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Low-Carbon Development of Livestock in China: Evolution, Predicaments and Paths Ahead

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Abstract

Livestock production is an important source of carbon emissions, and the low-carbon transformation of the livestock sector is a critical path to achieving sustainable development of the global economy and society. China is one of the most important livestock-producing countries in the world, so it is necessary to study the evolution and predicaments of low-carbon development in the livestock sector and put forward a scientific and reasonable emission reduction path. Our study first describes the development process of the low-carbon livestock sector in China and calculates the carbon emissions of the livestock sector from 2000 to 2019. It is found that carbon emissions from China's livestock sector show a trend of increasing and then decreasing continuously from 2000 to 2019, which has a great potential for emission reduction. Then the predicament of low-carbon development of the livestock sector in China is put forward. Finally, from the perspectives of the government, livestock farmers, enterprises, the public, and other social institutions, a multi-subject collaborative mechanism is constructed, and corresponding implementation paths are designed, to provide theoretical support and suggestions for accelerating the low-carbon transformation of the livestock sector in China.

Keywords

Low Carbon, Livestock Sector, Carbon Emission, Emission Reduction Path

1. Introduction

Livestock production is an important source of carbon emissions. According to relevant statistics, global livestock production accounts for about 12% - 18% of the total greenhouse gas emissions from human activities (Allen et al., 2019;

Persson et al., 2015). Carbon emission involves carbon dioxide, methane, chlorine oxide, perfluorocarbons, hydrofluorocarbons, sulfur hexafluoride and other greenhouse gas emissions. Livestock production contributes to about 37% of methane (CH_4) emissions and 65% of nitrous oxide (N_2O) emissions worldwide (FAO, 2006; Herrero et al., 2016). It has become an important source of non-CO_2 greenhouse gas (GHG) emissions (Herrero et al., 2016; Streets et al., 2003). As the demand for livestock products increases, particularly in developing countries such as China, GHG emissions from livestock production are expected to increase further and become an important factor in global warming (Caro et al., 2014; Dangal et al., 2017). Therefore, it is very important to study the low-carbon development of the livestock sector.

The low-carbon development of the livestock sector is a systematic project, which is inseparable from technological innovation and also needs the support of the government, the public and other social organizations. On the one hand, reducing greenhouse gas emissions from livestock production through technological innovation is an effective way. Beach et al. (2015), Caro et al. (2016), Herrero et al. (2016), Cai et al. (2017) and Frank et al. (2019) summarized methods for reducing CH_4 emissions in the livestock sector (Beach et al., 2015; Caro et al., 2016; Herrero et al., 2016; Cai, Chang, & Cheng, 2017; Frank et al., 2019), such as improving feed efficiency (Gerber et al., 2013a; Key & Tallard, 2012; Valin et al., 2013), adding lipids to daily dairy cow diets (Caro et al., 2016), replacing liquid systems with solid-liquid separation systems (Du et al., 2018; Hristov et al., 2013; Pelletier & Tyedmers, 2010), and building biogas digesters to recycle methane (Brink et al., 2013). It is estimated that improved feed quality can reduce intestinal CH_4 emissions from livestock production by 7% - 62.4% (Gerber et al., 2013b; Ogino et al., 2016; Zhang et al., 2018). Wang et al. (2017) reported that replacing liquid systems with solid-liquid separation systems can reduce non-CO_2 (CH_4 and N_2O) emissions by 65% (Wang et al., 2017). Furthermore, using CH_4 derived from fecal decomposition as a clean energy source is another effective option for reducing non-CO_2 greenhouse gas emissions (Clemens et al., 2006; Feng et al., 2012). On the other hand, many countries have also introduced corresponding policies to accelerate the process of low-carbon livestock. In 2005, the UK Department for Environment Food & Rural Affairs set out a ten-year research plan outlining key areas for funding in livestock production technology, including Global warming on livestock production and its sustainable development. In 2011, the French sustainable development formulated a series of new policies and regulations for low-carbon livestock such as to fully support the development and utilization of biogas resources, and by 2020, the injection amount of methane gas network to reach the 1/3 of France in natural gas production at present, equivalent to about 200,000 households of the gas consumption. Germany also has implemented many actions, such as the National Energy Efficiency Action plan, the German Energy and Climate plan, among those actions relating to the livestock sector, such as the integration of climate change into the

EU's rural development policy.

After years of development, China has become an important livestock sector country in the world, and the output of major livestock products ranks first in the world. However, it should also be noted that the development and management of livestock sector in China are extensive, having problems such as backward breeding technology, serious breeding pollution and high carbon emissions. CH_4 and N_2O emissions from China's livestock production account for 18.7% and 23.4% of global livestock emissions, respectively (Herrero et al., 2016; Zhuang et al., 2019). Moreover, with the growth of China's population, the improvement of people's living standards and the acceleration of urbanization, people's demand for livestock sector products will continue to increase, and more greenhouse gas will emissions in China if no effective measures are taken (Dangal et al., 2017; Du et al., 2018; Meng, 2014). China formulated an action to peak carbon dioxide emissions by 2030. Therefore, it is important and urgent to accelerate the low-carbon development of livestock sector. Nowadays, in the process of promoting the low-carbon development of livestock sector, the government is no longer the only participant. It is necessary to establish a diversified collaborative governance mechanism involving the government, enterprises, the public, universities, research institutes and other subjects. So far, there are only a few systematic studies on the low-carbon development of livestock sector in China, and the roles of different participants have not been fully considered. Under the new development situation, it is urgent to find out the current situation and predicament of low-carbon development of livestock sector and build an effective mechanism for low-carbon development of livestock sector in China.

China is a big livestock production country in the world, reducing carbon emissions and promoting low-carbon development of livestock sector is not only related to the high-quality development of livestock sector, but also related to the realization of "carbon peak and carbon neutrality" target. In this background, this article first expounds on the development of livestock sector in China. And then from China's livestock sector carbon emissions measurement to analyze its trend and the challenge for the current development, finally proposed to build multiple cooperative mechanisms and implement the path of China's livestock sector low-carbon development, to promote the high-quality development of low-carbon livestock sector in China.

This study enriches the relevant theoretical research on the low-carbon development of livestock sector in China. At the same time, this paper designed the multi-collaborative mechanism for the low-carbon development of livestock sector, and developed the corresponding development path, which can provide practical guidance for the low-carbon development of livestock sector in China.

2. Evolution of Low-Carbon Development of Livestock Sector in China

To clearly describe the current situation of livestock sector in the development of

low carbon, our study first on clarifying the development of China's low-carbon livestock from 1978 to the present, and then collect data and build a model. We measured livestock sector carbon emissions in China during 2000-2019, in order to intuitively understanding development trend of China's low-carbon livestock.

2.1. Low-Carbon Development of Livestock Sector in China

The development process of livestock sector in China can be divided into three main phases (as shown in Figure 1): rapid development stage, transformation stage and green ecological development stage.

2.1.1. The Rapid Development Stage (1978-1997)

The fourth Plenary Session of the 11th CPC Central Committee in 1979 called for "vigorously developing livestock sector and increasing the proportion of livestock sector in agriculture", which greatly increased the enthusiasm of farmers to raise livestock. In March 1980, the State Council approved and transmitted *The Report on Accelerating the Development of Livestock sector*, pointing out that the proportion of livestock sector in agriculture should be increased, same as the proportion of meat, eggs, and milk in food (The State Council, 2016a). In 1984, the total output of meat in China reached 15.4060 million tons, an increase of 45.01% over 10.624 million tons in 1979. In 1992, the 14th National Congress of the Communist Party of China formally proposed the establishment of a socialist market economy system, and China's rural reform began to shift to a market economy, which promoted the integration of the development of livestock and industry, and built the division of labor in all aspects of the livestock industry chain. Then the livestock industry has developed rapidly. In general, China's livestock sector economy developed rapidly in this stage, but it showed a trend of extensive growth, with a small breeding scale, backward breeding technology and livestock product processing technology, and simple livestock sector structure.

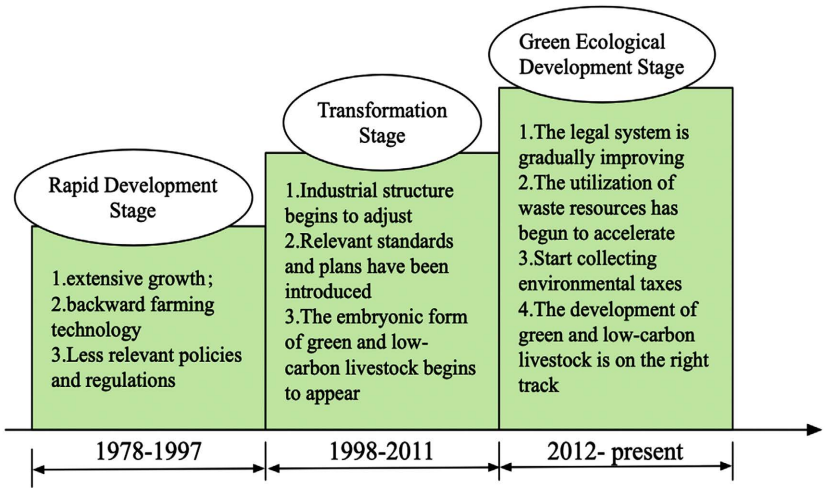

Figure 1. Evolution characteristics of low-carbon development of livestock sector in China. Note: The figure is drawn by the authors based on data.

2.1.2. The Transformation Stage (1998-2011)

In the late 1990s, there appeared many problems in China's livestock sector. For example, the structural and regional problems, and the product safety problem. Therefore, China implemented a series of policies to promote the development of livestock sector, and macro regulation means gradually strengthened. In October 2001, the Ministry of Agriculture issued *the Opinions on Accelerating the Development of Livestock sector*, focusing on the adjustment and optimization of the structure and distribution of livestock sector (The Ministry of Agriculture, 2001). In January 2002, the Central Rural Work Conference pointed out that we should unswervingly advance the strategic adjustment of agriculture and rural economic structure, improve the overall quality and efficiency of agriculture, and promote the livestock sector structure. In 2004, the Ministry of Agriculture formulated *the Plan for the Construction of National and Industry Standards for Livestock sector* (2004-2010). China has launched a special revision plan for agricultural industry standards and a series of policies to promote the development of livestock sector (The Ministry of Agriculture, 2016). In January 2007, the State Council issued *the Opinions on Promoting the Sustainable and Healthy Development of Livestock sector* to promote and accelerate the transformation of livestock sector from traditional to modern (The State Council, 2007). In this stage, the rudiment of green low-carbon livestock sector begins to appear.

2.1.3. The Green Ecological Development Stage (2012-Present)

Since the 18th CPC Central Committee, the construction of ecological civilization has been placed in a prominent position. In 2012, the CPC Central Committee and the State Council issued *The Guidance on Accelerating the Promotion of Agricultural Science and Technology Innovation and Continuously Strengthening the Supply and Guarantee Ability of Agricultural Products*, which pointed out that strengthening pollution control in agriculture, and livestock sector has entered the stage of ecological health breeding (The Central Committee of the Communist Party of China and the State Council, 2012). After that, China introduced a series of policies to standardize and guide the healthy development of livestock sector. In November 2013, the State Council issued *The Regulations on the Prevention and Control of Pollution from Large-scale Livestock and Poultry Breeding*, focusing on promoting the comprehensive utilization and harmless treatment of livestock and poultry breeding waste, and adhering to the principle of prevention first and prevention combined (The State Council, 2016b). In June 2017, The General Office of the State Council issued *The Opinions on Accelerating the Resource Utilization of Livestock and Poultry Waste*, pointing out that we should attach equal weights to the protection of supply and environment, and comprehensively promote the resource utilization of livestock and poultry waste (The State Council, 2017a). *The Environmental Protection Tax Law*, which took effect in January 2018, levied environmental taxes on farmers with more than 50 cattle or 500 pigs or 5000 chickens and ducks, in the meantime, proposing to establish a subsidy policy for increasing the organic fer-

tilizer on agricultural land (The State Council, 2017b). In June 2018, the CPC Central Committee and the State Council issued *The Opinions on Comprehensively Strengthening Ecological Environmental Protection and Resolutely Fighting the Tough Battle of Pollution Prevention and Control*, which provided important instructions on many aspects, such as balancing grass and livestock, controlling and utilizing livestock manure (The Central Committee of the Communist Party of China and the State Council, 2018). These actions have greatly promoted the recycling of livestock and poultry waste and promoted the green and low-carbon development of China's livestock sector.

2.2. Carbon Emission Measurement of Livestock Sector in China

The carbon emissions in livestock sector mainly come from the following aspects: first, the intestinal fermentation of livestock. The food fermentation in the intestinal of livestock will produce a large amount of methane, and the carbon emissions generated by different fermentation locations of livestock are different. Second, carbon emissions are generated by the decomposition of livestock feces. During the decomposition process of livestock feces, methane and other greenhouse gases will be produced. The humidity, energy feed, digestibility and feces treatment will affect the carbon emissions of feces decomposition. The third one is the carbon emissions generated by energy consumption in the feeding process, such as heating, lighting, feed production, etc.

Our study adopts the emission coefficient method of IPCC (IPCC, 2006) to measure the carbon emissions of China's livestock sector from 2000 to 2019. The calculation method of carbon emissions is shown in Formula (1).

$$E_t = E_{CH_4} + E_{N_2O} = \sum N_i \times \alpha_i + \sum N_i \times \beta_i \tag{1}$$

where, E_t, E_{CH_4}, E_{N_2O} refer to the total carbon emission, the corresponding carbon dioxide emission of CH_4 and the corresponding carbon dioxide emission of N_2O respectively. N_i refers to the average feed quantity of the ith species, α_i and β_i refer to the emission factors of CH_4 and N_2O of the ith species, respectively. CH_4 mainly comes from intestinal fermentation and manure management of livestock, while N_2O mainly comes from manure management of livestock. As there are significant differences in the feeding period of livestock, the calculation of the average feeding quantity of all kinds of livestock should be adjusted according to whether the feeding period is longer than one year. The specific method refers to the research of IPCC (IPCC, 2006) and Hu Xiangdong (Hu & Wang, 2010), as shown in Formula (2).

$$N_i = \begin{cases} DA_i \times \dfrac{M_i}{365}, & DA_i < 365 \\ \dfrac{C_{it} + C_{i(t-1)}}{2}, & DA_i \geq 365 \end{cases} \tag{2}$$

where, N_i represents the average annual feeding quantity of the ith species, while DA_i represents the life cycle of the ith species. Generally, the life cycle of

the poultry, the rabbit and the pig is less than one year, which are 55*d*, 105*d* and 200*d* respectively. M_i represents the annual output of the *i*th species, C_{it} represents the year-end stock of the *i*th species in year *t*.

CH_4 emission coefficient refers to IPCC (IPCC, 2006), and N_2O emission coefficient refers to Hu Xiangdong et al. (Hu & Wang, 2010). For details, see **Table 1**.

According to IPCC (IPCC, 2006), the greenhouse effect indices of CH_4 and N_2O are shown in **Table 2**.

The data of all kinds of livestock in this paper mainly come from *China Rural Statistical Yearbook*, *China Statistical Yearbook* and *China Agricultural Yearbook*.

The carbon emissions of livestock sector in China from 2000 to 2019 can be estimated according to the Formula (1). Specific results are shown in **Figure 2**. In general, carbon emissions from China's livestock sector industry kept growing after 2000, peaked around 2006, declined sharply in 2007, and then remained stable. After that, carbon emissions showed a declining trend and kept decreasing. Specifically, the short-term drop in carbon emissions between 2006 and 2007, it was caused by the influenza epidemic in 2006. And it was also affected by a variety of factors. For example, the Chinese government's policy on sustainable and healthy development of livestock in 2007 led to the transformation

Table 1. Greenhouse gas emission coefficients (Unit: Kg/head/year).

Livestock Type	Methane Emission Factor		Nitrous Oxide Emission Factor
	Gastrointestinal Fermentation	Fecal Fermentation	
Poultry	0	0.02	0.02
Rabbit	0.254	0.08	0.02
Pig	1.00	3.50	0.53
Cow	68.00	16.00	1.00
Cow/Buffalo	51.40	1.50	1.37
Horse	18.00	1.64	1.39
Donkey	10.00	0.90	1.39
Mule/Hinny	10.00	0.90	1.395
Goat	5.00	0.17	0.33
Sheep	5.00	0.15	0.33
Camel	46.00	1.92	1.39

Table 2. Greenhouse effect index of methane and nitrous oxide.

Types of Greenhouse Gases	Greenhouse Benefit Index (CO_2 Equivalent)
CH_4	25
N_2O	298

Figure 2. The carbon emissions of livestock sector in China from 2000 to 2019.

of livestock sector (The State Council, 2007); modern machines replaced beef cattle and buffalo with traditional functions (Hu & Wang, 2010). In 2007-2015, Carbon emissions from livestock sector have a relatively small change and have been declining since 2016. It reflects the gradual adjustment of livestock sector production after the impact from 2006, which is mainly reflected in the structural change of livestock sector, the progress of cultivation technology and fertilizer management (Gao et al., 2014; Cai & Akiyama, 2017), and the improvement of production efficiency (Chen & Shang, 2014; Bai et al., 2018). In the long run, China's livestock sector carbon emissions have a lot of room to reduce, and it must be imperative.

3. Predicaments of the Low-Carbon Development of Livestock Sector in China

3.1. Lack of Environmental Awareness

With the rapid development of China's rural economy, the income level of rural residents is growing daily. By 2015, the average per capita income in China's rural areas has exceeded 10,000 yuan. However, the rural environmental pollution has become more serious. On the one hand, due to the lack of environmental awareness and driven by economic interests, farmers will randomly discharge pollutants such as feces and sewage into rivers and soil without equipment treatment in the process of livestock breeding, which causes serious pollution to the rural environment. On the other hand, the public's low-carbon consumption can force enterprises to produce low-carbon products, but at present, Chinese consumers' participation in low-carbon consumption is low (Bo et al., 2022). That is because Chinese consumers haven't formed and established the concept of green and low-carbon consumption, which is not conducive to reducing carbon emissions from China's livestock industry from the demand side.

3.2. Lack of Technological Innovation

Firstly, the technology of China's independent innovation energy-saving and emission reduction has a limitation, and the traditional emission technology such as biogas technology and composting technology cannot solve the problem of nitrogen loss well. Second, research institutions and universities pay more attention to theoretical research on livestock sector, but lack of awareness of the transformation of scientific research results, resulting in a lot of research results that cannot be well promoted. The development of livestock sector's marketization and industrialization process of slow, and the mechanism of industry-university-research collaboration has not yet been formed (Wang et al., 2020). Third, due to the lack of corresponding funds, equipment and technical support, there is still a certain gap between China and developed countries in the low-carbon livestock sector technology, which has a great impact on the development of low-carbon livestock sector. The last one is the feed formula unscientific, and uses backward processing technology. Feed formula is mostly processed through a simple mixing ratio, instead of a scientific ratio. Moreover, the formula uses a single selection of raw materials and additives. There are not many pollution-free and high-utilization raw materials. After the crude feed is eaten by livestock and poultry, the utilization rate is low, the excretion of nitrogen in feces increases correspondingly, causing environmental pollution.

3.3. Imperfect Policies and Regulations

At present, China has a series of laws and regulations such as *Animal epidemic Prevention law*, *Farming practices*, *Veterinary method* to ensure the healthy development of livestock sector, but many provisions in laws and regulations are out of date (Chen, 2016), not rigorous, and the lack of specific laws and regulations that aimed at livestock sector green and low-carbon development. Compared with developed countries, there is still a considerable gap. Moreover, it is too expensive for farmers to change their production methods without adequate government subsidies and market support, so most of them will remain the status quo (Xu & Wu, 2022). There is a lack of incentive policies for low-carbon technology development research and procurement of low-carbon equipment, which restricts the large-scale promotion of livestock sector low-carbon technology.

4. Design of Multi-Subject Collaborative Mechanism

Under the background of "carbon peak and carbon neutrality", China's livestock sector is in a critical period of transformation from traditional livestock sector to modern livestock sector with green and low carbon. Carbon emission reduction in livestock sector involves not only farmers, but also governments, enterprises, the public, scientific research institutes, industry associations and other social organizations. Different entities have different roles and roles to play. Therefore, it is necessary to establish an innovative mechanism of multi-subject coordina-

tion, efficient coordination and win-win cooperation to promote the low-carbon development of Livestock sector in China.

Livestock farmers are the core of the multi-subject collaborative mechanism, undertake the important task of low-carbon farming, and they are also the carriers of policy, technology, and other factors transformation. They have interests related to the government, the public, enterprises, and other organizations. Specially speaking, firstly, the breeding behavior of farmers will be supervised by the government. Meanwhile, as the country encourages the low-carbon transformation of the livestock sector, farmers will also receive incentives from the government, such as various subsidies and tax exemption policies. Secondly, livestock farmers are in the supply, livestock products are mainly purchased by the public, so farmers are bound to have contact with consumers. Thirdly, farmers generally buy production technology and pollutant disposal equipment from livestock technology enterprises, and these related enterprises also strengthen the relationship with farmers for profit, to facilitate the promotion of their products. Finally, farmers will also be affected by the industry they are in. The industry association has formulated relevant standards and industrial agreements to regulate the behavior of farmers, accompanied by resource allocation and interest cooperation. Universities and other institutions will also exert an influence on farmers, mainly reflected in the establishment of related majors in universities, which can continuously export talents and related concepts for this field. Therefore, the livestock farmer is at the center of the whole mechanism, as shown in Figure 3.

The government plays an overall and coordinating role in promoting the low-carbon development of livestock sector, mainly by means of policy formulation, coordinating benefits, propagandizing, and directing. In this multi-collaborative mechanism, the government needs to strengthen the publicity and guidance of low-carbon consumption to the public. Moreover, the government should encourage livestock sector enterprises to increase low-carbon

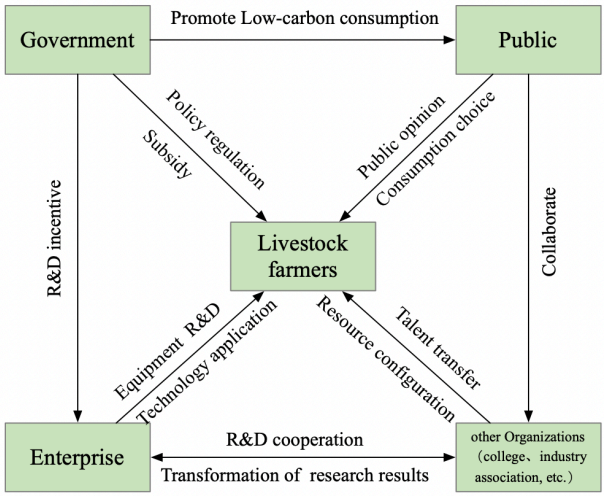

Figure 3. Multi-subject collaborative mechanism of low-carbon development of livestock.

technology research and equipment production through R & D subsidies and should encourage and guide farmers to purchase low-carbon production equipment through subsidies. Strong government leadership can accelerate the progress of low-carbon livestock.

Enterprises are the key to the low-carbon development of livestock sector. Technological progress will significantly reduce greenhouse gas emissions (Dai et al., 2021). The low-carbon development of livestock sector cannot be separated from the support of low-carbon breeding technology, while the promotion of breeding technology should have the participation of enterprises. In the meanwhile, the research achievements of universities and scientific research institutions should get practice in the enterprises. However, at present, there are only a few enterprises focusing on the research and development of low-carbon breeding technology in China, and there is a lack of certain incentive mechanism for research and development, so the development of low-carbon breeding technology is slow.

The public is an important driving force for the low-carbon development of livestock sector. On the one hand, the public is the end consumer of processed livestock sector products and has the right to choose low-carbon livestock sector products. On the other hand, the public is an important disseminator of public opinion and plays an important role in social supervision. At present, the concept of green and low-carbon consumption has gradually gained public support. Some consumers begin to choose products that adhere to green and low-carbon, which plays an important role in promoting the development of low-carbon livestock sector.

Universities, scientific research institutes, industry associations and other social organizations play an important auxiliary role in the low-carbon development of livestock sector. On the one hand, these institutions can continuously transfer talents and management concepts to farmers to promote the R & D of low-carbon technologies, for the practical application of low-carbon technologies. On the other hand, these institutions also play an important role in the formulation of industry rules and the allocation of market resources.

The realization of low-carbon livestock sector needs the cooperation of all kinds of entities, and through certain mechanisms designed to eliminate or alleviate the original promotion resistance and estrangement, achieve win-win cooperation of multiple subjects, and ultimately promote the development of low-carbon livestock sector.

4.1. Establish the Overall Planning and Regulation

1) Improve policies related to the development of low-carbon livestock sector.

At present, there are few policies for the development of low-carbon livestock sector in China, and many restrictive policies and insufficient incentive policies. There are certain legal blind spots, which cannot support the high-quality development of low-carbon livestock sector in China. To provide guidance and

support for the development of low-carbon livestock sector, it is necessary to comprehensively improve the relevant administrative regulations of low-carbon livestock sector. On the one hand, it is necessary to establish a low-carbon livestock sector policy system, formulate and issue relevant administrative regulations, such as large-scale livestock breeding, ecological animal husbandry reserves, and resource utilization of livestock breeding waste. It should be strengthened supervision of livestock breeding, storage, circulation, and operation. On the other hand, law enforcement should be strengthened to severely punish enterprises and individuals who violate relevant regulations.

2) Make a scientific plan for livestock sector layout and development.

Local governments should make regional management plans. Specifically speaking, setting delimit control and prohibited breeding areas. Then, calculate the maximum carrying capacity of livestock, and ammonia and phosphorus content of the areas. At the same time, given the disconnection between livestock sector and planting, relevant departments should select suitable places, combine agriculture and livestock sector, and formulate plans following with local conditions.

4.2. Strengthen Research and Promotion of Low-Carbon Breeding Technology

1) Accelerate research and development of low-carbon farming technologies.

Livestock sector enterprises should be guided to actively conduct research and development of low-carbon breeding technologies and manufacturing of low-carbon equipment. The government should support them using research subsidies and tax reductions. Meanwhile, an integrated research and development system of "production, learning and research" should be established under the guidance of the government. Moreover, learning and drawing on the development experience of the foreign advanced livestock sector. Cooperation with countries with the successful development of low-carbon animal husbandry, and appropriately introduce their advanced technology and equipment, to get an advanced international technical guarantee for the sustainable development of low-carbon livestock sector in China.

2) Increase the promotion and application of low carbon farming technology.

Relevant departments and industry organizations should establish low-carbon breeding standards and guide the development of the industry scientifically. A special fund for the development of low-carbon livestock sector will be set up to subsidize farmers who purchase low-carbon technology and equipment. Explore low-carbon livestock development projects to compensate farmers for "additional" emissions reductions caused by the adoption of low-carbon production technologies and management patterns.

4.3. Build the Farming Operation Mode

1) Promote the low-carbon transformation of breeding sites.

Adopt low-carbon architectural design, such as choosing reasonable building orientation, wall penetration ratio and building structure, to enhance the cold and heat resistance of the building and reduce energy consumption. Moreover, use low carbonization in heating methods, such as floor heating. Use of new energy sources such as geothermal energy, solar energy, and wind energy to reduce carbon emissions.

2) Optimize the selection of feed and additives.

Methane emissions from animals can be reduced through treatments such as ammonification and silage to improve the digestibility of livestock straw, or by increasing the use of low-protein diets. Use of multifunctional blocks rich in trace elements, minerals and vitamins to reduce greenhouse gas emissions. A reasonable ratio of crude and concentrate feed can reduce methane emission of individual animals without affecting animal health.

3) Reduce methane emissions from manure.

If conditions permit, centralized treatment of feces can be carried out, and establish different regions to collect and process feces from farms uniformly. Then, methane produced by feces fermentation can be converted into biogas. For example, methane emissions can be reduced while improving manure collection rates by separating dry manure from solid liquids, it can also be reduced by covering manure or using membrane-covered storage.

4.4. Strengthen Public Opinion Guidance and Advocate Low-Carbon Consumption

1) Strengthen public opinion guidance of low-carbon livestock sector development.

Through the brochure, television, new media and so on to spread the concept of low-carbon farming, to let farmers realize environmental pollution existing in the breeding process, and the importance of low-carbon farming. Through social circumstances guide farmers to change the mode of operation, and organize regular training to let them study low carbon farming methods.

2) Strengthen green supply and low-carbon consumption.

From the supply side, to strengthen green supply, the government should provide convenience and reduce the entry threshold of the green and low-carbon livestock enterprises, such as, reducing taxes. From the demand side, it is necessary to strengthen the publicity of low-carbon consumption and guide the public to establish awareness of low-carbon consumption. Let the public truly understand the high-cost performance and a high ecological output value of green and low-carbon consumption, and finally promote the whole society to form a green and low-carbon consumption lifestyle.

5. Conclusion

This paper studies the evolution, predicaments and future development path of the low-carbon livestock sector in China and draws the following conclusions: 1) The low-carbon development of the livestock sector in China can be divided into

the rapid development stage, transitional development stage and green ecological breeding stage. 2) Carbon emissions from the livestock sector in China increased first and then decreased from 2000 to 2019. 3) The low-carbon development of the livestock sector in China is faced with some difficulties, such as lack of environmental awareness, lack of technological innovation and imperfect policies and regulations. 4) We suggest that China's livestock sector should build multiple subjects of low carbon development synergy mechanism, from the government, farmers, enterprises, public and other social institutions, and other aspects. To be specific, the first one is government should do a regulation; the second is to strengthen and promote low-carbon farming technology research and development; the third is to shift the breeding model, and the last one is to strengthen public opinion to guide and advocate low carbon consumption.

Authors' Contributions

Conceptualization, S. M.; methodology, S. M.; software, Z. C.; formal analysis, S. M.; writing—review and editing, S. M. and Z. C.; visualization, Z. C. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

All data are available online.

Conflicts of Interest

The authors declare no conflict of interest.

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