 2019; Wang, 2020). In addition, numerous empirical attempts have been carried out to analyze the impact of farmer perception on farmers' willingness from the perspectives of environmental, risk, fairness, value and moral perceptions (Bin et al., 2017; Li, 2019; Qiao and Zhang, 2019).

Furthermore, earlier studies looked at a range of factors related to command-and-control regulations, including the degree of supervision provided by environmental protection departments (Zhang et al., 2014), the capacity of local governments to manage regulations (Bin et al., 2017), and whether or not a penalty was imposed for non-compliance (Xu et al., 2020). Scholars also investigated various aspects of incentive-based policies, including whether or not farmers received technical training (Pan and Kong, 2018), whether or not subsidies were offered (Yu et al., 2012), the magnitude of incentives (Zhang and Jiang, 2016), and whether or not they were covered by the environmental quality incentive programme (Zhang et al., 2020). However, with few exceptions[1], little empirical investigation has been conducted into the influence of government policies or regulations (policy regulation, subsidy policy, and village rules and regulations) on farmers' willingness to utilize policy-based resources to change their manure management practices (Li et al., 2015; Qiao and Zhang, 2019; Shu et al., 2019). What is more, previous research primarily analyzed this willingness as a regulatory variable whereas it is relatively rare to analyze the policy factors as the key independent variables. Previous studies did not consider mediation or moderating effects on farmers' willingness to utilize resources.

To this end, this study seeks to fill a gap in the existing literature by examining the internal relationship between incentive policies and farmers' willingness to utilize resources. It does so by employing stimulus-organism-response (SOR) theory as a unifying theoretical framework to develop a conceptual model that investigates the relationship between incentive policies and farmers' willingness to utilize resources. According to SOR theory, the primary external stimulus (S) for farmers' willingness to utilize manure resources (R) is support policy. Farmers' perception, which is involved in the processing and integration of external stimuli, serves as the mediator (O) between external stimulus and willingness. In addition, this study explores how different dimensions of support policies (service policy, subsidy policy, and propaganda policy) affects farmers' willingness to utilize resources. The study further analyzes the mediation effect of farmers' perception as well as the regulating effect of farmers' attitude toward risk on the relationship between support policies and farmers' willingness to utilize resources. We derive a set of hypotheses from the theoretical discussion. The empirical study is based on a survey of 607 farmers from 11 counties and cities in China's Hunan province.

Our study contributes to the existing body of work on farmers' willingness to use livestock and poultry manure resources in following major ways. This is the first study to our knowledge that uses a theoretical framework based on SOR to examine a variety of factors that influence farmers' behavior and, as a result, their willingness to utilize manure. Second, this adds to the literature by posing the question of how farmers' perceptions of incentive policies affect their willingness to utilize manure resources. Finally, this study adds to current knowledge by looking into the heterogeneous moderating effect of risk attitudes in regulating the effect of supportive policies on overall willingness to utilize manure resources. Furthermore, the findings of this study can be applied to other regions to develop local manure recycling policies.

The structure of the paper is as follows. Section 2 includes theoretical analysis, research hypotheses, and a research strategy. Section 3 describes the data source and variables. Section 4 presents the analysis results while Section 5 concludes the study.

2 Theoretical analysis and hypothesis

According to psychologist Bandura, a person's will and behavior result from the interaction of environmental and individual psychological factors. Based on this, environmental behavior psychology proposed the stimulus-organism-response (SOR) theory, which holds that all aspects of the environment play a stimulating role (S) in influencing people's internal states (O) and thus triggers an individual's willingness and behavioral response (R) (Mehrabian and Russell, 1974). Hence, the combination of an individual's emotional and behavioral response with his or her perception constitutes an individual's adaptive response to external stimuli (Mazursky and Jacoby, 1986). Prior studies held that these factors could have both positive and negative effects (Verhagen and Van Dolen, 2011). Individuals make the final decision and choose their behavior accordingly.

Due to its intuitive and potent exploratory nature in analyzing human behavior, the SOR theory has garnered a great deal of attention in a variety of academic fields over the past few decades. Due to its broad applicability, scholars have modified the SOR approach for their own research contexts and incorporated cognitive and affective elements into the framework. For two reasons, the SOR model is applicable to the current investigation. First, the SOR model has been widely used in the past to study human behavior (Ge et al., 2022). Second, given the significance of environmental stimuli in influencing human behavior, the SOR model provides a detailed and structured framework for examining the impact of environmental stimuli on farmers' cognitive or emotional responses, and thus on their willingness to change their manure management behavior.

Farmers' willingness to utilize manure as resource is an adaptive emotional response to the external environment. We can consider the manure resource utilization policy to be the primary stimulus (S) of farmers' willingness to use manure resources, and farmers' willingness to reuse manure to be the emotional response of farmers to external environmental stimuli (R), with farmer perception serving as a mediator (O) between external stimuli and individual responses

1 Yu and Yu (2019), for example, investigated how farmers' perceptions of manure resource utilization influenced their willingness to participate, as well as how knowledge of manure-related water pollution, environmental protection policies, and financial subsidy policies influenced their willingness to participate.

(Zhu et al., 2018). Farmers can shape their perspective on waste resource utilization by assimilating and integrating external policy stimuli, which shapes their emotional and behavioral responses (Wang, 2020).

Government support policies and environmental regulations, as well as the influence of the market, technology, and traditional culture are among the external environmental factors that affect farmers' behavior and willingness to recycle manure (Pan and Kong, 2018; Huibo et al., 2022). However, there is no market system for utilizing livestock and poultry manure resources, and it is primarily the responsibility of government departments to promote resource utilization technologies. Consequently, various government support policies are now the primary motivator for farmers to utilize livestock and poultry waste resources. Supporting policies for utilizing livestock and poultry waste resources include a variety of categories, including publicity and training, technical services, and project compensation. For example, through a variety of channels and forms of publicity, education, and popular science training, propaganda policies attempt to raise the value of farmers in public perception, as farmers lower environmental costs and create value by reusing what had been waste resources. This in turn will create a favorable social environment for farmers to utilize waste resources.

Furthermore, through technical counseling, promotion, information sharing, and service policies enable farmers to quickly improve technology for utilizing waste resources, identify sufficient channels for manure consumption, and save a significant amount of time and energy. These are conducive to improving the ability and confidence of farmers to utilize waste resources (Li et al., 2020). Compensation policies, rather than subsidies, reduce farmers' investment in waste resource utilization through tax breaks and awards, while increasing farmers' risk tolerance. To some extent, the government subsidies make farmers feel more accountable for utilizing waste resources. Therefore, different types of support policies affect farmers willing to utilize waste resources by influencing how they perceive their competence, worth, and morality. The impact of these support policies varies by policy. Based on this, this study proposes the following hypothesis.

Hypothesis 1: Support policies positively impact farmers' willingness to utilize resources.

Hypothesis 2: Different support policies have varying effects on farmers' willingness to utilize resources.

Furthermore, people's preexisting beliefs, ideas, emotions, and experiences frequently influence how they respond to external stimuli. The processing and selection of external stimuli tend to be relatively consistent, with risk tolerance a dominant factor. A risk-disposition can be either positive or negative, with unpredictable effects on one's goals (Li et al., 2014; Wu et al., 2021). A subject's willingness and behavior will change with how they perceive their decision context (Liu et al., 2021; Ge et al., 2022). The risk attitudes of farmers can be categorized into three groups: risk averse, risk neutral, and risk preferring (Dillon and Scandizzo, 1978).

Existing studies generally conclude that risk aversion influences farmers "micro-decision-making behavior" (Liu et al., 2021). On the one hand, some scholars are of the view that farmers are risk-averse (Yin and Li, 2011), and their risk aversion has a substantial impact on their decisions to invest in new technologies (Dong, 2021). That is, a risk-averse mindset causes more unwillingness or delay, while a higher risk preference increases the likelihood of adopting new technologies (Gao et al., 2017). Thus, the risk attitude will influence farmers' willingness to use waste resources in the same way as it will influence other technological decision-making behaviors. On the other hand, regardless of whether farmers are willing to use waste resources, risk-averse traits will motivate them to avoid penalties and simply follow the government-supported and encouraged waste treatment methods. The more risk-averse a person is, the more likely he or she is to use waste resources. Therefore, farmers' attitude toward risk will either increase or decrease their willingness to use resources. In other words, it regulates the relationship between farmers' perception and their willingness to adopt new or variant waste management practices, although the direction of this relationship is unclear. Thus, we propose the following hypotheses based on farmers' perceptions and risk attitudes.

Hypothesis 3: Farmers' perception mediates the relationship between support policies and farmers' willingness to adopt new waste management practices.

Hypothesis 4: Farmers' attitude toward risk moderates the relationship between their perception and their willingness to change waste management practices.

Based on the reasoning outlined above, this study proposes the conceptual model depicted in Figure 1.

3 Research design

3.1 Data source and sample characteristics

This study collected data from 11 counties in Hunan Province from March to July 2021, according to different terrain areas, including Hengyang, Hengnan, Xupu, Xiangyin, Xiangtan, Xiangxiang, Xinhua, Shuangfeng, Lianyuan, Yiyang, and the Yueyang Qu yuan management area. Sixty pig farmers were randomly selected from 38 villages and towns in each sample county based on the scale of the questionnaire respondents. A total of 13 questions were included in the questionnaire, all of which adopted a five-level scale. In this study, 10 corresponding dimensions were included, using the total average method. The research group issued 619 questionnaires and received 607 valid questionnaires, with an effective rate of over 98%.

The sample distribution in this study is as follows: sample households included 567 male and 40 female farmers, with male and female farmers accounting for 84% and 16%, respectively. The proportion of respondents over 50 was 51.89%, indicating that farmers are generally middle-aged. Farmers' education level are classified as follows: primary school and below, junior high school, technical secondary school or high school, junior college, undergraduate or above. 84.84% of the respondents have a high school diploma or less, indicating that farmers have a generally low level of education. Among the households surveyed, 84 respondents were village-level cadres or above, and 132 were CPC members, accounting for 13.84% and 21.75%, respectively. In general, the proportion of cadres and CPC

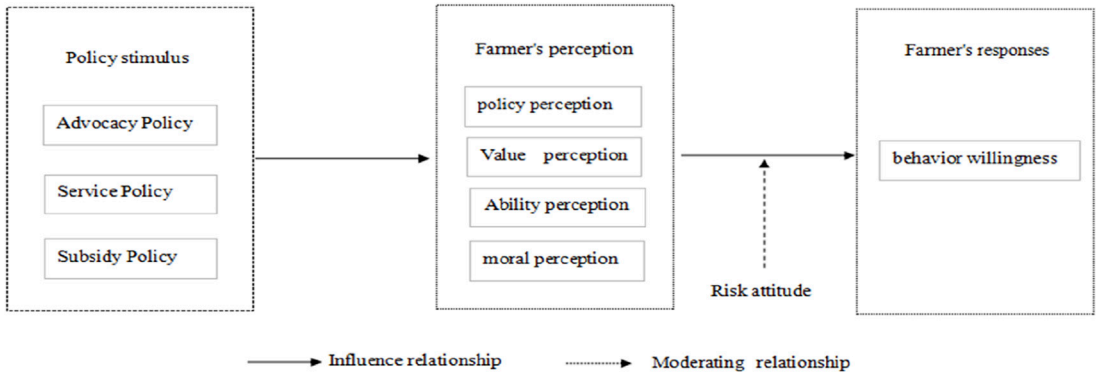

FIGURE 1
Theoretical model of support policy affecting farmers' willingness of resource utilization.

members in the households surveyed is low. The majority of sampled households were risk-averse, preferring projects with low risks and low returns, indicating a relatively conservative risk attitude. 83.85% of the respondents were willing or very willing to learn management and resource utilization knowledge, and 70.18% were satisfied or very satisfied with their current living conditions.

Operating characteristics of the sample households is as follow: 48.43% of the sampled household have a livestock production of less than 500 head of livestock, while those producing between 501 and 3,000 head and those producing more than 3,000 head accounted for 23.56% and 28.01%, respectively. Small and medium-sized farms continue to dominate the pig breeding industry. 75.45% of the households surveyed combined planting and breeding management, whereas only 24.55% were pure farmers, demonstrating that the ecological planting and breeding method is gaining popularity. In terms of sales strategies, 20 of the households surveyed participated in agricultural cooperatives, while 129 used commercial collaboration. In addition, more than half of the households surveyed had more than 10 years of experience in breeding, demonstrating the industry's overall stability. In terms of resource utilization, only 26.52% of farmers recycled manure prior 2017. The number of farmers increased substantially between 2018 and 2019, suggesting that the manure resource utilization policy has a substantial impact, encouraging farmers' willingness to utilize waste resources.

Regional characteristics of the sample households. The proportion of households in hilly, plain, and mountainous areas was 31.8%, 27.18%, and 41.02%, respectively. The majority of farms were in geographically convenient areas, while only 10.87% of respondents reported having farms in geographically inconvenient areas. Table 1 lists specific sample characteristics.

3.2 Variables and descriptive statistics

Dependent Variable: Farmers' willingness to utilize livestock and poultry manure (WILL) is the dependent variable, which is derived based on the response to the questionnaire item "you are willing to carry out manure resource utilization". The value is based on a scale of 1–5, with one meaning "very unwilling" while five meaning "very willing".

Core Explanatory Variables: The primary explanatory variable in this study is the support policy (SP), which consists of a series of incentive policies issued by government departments for utilization of livestock waste resources. For the selection of policy tools, we followed previous research (such as Li, 2020) and included three dimensions: propaganda policy (PGP), service policy (SVP), and subsidy policy (SBP). The dimension of PGP is measured by the amount of time farmers spend on publicity and training. The SVP dimension is measured by whether farmers have received technical service and market information services. Finally, the measurement of SBP includes three factors: whether standard subsidies are obtained for breeding farms, whether special subsidies are obtained for waste resource utilization, and whether other policy waivers and exemption preferences are obtained.

The PGP is rated on a scale of 1–5, while the SVP and SBP are assigned as yes = 1 and no = 0. Based on measuring each support policy dimension and averaging the sample data from PGP, SVP, and SBP, the overall score of SP was included in the regression model to investigate the influence of support policy on farmers' perception and willingness of resource utilization.

Mediation Variable: According to the theory of new behavioral psychology, the perceptions and feelings of farmers toward the resource utilization of livestock and poultry waste serve as a mediator between policy stimulus and farmers' willingness to utilize manure resources. This study decomposes farmers' perception (FP) into four dimensions: policy perception (PP), value perception (VP), ability perception (AP), and moral perception (MP) (Zheng, 2020). The specific measurement of each dimension is as follows. Policy comprehension, knowledge of regulation, and policy attention are the three items used to assess PP, with specific measuring topics corresponding to PP1-PP3 in Table 2. For measuring VP, three items including Economic, ecological, and social values are used, and the specific measuring topics correspond to VI1-VP3 in Table 2.

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TABLE 1 Basic characteristics of the sample farmers.

Basic characteristics of sampled farmers	Answers options	Frequency	Percentage (%)	Cumulative percentage of (%)
Sex	man	567	93.41	93.41
	woman	40	6.59	100.00
Age	1 = Age of 29 years and under	7	1.15	1.15
	2 = 30–39 years old	81	13.34	14.50
	3 = 40–49 years old	204	33.61	48.11
	4 = From about 50 to 59 years old	270	44.48	92.59
	5 = Age of 60 and older	45	7.41	100.00
Degree of education	1 = Primary school or below	45	7.41	7.41
	2 = Junior high school	268	44.15	51.57
	3 = Technical secondary school or high school	202	33.28	84.84
	4 = Junior college	66	10.87	95.72
	5 = bachelor's degree or above	26	4.28	100.00
Cadre	1 = Cadres	84	13.84	13.84
	2 = non-cadres	523	86.16	100.00
Party member	1 = Party members	132	21.75	21.75
	2 = Non-party members	475	78.25	100.00
Scale of operation	1 = Less than 500 head	294	48.43	48.43
	2 = 501–3,000 head	170	28.01	76.44
	3 = 3,000 and above	143	23.56	100.00
Management model	1 = Pure breeding	149	24.55	24.55
	2 = The combination of planting and breeding	458	75.45	100.00
Sales model	1 = Self-produced and self-sold	458	75.45	75.45
	2 = Cooperative	20	3.29	78.75
	3 = Corporate cooperation	129	21.25	100.00
Operating years	1 = 2 years and less	44	7.25	7.25
	2 = 3–9 Years	210	34.60	41.85
	3 = 10–15 years	199	32.78	74.63
	4 = 16–20 years	69	11.37	86.00
	5 = 21 years and more	85	14.00	100.00
Year of Implementation	1 = 2016 and before	161	26.52	26.52
	2 = 2017	95	15.65	42.17
	3 = 2018	165	27.18	69.36
	4 = 2019	112	18.45	87.81
	5 = 2020	59	9.72	97.53
	6 = 2021	15	2.47	100.00

(Continued on following page)

TABLE 1 (*Continued*) Basic characteristics of the sample farmers.

Basic characteristics of sampled farmers	Answers options	Frequency	Percentage (%)	Cumulative percentage of (%)
Risk attitude	1 = prefers small risk and small return	390	64.25	64.25
	2 = prefers medium risk and medium return	156	25.70	89.95
	3 = prefers large risk and large return	61	10.05	100.00
Learning willingness	1 = Not willing to	11	1.81	1.81
	2 = Do not want to	22	3.62	5.44
	3 = General	65	10.71	16.14
	4 = Willing to	173	28.50	44.65
	5 = Very willing to	336	55.35	100.00
Life satisfaction	1 = Very dissatisfied	4	0.66	0.66
	2 = Not satisfied	30	4.94	5.60
	3 = General	147	24.22	29.82
	4 = Satisfied	306	50.41	80.23
	5 = Very satisfied	120	19.77	100.00
Terrain of farm	1 = hills	193	31.80	31.80
	2 = Plain	165	27.18	58.98
	3 = Mountainous	249	41.02	100.00
geographical conditions	1 = Very inconvenient	27	4.45	4.45
	2 = Not convenient	39	6.43	10.87
	3 = General	256	42.17	53.05
	4 = Convenient	212	34.93	87.97
	5 = Very convenient	73	12.03	100.00

In addition, AP is measured using three items (Channel perception, technology perception, and behavioral confidence) with three questions, corresponding to AP1-AP3. Finally, four items including peer demonstration, peripheral relationship, behavioral intervention, and neighborhood perception are used to measure MP, from our four questions: MP1:MP4.

All the measurements in these four dimensions are weighted one to five points based on one to five on these options: completely inconsistent, basically inconsistent, general, basically consistent, and completely consistent. The final score of each dimension is the sum of the average scores of each item in the dimension. The weighted average of the scores of farmers' different dimensions of FP (including PP, VP, AP, and MP) was used to calculate the score of overall FP, which was included in the regression model for investigation of the mediator effect of overall FP.

Adjustment Variable: To examine farmers' risk attitude (RA), this study developed a questionnaire with risk attitude-related questions such as "your investment choice for a risky project", with answer options including "small-scale project with low risk", "project with medium risk", and" large-scale project with high risk", with respective weighting points of one to three.

Control Variables: To analyze the impact of support policy on farmers' willingness to adopt manure utilization practice, this study included control variables such as gender, age, cadres, party membership, education level, learning willingness, life satisfaction, farmers' personality and characteristics, business scale, business model, management years, year manure utilization adopted, terrain of farm, geographical conditions of farms.

4 Results and discussion

4.1 Baseline results and discussion

Because livestock and poultry waste perception variables are continuous variables, this study used the least squares method (OLS) for analysis. The regressions in Table 3 (Model 2) shows that the overall support policy (SP) has a significant positive effect on farmers' willingness to utilize manure resources (WILL) at 1% level. Farmers are more willing to utilize waste resources when there is a

TABLE 2 Description of the key variables and their statistical description.

Variable (symbol)	Measures	Description	Variable value	Mean	Standard deviation
Willingness to utilize resources (WILL)	Willingness to utilize resources	Willing to carry out the resource utilization of livestock and poultry waste	1–5	4.468	0.87
Policy perception (PP)	PP1: Knowledge of regulations	Good understanding of environmental protection regulations	1–5	3.606	0.831
	PP2: Policy understanding	Very familiar with the waste resource utilization policy	1–5	3.626	0.842
	PP3: Policy attention	Pays close attention to the changes in resource utilization policies	1–5	3.975	0.843
Value perception (VP)	VP1: commercial value	Manure resource utilization is profitable	1–5	4.336	0.906
	VP2: ecological value	Manure resource utilization is conducive to environmental protection	1–5	4.636	0.685
	VP3: social value	Resource utilization is conducive to agricultural and rural development	1–5	4.586	0.693
Ability perception (AP)	AP1: Channel perception	There are enough channels for manure consumption	1–5	4.138	0.866
	AP2: Technology perception	Masters the waste resource utilization technology	1–5	3.685	0.955
	AP3: Behavioral confidence	Have the confidence to achieve waste resource utilization	1–5	4.01	0.91
Moral perception (MP)	MP1: Peer demonstration	Manure treatment methods came from peer advice	1–5	3.969	0.879
	MP2: Peripheral relations	Maintains good relations with the people around you	1–5	4.229	0.94
	MP3: intervention	Will stop others from being environmentally unfriendly	1–5	4.199	0.907
	MP4: Neighborhood views	Value other people's opinions very seriously	1–5	4.407	0.771
Propaganda policy (PGP)	PGP1: Publicity views	The number of times the government publicity is received	1–5	3.494	1.297
	PGP2: Number of trainings	Number of government training sessions received	1–5	2.781	1.15
Service policy (SVP)	SVP1: Market information services	Whether to obtain the government consumption channel of market information services	0–1	0.25	0.434
	SVP2: technical service	Whether to obtain technical guidance from government departments	0–1	0.272	0.445
Subsidy policy (SBP)	SBP1: Standardized construction subsidies	Whether to get a standardized site construction subsidy	0–1	0.46	0.499
	SBP2: Subsidies for resource utilization	Whether to get manure resource utilization subsidies	0–1	0.59	0.492
	SBP3: Tax reduction	Have you ever obtained the policy tax reduction	0–1	0.155	0.362
Risk attitude (RA)	Risk attitude	Risk attitude on your project investment selection	1–3	1.458	0.671

Number of Respondents = 607.

strong policy support. These findings are consistent with those of Li et al. (2020), who discovered that support policies influence beef farmers' willingness to recycle manure in China's Henan province. The underlying reason is that utilizing animal and poultry manure as a resource has a clear public goods component that can both lessen negative externalities and, after treatment, introduce production input into the economy, while having positive externalities on easing resource pressure. On the other hand, livestock and poultry manure has the biological resource qualities that make it a superior organic fertilizer and a vital component in the cultivation of organic agricultural products.

In light of these results, it is suggested that using livestock and poultry waste as resources has numerous advantages. Government departments to encourage utilization of livestock and poultry waste to lower their resource costs, improve their resource efficiency, and be recognized for adopting business practices that align with the government's energy conservation and carbon reduction objectives. However, if policy support is insufficient to offset the positive external cost of farmers' adopting new resource utilization methods, farmers' willingness and behavior to utilize resources will be weakened. This mostly aligns with the results of Zhao et al. (2019).

Furthermore, the regression results in Table 3 (model 3) indicate that both service policy (SVP) and subsidy policy (SBP) have a positive and significant impact on farmers' willingness to utilize resources (WILL), while the effect of propaganda policy (PGP) was

TABLE 3 OLS regression results of support policies' impact on farmers' willingness to utilize manure resources.

Dependent variable	Zxhlizc		
	Model 1	Model 2	Model 3
sex	−0.038 (−0.356)	0.010 (0.092)	−0.017 (−0.170)
age	−0.095* (−2.564)	−0.073* (−2.076)	−0.060 (−1.791)
degree of education	0.021 (0.534)	0.039 (1.025)	0.027–0.733
cadre	−0.026 (−0.277)	−0.028 (−0.310)	−0.087 (−0.985)
party membership	0.066 (0.918)	0.102 (1.439)	0.102 (1.452)
scale of operation	0.093* (2.060)	0.076 (1.722)	0.023 (0.529)
management model	0.185* (2.163)	0.142 (1.758)	0.163* (2.138)
Sales model	0.096** (2.597)	0.105** (2.927)	0.112** (3.078)
Operating years	−0.012 (−0.377)	−0.016 (−0.515)	0.000 (−0.006)
Year of Implementation	0.003 (0.132)	0.004 (0.204)	0.019 (0.892)
Risk attitude	0.012 (0.257)	−0.012 (−0.268)	−0.031 (−0.722)
Willingness to learn	0.409** (7.302)	0.366** (6.234)	0.313** (5.660)
Life satisfaction	0.033 (0.863)	0.008 (0.204)	−0.033 (−0.908)
Terrain	0.002 (0.046)	−0.012 (−0.309)	−0.006 (−0.174)
geographical conditions	−0.005 (−0.137)	−0.025 (−0.667)	−0.033 (−0.879)
SP	—	0.375** (5.323)	--
PGP	—	—	0.001 (0.022)
SVP	—	—	0.154* (1.957)
SBP	—	—	0.810** (8.555)
Number of observations	607	607	607
R-Square	0.282	0.314	0.393
adjusted R-Square	0.263	0.295	0.375
F price	F (15,591) = 10.103,p = 0.000	F (16,590) = 13.037,p = 0.000	F (18,588) = 20.878,p = 0.000

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

insignificant. Moreover, the regression coefficients indicate that SBP has the greatest effect on farmers' willingness to utilize resources, followed by SVP. As PGP does not have a significant effect, it does not rank in greatest effects. It is statistically 0, so has no effect. These findings support hypothesis two of the study: different support policies have varying effects on farmers' willingness to utilize resources. These findings align with those of Yu and Yu (2019), who discovered that financial subsidy policies and environmental protection policies have a significant positive effect on farmers' willingness to participate in resource utilization. Increases in financial subsidies can reduce information asymmetry and pressure on farmers' own finances, effectively dispersing the potential risks associated with adopting new technologies, and encouraging farmers to boost their demand for green production behavior (Wang et al., 2022).

Subsidy policies have a profound impact because they reduce farmers' investment in waste resource utilization as well as their net cost per unit through project-proportional subsidies, awards, and tax breaks. The government should make timely payments for waste recycling subsidies a priority, emphasizing the establishment of compensation guidelines and rules that take into account farmers' breeding level. Farmers, for example, who use more resources or generate a large amount of waste to recycle should have their compensation level immediately increased. Therefore, as policy subsidies increase, farmers will use waste resources more intensively. Farmers have difficulty utilizing waste resources due to a lack of knowledge regarding resource utilization technology and waste disposal methods. Various training programmes, such as one-on-one assistance and group training, should be organized to address the technical issues that farmers face. Technical assistance, market information services, and market cultivation service policies can all assist farmers in improving their capacity to utilize livestock and poultry waste as resources. This suggests that the more effective the SVP, the more efficiently farmers can utilize waste resources.

The not significant effect of PGP on farmers' willingness to utilize resources may result from a diminished impact of government propaganda and training on farmers, given the

TABLE 4 Progressive regression results of the overall perceived mediation effect among farmers.

	First step	Second step	Third step
	WILL (model 4)	FP(model 5)	WILL (model 6)
constant	1.946**	2.465**	0.574
	(5.149)	(12.696)	(1.404)
SP	0.368**	0.538**	0.068
	(5.189)	(14.782)	(0.857)
FP	—	—	0.557**
			(7.255)
Additional controls	Yes	Yes	Yes
Number of observations	607	607	607
R-Square	0.313	0.443	0.369
Adjusted R-Square	0.297	0.43	0.353
F price	F (14,592) = 19.260, p = 0.000	F (14,592) = 33.618, p = 0.000	F (15,591) = 23.053, p = 0.000

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

proliferation of Internet-based tools. Local governments should utilize a variety of media outlets to publicize the environmental impacts of livestock and manure discharges and the ecological and economic benefits of waste resource treatment in order to increase farmers' understanding of the necessity, urgency, and value of resource utilization. Modern information transmission channels significantly improve agricultural productivity by optimizing farmers' resource utilization behavior (Odhiambo, 2015), and providing adequate technical information (Si et al., 2021).

In terms of farmers personality traits, and age has a negative and significant impact on farmers' willingness to utilize resources (models one and two in Table 2), indicating that the older the farmers are, the less willing they are to utilize waste resources. In addition, the results imply that the stronger the willingness to learn, the stronger the farmers' willingness to utilize waste resources. In terms of the operating characteristics of farmers, results reveal that larger the scale of the farm, the stronger the farmers' sense of responsibility for preventing and controlling fecal pollution and their willingness to utilize waste resources.

What is more, results suggest that the farm's business model has a significant positive impact on farmers' willingness to utilize resources. These findings indicate that farmers using more of their own manure on their own farms are using it more efficiently than pushing it into a market with undeveloped demand. Finally, the sales model positively impacts farmers' willingness to utilize resources. As a commercial strategy, farmers adopted a cooperative breeding strategy. Therefore, preventing environmental contamination and control of manure are the prerequisites for cooperative companies to carry out breeding cooperation. Hence, partner companies exert pressure on farmers to be more receptive to utilizing waste resources. These findings are consistent with those of Verhofstadt and Maertens (2015) and Si et al. (2021), who discovered that farmers' contract commitment with the cooperative organization has a significant impact on farmers' reporting of manure management, and that farmers' relationship with the cooperative organization is governed by the organization's rules and regulations.

TABLE 5 Operation results of the Bootstrap of overall perceived mediation effect (Model 7).

	Coef	Std.Err	z	P > z	[95% Conf.Interval]
indirect effect	0.297	0.058	5.110	0.000	0.183–0.411
direct effect	0.071	0.079	0.890	0.373	−0.085–0.226

4.2 Mediating effect of farmers' overall perception between support policies and willingness to utilize manure resources

Table 4 shows the results of a mediation test on farmers' overall perception (FP) of support policies and farmers' willingness to utilize manure resources (WILL). The first step in Baron and Kenny's (1986) three-step test method is to validate policies and farmers' willingness to utilize manure resources. According to the regression results, support policies have a significant and positive impact on farmers' willingness to utilize manure resources. The second step is to assess the impact of support policies on the factors that influence farmers' overall perception. The findings were found to be statistically significant at the 1% level. The third step is to test whether the effect of support policies on farmers' willingness to use resources is significant by incorporating support policies and overall perception into the regression model at the same time.

After controlling for farmers' overall perception, the regression results indicate that the core explanatory variable of support policies on

TABLE 6 Results of the effect of risk attitude.

	WILL		
	model 8	model 9	model 10
constant	2.967** (8.140)	2.971** (8.142)	2.999** (8.290)
FP	0.591** (9.015)	0.591** (9.011)	0.635** (9.583)
RA	--	0.016 (0.364)	0.006 (0.136)
FP*RA	—	—	−0.261** (−3.392)
Additional controls	Yes	Yes	Yes
Number of observations	607	607	607
R-Square	0.368	0.368	0.380
Asdjusted R-Square	0.354	0.353	0.365
F price	F (13,593) = 26.583,p = 0.000	F (14,592) = 24.658,p = 0.000	F (15,591) = 24.189,p = 0.000
$\triangle R^2$	0.368	0.000	0.012
$\triangle$F price	F (13,593) = 26.583,p = 0.000	F (1,592) = 0.132,p = 0.716	F (1,591) = 11.505,p = 0.001

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

farmers' willingness is not significant, with the value decreasing from 0.368% to 0.08%. The three-step test method (Baron & Kenny, 1986) identifies a complete mediation effect when the core explanatory variables are significant in the first and second steps but not in the third. In light of this, the general perception of farmers served as the sole mediator between support policies and the willingness of farmers to utilize resources. Consequently, hypothesis three is supported by the regression results. The results are consistent with the findings of Li et al. (2021), who discovered that farmers' willingness to participate in the resource utilization of livestock manure was proportional to the strength of their cognitive behavioral control.

We used the bootstrap method with 5,000 bootstrap samples to examine the mediating effects of farmers' overall perception on the relationship between support policies and farmers' willingness to use resources. The reported results in Table 5 reveals that the mediation test did not contain a value of 0 within the 95 percent confidence interval. We discovered that Farmers' perception has a significant positive impact on support policies (β = 0.29, p = 0.001), supporting Hypothesis 3, which states that farmers' perception mediates the relationship between support policies and farmers' willingness to use resources. These findings show that policy support is the most important environmental stimulus for farmers to recycle waste resources, and farmers' willingness to use resources reflects their emotional response to this stimulus. In order to form an overall perception of external stimuli and corresponding emotional responses, farmers must engage in internal self-regulation for storage, processing, and integration of information in addition to external environmental stimuli.

4.3 Regulation effect of farmers' attitude toward risk

This study investigates the relationship between risk attitude, farmers' overall perception, and resource utilization by first centralizing data on farmers' overall risk perception and risk attitude, and then incorporating the overall perception, risk attitude, and their interaction term into the regression model. Following that, the F values of various models are compared to determine the importance of the interaction term. The regression coefficient of the interaction term between overall perception and risk attitude in Table 6, model 10, is −0.261, which is statistically significant at the 1% level. These results indicate that risk attitude plays a negative role in regulating the effect of overall perception on farmers' willingness to utilize waste resources. Therefore, Hypothesis four is supported.

To investigate the adjustment effect of risk attitude on farmers' overall perception and willingness to use resources, the risk attitude variables are classified as average, high (average value plus one standard deviation), and low (average value with 1 standard deviation). All of the regression results in Table 7 passed the significance test at various levels (each had p = 0.000). The overall perception of resource utilization willingness among farmers has a regression coefficient of 0.460 when the regulatory variable farmer risk attitude is at a high level (+1SD). When the risk attitude was low, the regression coefficient increased to 0.811. (−1 SD). According to these findings, the higher the risk aversion, the greater the positive effect of farmers' overall perception on their willingness to use resources. These findings are in line with those of Wang (2020). One possible explanation is that a risk-taking mindset helps people predict how uncertainty will affect them. It will change the willingness of the decision maker to make a decision based on how they perceive the decision scenario (Liu et al., 2021). More importantly, farmers with greater risk management capabilities have a high level of behavioral responsibility, which influences the resource utilization behavior of neighboring farmers when information disseminates and is shared (Achiba, 2018), thereby promoting technology adoption.

Given the need to protect the environment, the handling of livestock and poultry breeding manure is frequently brought to the attention of government agencies. Government departments encourage and support farmers in utilizing waste resources in order to maximize the positive effects of livestock and poultry manure while minimizing the negative externalities associated

TABLE 7 Analysis of the regression results at different levels of farmers' attitude toward risk.

Regulatory variable levels	Coef	St.Err	t-value	*p*-value	[95% Conf interval]
Average value (Model 11)	0.635	0.066	9.583	0.000	0.505–0.765
High Level (+1SD) (Model 12)	0.460	0.076	6.090	0.000	0.312–0.608
Low level (-1SD) (Model 13)	0.811	0.092	8.832	0.000	0.631–0.991

TABLE 8 Regression results of policy comprehensive score and farmers' resource utilization willingness (Model 14).

WILL	Coef	St. Err	t-value	*p*-value	[95% Conf interval]
comSP	0.23	0.051	4.51	0.000	.130–0.331
Additional Controls	Yes	Yes	Yes	Yes	Yes
Constant	2.388	.379	6.31	0.00	1.644–3.131
Mean dependent var		4.468	SD dependent var		0.870
R-square		0.306	Number of obs		607
F-test		18.601	Prob > F		0.000
Akaike crit. (AIC)		1,361.816	Bayesian crit. (BIC)		1,427.944

TABLE 9 Order-Probit regression results of the factors influencing farmers' willingness to utilize resources.

	WILL	Coef	St. Err	t-value	*p*-value	95% Conf interval
model 15	SP	0.808	0.14	5.78	0.000	0.534–1.082
model 16	PGP	−0.006	0.057	−0.1	0.918	−0.117–0.105
	SVP	0.712	0.208	3.42	0.001	0.304–1.119
	SBP	1.88	0.207	9.1	0.000	1.475–2.285

with them. It is difficult to completely offset the cost of utilizing waste resources with the benefits of resource utilization due to technical limitations and certain inherent flaws with organic manure. As a result, farmers' willingness to use resources is low when they take excessive risks, directly discharge waste, surreptitiously discharge waste, and other methods to treat livestock and poultry manure. Farmers' willingness to use resources is strengthened by a more cautious risk-taking attitude.

4.5 Robustness test

4.5.1 Main component method test

To assess the robustness of the results of support policies on farmers' willingness to utilize resources, this paper included support policy of seven observations, including training, market information services, technical services, standardization construction subsidies, resource utilization subsidies, and tax reduction, in the principal component analysis, and obtained a comprehensive score to replace the support policy variables in the OLS regression. First, the KMO and Bartlett spherical tests were performed. The KMO and Bartlett spherical tests values were greater than 0.5, indicating that factor analysis is plausible. The predict command was used in the principal component analysis to obtain three principal component scores, the extracted composite score policy (comSP), and farmers' resource utilization willingness proportional to the principal component. Table 8 shows that the policy comprehensive score (comSP) has a significant positive impact on farmers' overall perceptions, with a regression coefficient of 0.23 (p = 0.000). These findings are consistent with the previous OLS regression findings, indicating that our findings are robust to different proxies for supporting policies.

4.5.2 Method replacement test

This study uses an ordered Probit (OP) model to analyze the impact of different dimensions of support policies on farmers' willingness to use resources in order to validate the main findings. Because farmers' willingness to utilize resources is one of several variables with a progressive ranking relationship, the OP model can be applied to such variables (Zhao and Yu, 2021). Table 9 reports results of the OP model. The results indicate that support policies for farmers' willingness to utilize resources have a significant positive impact, with the impact of each dimension of support policies for farmers' willingness to utilize resources being

heterogenous. The subsidy and service policies have significant impact on farmers' willingness, whereas impact of PGP remains insignificant. SBP is ranked higher in terms of influence than SVP and PGP. These results are consistent with the regression results of the OLS model, indicating that they are robust.

5 Conclusion and policy implications

Although China's intensive livestock sector has undergone a significant transformation and has a significant impact on domestic and global food supply, the sector's expansion goes hand in hand with increased resource consumption and massive manure production, which has implications for the environment and climate change. The Chinese government has prioritized the comprehensive management of the rural ecological environment in recent years and has implemented a number of environmental regulation measures, including supervision policies, subsidy policies, and technology promotion to actively encourage new manure management behaviors. Utilizing waste resources from livestock and poultry is essential for China to achieve its carbon-reduction objective while also advancing high-quality animal husbandry. Increasing the resource utilization of livestock and poultry waste in China necessitates greater farmer participation.

Based on the stimulus-organism-response theory, this study examined the effect of support policies on farmers' willingness to utilize resources, as well as the mediating effect of farmers' perception and the moderating effect of farmers' attitude toward risk. This study utilized survey responses from 607 farmers residing in eleven counties of Hunan Province, China. The empirical analysis of the current study yielded the following main findings. First, this study found that farm support policies have a positive impact on farmers' willingness to utilize resources. In addition, different dimensions of support policies had different effects on farmers' willingness to utilize resources: service policy had the greatest impact, followed by subsidy policy, and propaganda policy had a negligible impact. The empirical evidence further revealed that farmers' perceptions completely mediate the relationship between support policy and willingness utilize resources. It demonstrates that the effect of policy on farmers' willingness utilize resources is primarily transmitted through farmers' perceptions. Finally, the study findings indicated that farmers' willingness to use resources is influenced negatively by their risk attitude. It demonstrated that the more cautious a farmer's risk preference, the greater the impact of policy perception on their willingness to utilize resources; conversely, the greater a farmer's risk preference, the smaller the impact of farmer perception on willingness to utilize resources.

The study's findings suggest following policy implications. First, policy compensation should be increased in accordance with the impact of various policy characteristics on farmers' willingness to utilize resources, and farmers' willingness to participate should be improved through both reward and compensation. In order to encourage livestock farmers to recycle manure, the regulatory body should offer them financial assistance. The government should prioritize timely payment of subsidies for waste recycling. Emphasis should be placed on establishing compensation guidelines and regulations that take into account the breeding level. The purchase of recycling facilities and equipment, the subsidization of electricity use, tax breaks, advanced technology training, and the funding of recycling equipment and technology research initiatives are examples of policies that this study's empirical results suggest will improve farmer uptake of more environmental waste management practices. Third-party involvement in manure recycling, such as commercial services, should be encouraged in order to develop diverse recycling channels.

Second, manure resource utilization technology, as well as its technical capabilities, should be promoted and application guidance offered. Furthermore, it is critical to establish a supply and demand platform for manure resource utilization products and associated market information services, as well as to broaden the channels through which farmers consume manure and achieve regional planting and breeding balance. Third, it is suggested that emphasis be placed on the implementation of diverse resource use policies, and the raising of public awareness of farmers' manure utilization of resources. Fourth, it is suggested that farmers be encouraged to carry out resource utilization of livestock and poultry waste by improving the prevention, control, and supervision of livestock and poultry waste pollution, as well as increasing the treatment cost of non-resource utilization of farmers' waste. In summary, this study concludes that in order to achieve sustainable livestock production, policymakers must give top priority to initiatives that can enhance and strengthen regulatory control, promote resource utilization-related education and technology adoption, and provide financial incentives for manure treatment and utilization with increased farmer involvement.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Author contributions

GX: conceptualization, data curation, methodology, supervision, writing—original draft. DH: visualization, review, software, analysis, and writing. JK: methodology, review, editing, and writing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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