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Research on Sustainable Usage of Straw in China

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Abstract

Agricultural waste refers to the by-products or residue of agricultural activities, which mainly consists of roots, stems, and leaves, which are left over after processing crops or harvesting (Li et al., 2021). Straw is one of the main agricultural residues produced from cereals during the harvesting process. Cereal waste has led to significant agricultural waste issues, which presents great challenges in terms of sustainable development in China. This study focuses on the sustainable use of straw waste in China. Some researchers pointed out that the 3R approach is recognized as a successful model used to analyze the circular economy and sustainable social development. The sustainable barriers framework is regarded as a reasonable framework for analyzing the obstacles to sustainable behaviors in society. The combination framework will be used in conjunction with the 3R approach in this research to evaluate the issue and demonstrate the obstacles in China's agricultural industry more intuitively and effectively. This study will also analyze the reasons for the unsustainable use of straw in Chinese society from three perspectives: social, economic, and policy, and analyze how the sustainable use of straw in China can be achieved, including media communication, modification of production lines, and division of government function, according to the 3Rs and sustainable barrier framework.

Keywords

Agriculture sustainability, Government policy, Urban development, 3R, Qualitative research

1. Background

Cereals such as maize and wheat have historically been considered the staple food for humans around the globe. According to Duque-Acevedo et al. (2022), the United States (US) and China are the major cereal-producing countries in the world. In 2021, China's annual cereal production exceeded 600 billion tonnes, accounting for 20.64% of the global total cereal production (Li et al., 2021). With the rapid growth of China's economy and population, the demand for agricultural products has shown an annual growth rate of 5-10 percent, but the amount of agricultural waste is also growing simultaneously (Pickson et al., 2020).

Currently, low utilization and low sustainability awareness among citizens are the main reasons contributing to the issue and it has unsustainable harmful impacts on the environment such as poor air and water quality (Guo et al., 2021). According to Ren et al. (2019) and He et al. (2016), China produces about one billion straws annually, with only about 30 per cent of them being reasonably utilized. Due to a lack of sustainability awareness, Chinese farmers prefer burning straw directly as they believe it is a cost-effective and convenient way of disposing of straw waste (Chen et al., 2022). However, Li et al. (2021) claimed that burning straws may pose significant fire hazards, especially in places where buildings and haystacks are nearby. The China Agricultural Economics Association (CAEA) estimates that there has been a huge economic loss from straw fires of over 100 million RMB in China over the past three years. Despite the

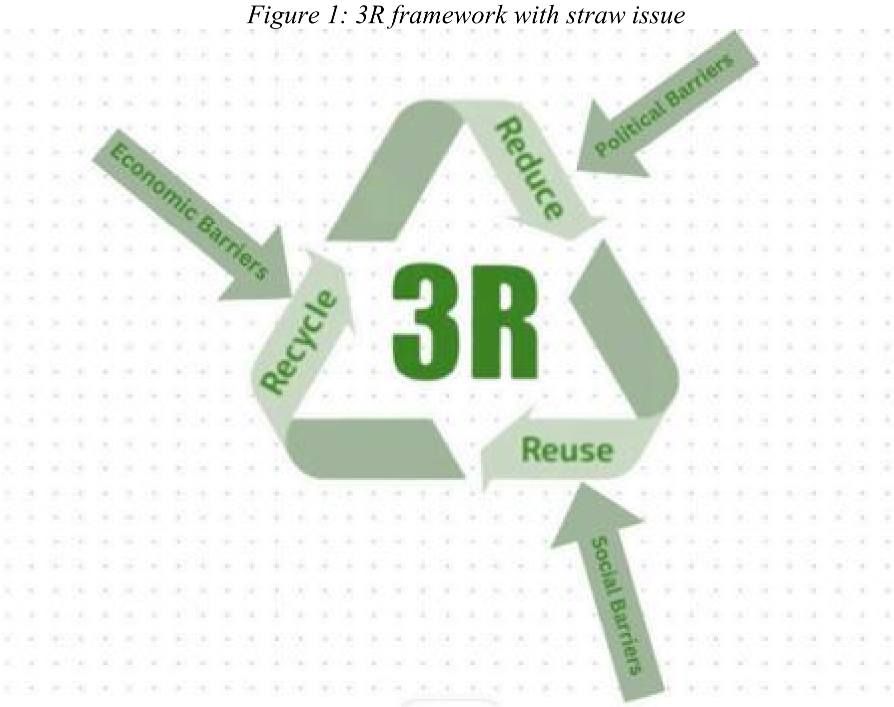
Chinese government having proposed a policy of banning straw burning, effective enforcement remains challenging due to the vast geographic extent of the country.

Mohammed's (2019) study on the sustainable use of construction waste based on the 3R approach model found that the reduction, reuse, and recycling of waste can help in achieving sustainable development. The Sustainable Barriers Framework can successfully analyze the industry's sustainability impediments, but the model has limitations in analyzing industries and elements (Álvarez Jaramillo et al., 2019). This study will use a combination of the 3R and the sustainable barriers framework to make effective recommendations for the sustainable development of China's agricultural waste industry from three perspectives including social, product, and policy.

Since China and the United States are the world's largest producers of agricultural products, they both face the problem of large-scale agricultural waste disposal, but the United States has a better system of sustainable resource use (Wei et al., 2021). Therefore, different strategies to promote the sustainable development of straw in the United States will be comparatively analyzed in the analysis process. At the same time, the problems and suggestions for the sustainable use of agriculture in China will be analyzed through the comparison with current agricultural development in the United States.

2. Problems

Figure 1: 3R framework with straw issue



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2.1 Social Barriers and Reuse

Reuse refers to utilizing a product again without altering its fundamental form (van de Sandt et al., 2019). It implies that the basic physical structure of the product remains unchanged but the product may serve a different function or purpose. The low rate of straw reuse in China has been exacerbated by farmers since they are faced with great pressure of land use and receive limited education relating to sustainability.

Xie and Huang (2021) emphasized that the straw problem is not simply caused by farmers' behaviour, but it is also affected by the nature of the authority in rural areas. The ownership of agricultural land in China has changed from private to public while farmers rely greatly on land for a living, which is also fundamentally different from land ownership in the United States. In the United States, private land ownership is upwards of 58 per cent of all land, which means that most people have discretionary power over land (Litvaitis et al., 2021). Compared to the United States, Chinese farmers only have the right to use the land so they have to return the land to the state without compensation when the duration of the land use right expires. Therefore, Chinese farmers tend to dispose of straw from the fields quickly to maximize land use and revenue. Due to the limitation on use period, farmers prefer direct burning or piling it up in ditches next to the fields, leading to severe air pollution. In contrast, American farmers prefer to rest the land so that the straw can naturally decay in the soil, forming beneficial livestock feed (Litvaitis et al., 2021).

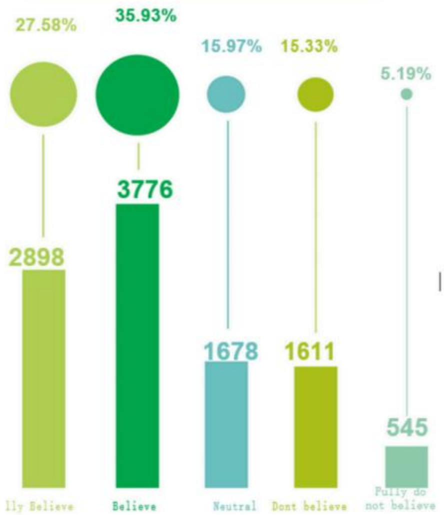
Aside from the land itself, differences in the educational backgrounds of farmers are also contributing to straw burning. Less than 30 per cent of Chinese farmers have a high school education background, so most farmers are unaware of the dangers of straw burning (Luo et al., 2022). In comparison, more than 87 per cent of farmers in the United States have a high school education (Han et al., 2021). Thus, the low education levels of Chinese farmers are the main reason for the low penetration of straw sustainable reuse in China.

2.2 Economy Barriers and Recycling

The recycling process involves the processing of raw materials to produce products that can effectively serve different industries (Koul et al., 2022). This means that straw can be used as a raw material for remanufactured products or other products in different forms. An ineffective supply chain for straw waste and low market acceptance are the main economic barriers to the development of the straw recycling industry in China.

Despite the availability of various methods to collect straw waste in China, there still exists a significant quality bias concerning the specific raw materials for the supply chain of straw-recycled products (Hu et al., 2022). The purchase of raw materials for straw recycling products in China is mainly from individual agricultural waste collectors in rural or urban areas. As a result, the straw recycling products of different brands may not have the same quality since the quality of raw materials differs when they are purchased from various individual merchants. Poor-quality straw is more likely to burn in high-temperature processing, leading to a secondary pollution issue in the processing line of straw raw products (Hu et al., 2022). In contrast, in the United States, the quality of agricultural straw is repeatedly screened by factory machinery after centralized collection to ensure that the quality of agricultural straw meets the requirements of the factory (Koul et al., 2022).

Figure 2: Consumer sustainable purchase data



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Data Research on Chinese consumer purchases of sustainable products (2020). Meanwhile, only 27.58% per cent of Chinese consumers are willing to purchase sustainable products, but more than 72 per cent of consumers in the U.S. agree with the concept of sustainability and would spend money on sustainable products (Li et al., 2021). Indicating that there is still a need to raise awareness among most Chinese consumers regarding sustainable products. For example, *China Earth* is a brand that sells handicrafts made from straw. According to the brand's annual report (China Earth, 2024), sales were low when it marketed recycled straw products to the public in its early days. Furthermore, this suggests that sustainable recycled products are still not widely accepted by Chinese consumers.

2.3 Political Barriers and Reduce

The reduction does not imply a significant decrease in the amount of agricultural waste straw produced but rather entails a series of measures aimed at reducing the pollution impact caused by agricultural straw waste in China in recent years (Wei et al., 2021). The absence of a unified straw management policy and effective management of agricultural waste is the primary factor contributing to the challenges in reducing pollutant emissions from straw in China (Liu et al., 2021).

The regulation level of agricultural straw varies by region in China due to the vast land size. For example, the Environmental Protection Department in Jiangsu Province imposes fines for straw burning and even detention in severe cases. But the government departments lean more towards persuasion rather than enforcement in inland cities such as Hunan and others (Liu et al., 2021). The fragmented regulatory policies across different regions also breed resentment among farmers, hindering the overall reduction of agricultural pollution in China.

Figure 3: Straw burning

Source: Zhou (2020).

Similarly, the lack of clarity in the roles of government departments has also contributed to the failure to reduce straw pollution. The United States Department of Agriculture (USDA) has issued guidance on agricultural waste resourcing for straw for clean energy generation. This department supports local agricultural universities with financial allocations based on land and crop growth in each state, promoting the sustainable use of agricultural resources through the implementation of bioscience research and policy in a two-way (Graham et al., 2021). The Chinese agricultural sector in comparison is different, focusing mainly on crop growth and ignoring waste reuse (Koul et al., 2022).

China's Environmental Protection Department is more focused on preventing farmers from directly burning and piling straw in drains but lacks adequate guidance for farmers on waste management. As a result, the longstanding regulatory gap has required farmers to be responsible for solving the straw issue, but their lack of educational background and theoretical knowledge hampers effective straw reuse.

After analyzing the 3R approaches combined with social, economic and policy barriers, and also comparing with the United States in sustainable agricultural development. Farmers' unsustainable handling of straw, the low quality of agricultural wastes and the lack of sustainable regulation of agricultural resources in policies have all acted as impediments to the sustainable development of the agricultural waste industry in China.

3. Literature Review

The Sustainable Development Agenda adopted by the United Nations in 2015 sets out 17 Sustainable Development Goals (SDGs), which implies that environmental sustainability goals need to be achieved through the combined efforts of all industries. The SDGs comprise 17 items, with SDG 12 focusing on ensuring sustainable consumption and production patterns, primarily for the sustainable use of waste products. It also demonstrates that agricultural waste is no longer only solely burned or landfilled. Waste materials such as straw can still be recycled, contributing to improvements in the waste management process in the agricultural industry.

As suggested by Duque-Acevedo et al. (2022), the sustainable utilization of agricultural waste holds significant developmental value for the sustainable development of society. The contemporary agricultural industry mainly operates in a linear mode, with the industrial chain centred on agricultural products, emphasizing crop production and processing. Under this model, additional functional value can be generated through the reuse of all agricultural waste, reducing agricultural waste and promoting the sustainable development of the agricultural industry. Although agricultural waste contains relatively few human-beneficial substances, its potential for sustainable use extends beyond the agricultural sector. This also implies that the value of agricultural waste can be harnessed far beyond farmers' expectations and that the sustainable use of agricultural waste can also effectively promote awareness of sustainable agricultural behaviour among social groups.

In the research of the Southeast Asian agricultural—sugarcane (Revathy & Hemmige, 2022), the remaining rhizomes after the fruit has been picked are used as biofuel while being sent to a sugarcane processing plant. It also shows that crop wastes such as roots and tubers are no longer discarded but are used as clean energy sources, reducing environmental pollution and contributing to energy usage in cities. This implies that agricultural waste is no longer perceived as having lower functional properties, but rather as a sustainable clean energy source with reduced environmental pollution characteristics. According to Shukla et al. (2022), rice husks can be important ingredients in concrete development. This multifaceted biotechnological breakthrough demonstrates that the sustainable usage of agricultural by-products is constantly being renewed and upgraded for the sustainable development of the industry.

In contrast, Chinnu et al. (2021) supposed the possibility of an inverse correlation between costs and benefits in the treatment of agricultural by-products. Hsu (2021) argued that farmers are reluctant to sell or centralize the treatment of agricultural products due to the high labour costs in some Southeast Asian regions. The sustainable value created by selling produce is much lower than the labour costs, and farmers may control the production management to cultivate more crops in an inverse return pattern. Despite the difficulties in cost control in developing agricultural by-products, technologies in biotechnology for creating sustainable agricultural products have improved in recent years. It will also lead to a reduction in the cost of using agricultural by-products and an increase in the value of reusing those products.

Previous research provides the value and scope of sustainable utilization of agricultural by-products, but there are still some limitations. Previous studies mainly focus on the regions where new biotechnologies are used while livestock is the main productive force. Thus, solutions for the sustainable use of agricultural by-products still need to be tested in countries where agricultural production dominates in terms of the number of crops.

Therefore, this report focuses on analyzing the sustainable use of straw in China to illustrate the reasons for the unsustainable usage in terms of social awareness, production lines and government functions. This report will also make recommendations for sustainable development in terms of media dissemination, production line rectification and government departments to promote the sustainable development of Chinese agriculture.

4. Methodology

This research mainly explores and analyzes the usage of sustainable stalk production in China. This study aims to analyze and demonstrate the reasons for the unsustainable use of straw-related agricultural wastes in China. This research will mainly explore the solutions to achieve SDG 12 for sustainable use of agricultural waste. Combine interview materials and desktop research to further demonstrate reasonable suggestions for sustainable development of China's agricultural waste industry. Using an inductive approach, this research method is based on data collection and the formation of new research reasoning or recommendations (Liu, 2016), which is highly industry-adaptable and applicable to many fields to deal with a wide range of research questions and gradually analyzes the research answers through the researcher's refinement of the research questions.

Qualitative research is one of the most efficient ways to better understand social phenomena and explore social essence (Hennink & Kaiser, 2022). Different from quantitative methods, qualitative research can effectively collect feedback from interviewees in depth based on individual experience, opinions and social situations to enrich the data diversity. This study adopted semi-structured interviews with open-ended questions, which can be changed based on the replies of interviewees. Semi-structured interviews offer a flexible framework that balances predefined questions and open-ended exploration, which are more flexible. Semi-structured interviews are particularly effective for enhancing the empirical validity of theories and developing reliable approaches based on data analysis. Thus, semi-structured interviews can result in knowledge advancement and a deeper understanding of the research.

A purposive sampling strategy is used in this research to ensure that the selected interviewees are relevant to the context under study or familiar with the research topic. To better answer the research question, interviewing people in the specific industry is beneficial for data collection. The purposive sampling strategy not only improves the efficiency of collecting relevant data in a particular field, but also helps conduct in-depth analyses.

The Purposive sampling includes different types of sampling strategies, including expert purposive sampling and typical case purposive sampling (Campbell et al., 2020). In contrast, typical case sampling selects a sample of individuals or collectives with experience of the project's research purpose for the study, and data are collected and analyzed through the average experience of the population (Palinkas et al., 2015). However, expert sampling involves collecting data from individuals or collectives with expertise and competence in the industry to provide insights into the research questions (Palinkas et al., 2015). Comparing the two types of data, the ability to analyze the issues in the expert sample is more in line with the purpose of this study to make recommendations for the sustainable development of China's agricultural industry. Thus, this research will adopt the expert purposive sampling method for higher accuracy. Professionals who have worked in the agricultural industry for many years are invited and their insights are important to make effective recommendations for the development of the straw industry in China. Although some researchers consider this method is highly subjective (Denieffe, 2020), it is still suitable for this research due to the advantages of higher flexibility and specialization. This method tends to conduct in-depth communication with respondents to collect rich and nuanced data essential for gaining deep insights into the research topic.

Thus, purposive sampling complements the method by targeting specific individuals who possess the relevant expertise and experiences required to address the research questions effectively.

This data was collected from December to January from four experts who have relevant experience in the industry. The data presents a summary analysis of the past development of the straw industry, followed by an in-depth demonstration of the new development of agricultural waste materials, with a focus on straw.

The in-depth interview mainly involves key stakeholders in agricultural resource companies, consultants, and government staff. This interview has been anonymised to protect the identities of the interviewees.

Mr. Shen was a consultant at McKinsey & Company and now he leads an agricultural waste reuse brand. The company opened an online shop on Taobao and sells crafts made from straw, including office notebooks and gift boxes.

Ms. Chen is a consultant in an ESG consulting firm and has a long-standing interest in China's agricultural waste industry. She is also an influencer who shares her opinions on the sustainable use of agricultural by-products on social media platforms where she received many likes and comments.

Ms. Christina runs a shop that sells reused agricultural waste and she owns a farm that also faces the problem of large-scale disposal of agricultural straw. She also creates shops on social media platforms such as RED to sell products such as handbags and hats, which are made through simple hand knitting of agricultural waste such as straw.

Mr. Jiang is a government officer from the Environmental Protection Department of China, who has been working in the environmental protection and straw-burning ban supervisory team. He has a deep understanding of straw-related policies and their impact on the development of the industry so he puts efforts into addressing the irrationality of existing policies and promoting positive change.

This research applied the thematic analyses by recording and coding the interview script transcript. Thematic research has a more pronounced flexibility and the research can be analyzed effectively by collecting different forms of data. Additionally, the interview data has been integrated and secondarily edited to further analysis. Although there are some issues of underrepresentation during the data collection, this research remains committed to enriching the diversity of the data through multifaceted integration of data, which enhances the persuasiveness of the research. This research will fully avoid potential ethical considerations in the research process. Prior to the interviews, the interviewees were asked to commit to the confidentiality of the information collected for the sole use of this research.

5. Solution

5.1 Social dimension - Reuse

To improve the reuse of straw in society, it is necessary to increase the sustainability awareness of farmers. Reuse differs from recycling since the latter refers to large quantities of agricultural waste being processed in factories to create new products. The quality of agricultural waste resources is especially important in the reuse process to effectively share the knowledge with others for achieving considerable expected results in a short period (Kong et al., 2021). This also implies that social media platforms play an important role in promoting the importance of sustainable use of agricultural resources. More than 85 per cent of Chinese use social media platforms daily so it is essential to fully use the tool (Zhang et al., 2022). Sharing educational videos relating to agricultural reuse on social media can be an effective solution to spread scientific and technological knowledge, improving public awareness of sustainability at a low cost.

In the interview with Ms Christina, she mentioned the example of an influencer who created a popular science video relating to sustainability on TikTok. "*The popular video used vivid animation to illustrate the main risks of direct burning of crop residues, demonstrating how to reuse agricultural waste resources through household items such as hats. The video has over 20,000 likes and 1,000 shares"*. This example shows the enthusiasm of Chinese influencers as well as the growing acceptance of educational videos for promoting sustainability in China. Therefore, creators are encouraged to create more educational videos on social media platforms to promote the concept of sustainability and improve the awareness of the public for deepening the understanding of sustainable agricultural resource use.

As in the U.S., there are professionals in the community who can provide farmers with ways to make agricultural waste sustainable, including converting agricultural waste into sustainable agricultural implements. In rural areas, local communities should collaborate with experts to organize regular offline sessions for farmers to share the advantages of straw reuse.

This approach can intuitively remove Chinese farmers' negative perception of straw use and raise their awareness of its effective reuse. These crafts with lower production costs not only enrich the lives of farmers but also allow farmers to understand the solutions of reusing agricultural waste resources and provide effective solutions for farmers to utilize agricultural waste resources at home in the future.

5.2 Production dimension – Recycle

The recycling of straw is an important aspect of using agricultural waste sustainably. Agricultural waste resources should also be recreated in factories, which emphasizes the importance of quality. The recommendations for recycling straws include the establishment of agricultural waste associations and improving systematic screening for higher quality.

Due to the lack of clear industry standards in China, inconsistencies in quality can still negatively affect the quality of the recycled product. Thus, the agricultural waste industry in China needs to establish a third-party industry association to promote a uniform standard for acquiring suitable raw materials. Yu (2021) also argued that the establishment of an industry association can not only standardize the quality requirements of the same product but also create a clear standard for the industry.

The association is also required to conduct regular monitoring to prevent low-quality raw materials from entering the industry. Berger (2021) pointed out that the agricultural industry lost 1/3 of the overall profit due to raw material quality issues. This further implies that the Chinese agricultural waste industry needs to set standards for straw recycling, and the relevant association has the power to maintain stability in the industry and effectively decrease the losses caused by straw quality issues.

The additional automatic screening of straw in the production line can also be an effective way to filter low-quality raw materials. In the United States, some Fast-Moving Consumer Goods (FMCG) factories use automatic machines to screen straws for higher efficiency (Berger, 2021). Those straws can be recycled into kitchen paper, which is baked and crushed at high temperatures in the production process. Due to the strengths of drying and water absorption, those recycled products have also gained great attention from the public as well as attracted many loyal users. Mr Chen also revealed that recycling is a valuable solution for the development of the agricultural industry in recent years.

This suggests that straw can be recycled after production, which is important for sustainable industrial development. Therefore, this solution can transform large-scale straws through centralized production lines in factories, thereby amplifying the value of agricultural waste resources.

5.3 Political dimension – Reduce

After analysis of the government's management of the sustainable use of straw from a policy perspective, it is obvious that there are areas where focus and improvement are needed (Clapp & Ruder, 2020). Government management of straw is not only about reducing pollution from unsustainable behaviour but also about improving the sustainable use of agricultural straw resources.

A clear division of government departments for providing specific solution strategies to social phenomena (Khan et al., 2020). This implies that the existence of government further facilitates decision-making on sustainable development. In China, farmers are under significant pressure for sustainable development since the government plays a limited role in helping them. However farmers lack the capability of dealing with large-scale agricultural waste, so government regulation remains important to the sustainable development of Chinese society. As Mr. Jiang stated, "*In the U.S. agricultural sector research on sustainable agricultural technologies was conducted in 2017 with strongfunding support.*" This suggests that the Chinese government needs to clarify the differences in roles and responsibilities between the agricultural sector and the environmental sector to regulate the agricultural waste industry effectively and to better help farmers use agricultural resources sustainably.

At the same time, the Government needs to introduce reasonable policies to manage the sustainable development of the agricultural waste industry efficiently. Take the example of the energy vehicles industry, the government should also provide financial incentives to agricultural waste factories and consumers to increase their motivation to produce and consume those suitable products. Meanwhile, the government should consider other policies such as lower taxes to stimulate the growth of relevant factories. In this way, the acceptance of sustainable products in China can be increased in the future.

6. Conclusion

In summary, this research adopts in-depth one-on-one interviews to collect relevant data and uses purposive sampling to deepen the understanding of the area with expert insights. The sustainable barrier framework and the 3R approach were also combined in this research to overcome the industry limitations and enhance the solutions for dealing with straw in China. This study analyzed the key factors contributing to the irrational use of agricultural waste resources from the socioeconomic and policy dimensions in China, which are farmers' low awareness of the use, poor quality of straw and lacking guidance from the government.

The research has certain issues of data limitations and under-representation since it mainly analyzes the straw issue in China but ignores other agricultural waste products that exist in the agricultural waste industry. Meanwhile, there are only four interviewed respondents in this study, and they are not representative. Although some efforts were made in the research to mitigate the negative impact of these issues, future research can provide a more comprehensive analysis of China's agricultural waste industry to promote the sustainable use of agricultural waste resources in China.

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Conflicts of Interest
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