Global Environmental Institute
北京市朝阳区永续全球环境研究所

Brazil's Certficate Seal for "Carbon Neutral" Agricultural Products Study Report

Author: Liu Qingzhi Cao Dandan Yan Tian Zhou Caihua Ren Peng Zhang Lina

Contents

I.Concept, development and application of carbon neutrality....2

1.1 Definition....2

1.2 Concept derivation and development....2

1.2.1 Concepts concerning carbon neutrality....2

1.2.2 Agricultural carbon emissions....3

1.3 Understanding low-carbon agricultural development....4

1.3.1 Low-carbon agricultural development in New Zealand....4

1.3.2 Australian low-carbon agricultural development....6

1.3.3 Canadian low-carbon agricultural development....9

1.3.4 Californian low-carbon agricultural development....11

1.3.5 Low-carbon agricultural development in the UK....11

1.3.6 Irish low-carbon agricultural development....12

1.3.7 Brazilian low-carbon agricultural development....12

II. Carne Carbono Neutro (CCN)....15

2.1 Concepts....15

1) Proposal of CCN....15

2) CCN label....15

3) CCN label technology/production requirements....15

2.2 Qualifications and procedures of applying for CCN label....16

1) Qualifications....16

2) Procedures....16

2.3 Accounting methodology of CCN....17

1) Accounting method of methane emissions from cattle intestines....17

2) Accounting method of carbon sink emissions from trees....17

2.4 Critical analysis of CCN....18

III. Lessons from CCN certificate seal....19

3.1 Profound significance of the CCN....19

3.2 Enlightenment to the establishment of agricultural carbon neutral system in China....20

3.2.1 Food-related certification system in China....20

3.2.2 Suggestions on the establishment of China's carbon neutral beef system....23

3.3 Analysing domestic marketing channels....23

1) Understanding the organic products'promotion system....23

2) Financing for green products....24

3.4 Conclusions....24

Annex I Agricultural policies and practices in response to climate change in agriculturally dominant countries....25

I. Concept, development and application of carbon neutrality

1.1 Definition

In December 2015, the United Nations (UN) established the *Paris Agreement* and introduced the term "net-zero emission" for the first time in an international convention. The convention aims to achieve, on the basis of equality, a balance between anthropogenic emissions of greenhouse gas (GHG) sources and removals of its sinks in the second half of this century. The *Paris Agreement* established the basic framework of international cooperation in response to climate change after 2020, and put efforts to control the global average temperature rise within 2°C above the pre-industrial level and the temperature rise within 1.5°C above the pre-industrial level.

In 2018, the Intergovernmental Panel on Climate Change (IPCC) published the *Special Report on the Impacts of Global Warming of 1.5°C*, in which the concept of "carbon neutrality" was put forward for the first time, which was **defined as a balance between the carbon dioxide (CO_2) emissions from an organization and the amount of CO_2 removed technically within a year.**

In order to implement the Paris Agreement, some major countries and state actors have successively defined "carbon neutrality" and put forward the corresponding goals. Among them, the EU Council formally adopted a resolution on March 5, 2020, and submitted the Long-term Low Greenhouse Gas Emission Development Strategy of the European Union and its Member States to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC). The Strategy points out that "carbon neutrality" means climate neutrality, a reduction of the net carbon dioxide emissions to zero, and a commitment to achieve net-zero carbon emissions by 2050.

At the 75th Session of the United Nations General Assembly on September 22, 2020, President Xi Jinping announced that China would scale up its Nationally Determined Contributions (NDCs) by adopting more vigorous policies and measures, strive to peak CO_2 emissions before 2030, **and achieve carbon neutrality before 2060.**

1.2 Concept derivation and development

1.2.1 Concepts concerning carbon neutrality

According to the above definition, the concepts similar to carbon neutrality include net-zero emissions, climate neutrality and net-zero carbon (carbon dioxide) emissions, with slight differences. Among them, the concept of **net-zero carbon (carbon dioxide) emissions** is basically consistent with the concept of carbon neutrality given in the *Special Report on the Impacts of Global Warming of 1.5°C* published by IPCC, that is, carbon neutrality or net-zero carbon dioxide emission refers to a balance between the carbon dioxide (CO_2) emissions from an organization and the amount of CO_2 removed technically within a year.

The concept of **net-zero emissions** doesn't take the year as the time unit, but points out that net-zero GHG emission is reached when all the GHG emissions **(CO_2e)** of an organization reach a balance with the GHG removals in a specific period. Finally, **climate neutrality**, defined from the perspective of climate change, refers to the situation when an organization's activities have no net impact on the climate system. The definition of climate neutrality must take regional or local geophysical effects (e.g., radiation effects from channels such as aircraft condensation trails) into consideration.

In conclusion, there are many similarities and differences among these concepts related to carbon neutrality. Net-zero carbon emission is similar to "carbon neutrality", only related to carbon dioxide, which generally refers to a balance between the removal and emission of carbon dioxide. The "net-zero emission" differs from the "carbon neutrality". "Net-zero emission" generally refers to a balance between anthropogenic emissions of GHG sources and removals of its sinks, while "carbon neutrality" refers to the balance between carbon dioxide emission and removal. The concept of "climate neutrality" is similar to "carbon neutrality", but "climate neutrality" includes the biogeophysics influence of human activity areas and places.

1.2.2 Agricultural carbon emissions

According to the Second Sustainable Development Goal (SDG 2 for short) put forward by the UN on September 25, 2015, i.e., "end hunger, achieve food security and improved nutrition and promote sustainable agriculture", the sustainable food production system depends on the ability of agriculture to adapt to and cope with climate change, extreme weather, drought, floods and other disasters. Globally, GHG emissions from agriculture and land use by deforestation accounted for 24% of global GHG emissions[1].

According to the Food Systems are Responsible for a Third of Global Anthropogenic GHG Emissions[2] published in Nature Food in May 2021, food systems accounted for more than a third[3] of global GHG emissions in 2015, with emissions up to 18 Gt CO_2e. The food production (including fisheries, aquaculture and agriculture, plus emissions from the production of inputs such as fertilizers) is by far the main contributor to the overall food system emissions, accounting for 39% of the total emissions, followed by the land use and land use change (including carbon loss from deforestation and degradation of organic soils including peatlands), accounting for 32% of GHG emissions, and other procedures including distribution (transportation, packaging aging and retailing), processing, consumption and end-of-life disposal, accounting for 29%.

Methane (CH_4) emissions, mainly from livestock and rice cultivation, account for about 35% of total global GHG emissions from food systems, with roughly the same proportion in developed and developing countries [4]. In 2014, China's agricultural and rural GHG emissions accounted for 15% of the total GHG emissions[5].

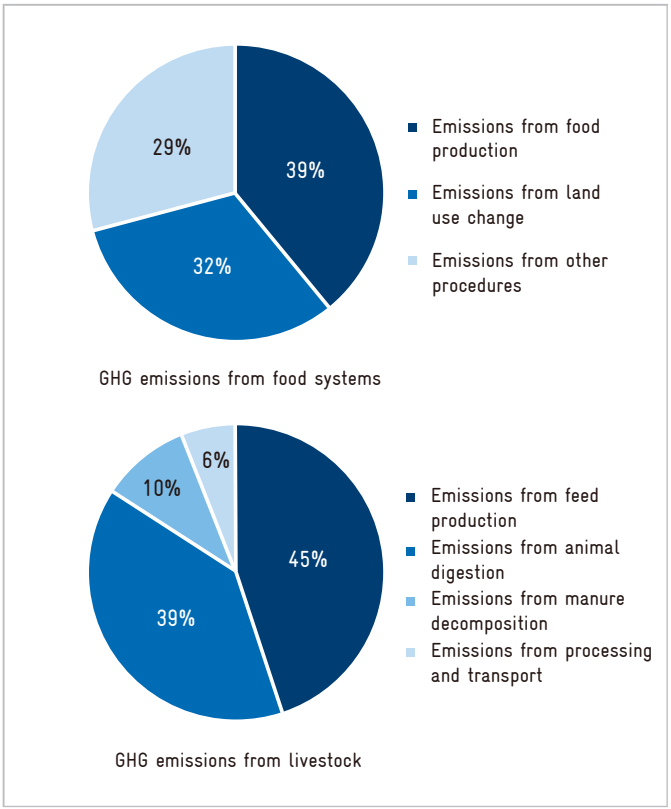


Figure 1 GHG emissions from food systems

As early as 2013, the Food and Agriculture Organization of the United Nations (FAO) released the report *Tackling Climate Change Through Livestock - A Global Assessment of Emissions and Mitigation Opportunities,* indicating that the annual global GHG emissions associated with the livestock supply chain total 7.1 billion tons CO_2e, accounting for 14.5% of total anthropogenic GHG emissions. Of the GHG emissions from livestock, feed production accounts for 45%, animal digestion for 39%, manure decomposition for 10%, and the remainder from the processing and transport of animal products. FAO pointed out that the global livestock industry is expected to reduce emissions by 30% by improving the composition of livestock feed, feeding cattle with less stomach gas, etc. This shows that it should prioritize the choice of digestible animal feed in low-carbon and carbon-neutral animal husbandry.

The *Special Report on the Impacts of Global Warming of 1.5°C* further stated the importance of less methane emissions, i.e., limiting warming of 1.5°C means achieving net-zero emissions of CO_2 globally around 2050, while significantly reducing non-CO_2 gas emissions, especially methane, which should be reduced by 35% from 2010 levels by 2050. The Report stated that agricultural deep emission reduction is

1 http://www.china.org.cn/chinese/2016-01/28/content_37684346.htm

2 Food systems are responsible for a third of global anthropogenic GHG emissions (ecbpi.eu)

3 https://www.nature.com/articles/s43016-021-00225-9

4 http://www.china.org.cn/chinese/2016-01/28/content_37684346.htm

5 http://dzb.rmzxb.com/rmzxbPaper/pc/con/202103/25/content_4018.html

one of the methods to reduce non-CO_2 gas emissions, and the possible paths include sustainable diet and food waste reduction, soil carbon sequestration, livestock and manure management, sustainable procurement, etc. In addition, other GHG emission reduction methods include reducing energy consumption demand, decarbonization of electricity and other fuels, electrification of end-use energy, and Carbon Dioxide Removal (CDR) represented by carbon storage on land or sequestration in geological reservoirs. Low demand for land and GHG-intensive consumer goods, as well as low energy demand, also contribute to limiting the warming of 1.5°C as close as possible.

In summary, it is indispensable to reduce agricultural carbon emissions. In order to promote the sustainable development of agriculture and food safety and enhance the adaptability of agricultural products to climate change, it is necessary for the agricultural system to experience low-carbon transformation and net-zero emissions. In terms of green development, the agricultural system can make great achievements, including innovative solutions and new breakthroughs made in its emission reduction and carbon sequestration capacity, non-carbon greenhouse gas emission methods, forage quality, wet waste recycling level and interdisciplinary development with the energy industry.

1.3 Understanding low-carbon agricultural development

In response to climate change and in line with the goal of net-zero emissions in the *Paris Agreement* of 2015, more and more countries have formulated "carbon neutrality" strategies and policy mechanisms. Quite a few great agricultural countries have been engaged in development of "carbon neutral" agriculture and its agricultural products, among which Brazil, Australia, New Zealand and other countries are committed to developing "carbon neutral" animal husbandry. This section takes New Zealand, Australia, Canada, California, United Kingdom and Brazil as examples to describe the policies, laws and mechanisms of agricultural emission reduction and carbon neutrality formulated by national and regional governments (Annex I). At present, the government-led policies are mainly voluntary and non-mandatory, intended to provide incentives for farmers to engage in emission reduction and adopt more sustainable agricultural ideas and practices.

1.3.1 Low-carbon agricultural development in New Zealand

New Zealand is an economically developed country based on agriculture dominated by animal husbandry. Because of its vulnerability to climate change, New Zealand is taking the initiative in coping with climate change in terms of agriculture and animal husbandry. The agriculture sector accounts for 50% of the country's total GHG emissions[6].

The New Zealand government's goals on GHG reduction consist of short-, medium- and long-term goals. The short-term goal of New Zealand is a committed international emissions reduction obligation of stabilizing carbon emissions in 2010 at 1990 levels, based on the requirements of *Kyoto Protocol's* first commitment period (2008-2012), which requires all developed countries to reduce emissions of six GHGs, including CO_2, by 5.2% by 2010 compared to 1990 levels. In August 2009, under the *Kyoto Protocol's* second commitment period (2013-2020), the New Zealand government announced a medium-term goal for emission reduction by 2020, further committing to reduce its GHG emissions by 10%-20% by 2020 compared to 1990 levels. In March 2011, the New Zealand government also proposed a long-term goal of GHG reduction by 2050, i.e., a 50% reduction in GHG emissions by 2050 based on the 1990 level[7].

Taking into account the potential costs of action by households and businesses to address climate change, New Zealand updated its 2020 goal of carbon emissions in 2013, with its government committing to a 5% cut in GHG emissions by 2020 from its 1990 levels[8], replacing the previous commitment of a 10%-20% reduction made in 2009. However, in order to fulfill the tasks of the Paris Agreement, New Zealand has committed to achieving net-zero carbon emissions by 2050.

1) New Zealand's national policy on low-carbon agricultural climate adaptation

In order to fulfill this commitment and in favor of the global action of controlling the global average temperature rise

6 http://news.skykiwi.com/na/zh/2018-03-27/255865.shtml

7 New Zealand Emissions Trading Scheme: Status, Characteristics and Enlightenment

8 http://www.nea.gov.cn/2013-09/03/c_132687310.htm

to 1.5°C set by the *Paris Climate Agreement,* in November 2019, the New Zealand Parliament adopted the ***Zero Carbon Bill,*** **and established the New Zealand Climate Change Committee,** which intends to take corresponding actions in New Zealand to curb carbon emissions and effectively respond to climate change, and **requires the government to formulate and implement policies to adapt to climate change,** and **set a "carbon budget" every five years** to limit the allowable carbon emissions every five years. It is also proposed that net-zero emissions of GHGs (except biomethane) will be achieved every calendar year from 2050. Biomethane emissions will be reduced by 10% compared with 2017 levels every calendar year from 2030, and by 24% to 47% compared with 2017 levels every calendar year from 2050[9].

He Waka Eka Noa, the Primary Sector Climate Action Partnership, is a partnership of New Zealand industrial sector, Maori and the government, including New Zealand beekeeping industry, dairy industry and meat industry associations, Ministry of Agriculture and Ministry of Environment, etc. It aims to find the best development path for farmers and growers through the joint efforts of all sectors and play a role in global response to climate change. In 2020, He Waka Eka Noa released the "HWEN Five-Year Work Plan", setting the goal of establishing a framework to reduce agricultural GHG emissions and enhance the resilience of the agricultural sector to climate change by 2025. Under this framework, farmers and growers will be able to measure, manage and reduce GHG emissions. The Plan also pointed out that by 2025, all farmers and growers will incorporate the mitigation of and adaptation to climate change into their agricultural business and environmental plans, and encourage them to take actions against climate change through appropriate carbon emission pricing mechanisms[10].

2) R&D in New Zealand low-carbon agricultural technology

(1) Domestic R&D plans of low-carbon agriculture

In order to reduce GHG emissions from agriculture, the **New Zealand Agricultural Greenhouse Gas Research Centre** (NZAGRC) was established in 2009. The NZAGRC's research plan aims to discover and develop cost-effective methods that can reduce GHG emissions from farms. The **methane research plan** aims to reduce intestinal methane produced by ruminant digestive system and methane emitted from manure management by determining the genetic marker of sheep with low methane emissions, to be included into the breeding index, and by means of alternative forage, methane inhibitor, methane vaccines and scientific manure management. The **nitrous oxide research plan** aims to develop effective and safe compounds that affect nitrification and denitrification rates by developing nitrification inhibitors and low-emission plants, and identify and test different forage plants that can reduce emissions. The **soil carbon plan** aims to quantify and monitor the change of carbon storage in different agricultural underground soils with time by monitoring, using experience and modeling methods, and combining measurement of pasture scale with modeling of different management practices (including plantain and corn)[11].

(2) International R&D plan of low-carbon agriculture

The Global Research Alliance on Agricultural Greenhouse Gases (GRA) was established in New Zealand in 2009, aiming at gathering the best researchers on agricultural GHG emissions in the world, expanding knowledge in this field and speeding up the development of appropriate mitigation technologies and practices. The GRA has established three research groups to engage in the research of three types of agricultural and livestock production systems (i.e., livestock, paddy and farmland) respectively. In addition, a "comprehensive" research group has been established to analyze relevant cross-system issues, such as investigation of soil carbon sequestration methods, modeling ability and compilation of national GHG inventory[12]. At present, more than 60 countries and 20 international and regional partner organizations have joined the GRA.

3) New Zealand low-carbon agriculture certification system

(1) Toitū Envirocare certification mechanism

9 https://www.legislation.govt.nz/bill/government/2019/0136/latest/whole.html#LMS183736

10 https://hewakaekenoa.nz/wp-content/uploads/2020/12/HWEN-Programme-Overview-Oct-2020.pdf

11 https://www.nzagrc.org.nz/domestic/

12 https://www.nzagrc.org.nz/international-activities/global-research-alliance/

The Landcare Research is mainly responsible for the research on land ecosystem, biodiversity, land resources, land environmental protection and sustainable development of agricultural land, and its scientific research results can be used in commercial services through Toitū Envirocare. Toitū Envirocare, as the wholly-owned subsidiary of Landcare Research[13], mainly provides carbon management, carbon emission reduction certification, carbon neutrality certification, environmental management and environmental labeling certification and other services. In addition, Toitū Envirocare also provides a farm certification program, which is the first carbon certification project specially designed for farms in New Zealand. Toitū Envirocare has developed a carbon management software, which can analyze the GHG emissions for cattle farms and dairy farms. The carbon-neutral farm certification includes five major steps. The first step is to monitor the farm's carbon footprint using the carbon emission software; the second step is to identify the emission reduction opportunities and formulate emission reduction plans; the third step is to certify the farm's carbon footprint by an independent third party; the fourth step is to obtain the Toitū carbon emission reduction certificate; and the fifth step is to obtain the Toitū carbon neutrality certificate after offsetting the remaining emissions by carbon credits[14]. In April 2021, Lake Hawea Station became the first farm that has passed the carbon footprint certification[15].

(2) Sustainable wine certification program

The sustainable wine certification is a relatively mature industrial sustainable certification system in New Zealand. The program facilitates local wine growers to measure GHG emissions from wine estates according to the international environmental standard ISO 14064-1:2018, establish annual carbon emission inventory, and make long-term plans to reduce total emissions, so as to achieve emission reduction targets[16]. Certified wines have been sold to quite a few countries around the world.

4) New Zealand low-carbon agricultural development market mechanism

(1) New Zealand emissions trading scheme (NZ ETS)

New Zealand emissions trading scheme (NZ ETS) has been established in accordance with *Climate Change Response Act 2002,* which not only regulates the trading rules of emission units set in the *Kyoto Protocol* in New Zealand, but also establishes "NZU" as a domestic emission unit for emission reduction trading among domestic enterprises in various industries. According to the nature of different industries, the emission trading mechanism distributes the emission units in New Zealand in three ways, i.e., "purchase, selling and free issuance of emission permits by the government"[17]. *Emissions Trading Reform Bill* issued in June 2020 sets caps on the total allowable emissions in the NZ ETS.

(2) Forestry in the NZ ETS

The forestry has been included in the NZ ETS since January 1, 2008. New Zealand is the first to include the forestry into the emissions trading scheme. In New Zealand, with 1990 as the baseline year, forests fall into two categories: pre-1990 forests and post-1989 forests. Moreover, a free quota system is set according to the system design of pre-1990 forests to strengthen forest protection and control emissions from deforestation. The"post-1989 forests"are mainly concerned with the ownership of the forest and the forest carbon sinks. The forest registered in the emissions trading scheme is calculated in accordance with the emissions report and any changes in the carbon storage in the forest are reported, and then the carbon storage unit is obtained after completion of the registration[18].

1.3.2 Australian low-carbon agricultural development

Australia has been actively promoting GHG emission reduction. As early as 1998, it established the *National Greenhouse Strategy*[19]. In 2011, the Australian government put forward the goal of reducing the total carbon emissions by

13 https://www.landcareresearch.co.nz/partner-with-us/toitu-envirocare/

14 https://www.toitu.co.nz/what-we-offer/farm-certification

15 https://www.toitu.co.nz/news-and-events/news/farms/the-first-carbon-zero-farm-in-new-zealand

16 https://www.nzwine.com/en/sustainability/swnz

17 Analysis of Australia and New Zealand's Legislation on Climate Change Response

18 https://www.mpi.govt.nz/forestry/forestry-in-the-emissions-trading-scheme/accounting-for-carbon-in-the-ets/overview-of-carbon-accounting-in-the-ets/

19 https://www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies

at least 80%[20] by 2050 compared with 2000. In 2016, Australia joined the *Paris Agreement,* and released the NDC target, committing to reduce GHG emissions by 26%-28% by 2030 based on 2005 level[21]. In 2019, the Australian government officially announced the *Climate Solution Package*[22], and planned to invest AUD 3.5 billion to tackle climate change[23].

In Australia, emissions from the agriculture and forestry currently account for about 23% of the national emissions[24], and 51% of the land is managed by farmers[25]. In the past 10 years, the agriculture had been the only sector in the Australian economy that continuously reduced the emission intensity and net emissions. Reduction of the GHG emissions on the land will play an important role in fulfilling Australia's commitment to reduce GHG emissions by 2030 set in the Paris Agreement.

1) Australian national policy on low-carbon agricultural climate adaptation

Since climate change has a significant impact on the agriculture, Australia attaches great importance to climate-adaptive development. In 2007, the Australian government issued *The Council of Australian Government National Adaptation Framework*[26] to guide the government to help vulnerable areas or departments, including agriculture. In 2015, the Australian government issued the *National Climate Resilience and Adaptation Strategy*[27], which explains Australia's strategy to deal with climate change risks, establishes a set of effective resilience and adaptation principles to guide climate adaptation, defines the key elements of climate adaptation, and puts forward measures to deal with climate change in agriculture, forestry and fisheries.

In accordance with this strategy, the Australian government mainly takes the following measures in agriculture, forestry and fisheries to improve the adaptability of agriculture to climate change: providing climate and weather information to support farmers' decision-making; investing in agricultural research and development; being committed to Australia's biosafety system; building drought resistance capacity and drought preparedness; and supporting sustainable and profitable agriculture through investment.

In terms of R&D, the Australian government and the industrial community jointly invest USD 550 million in R&D of advanced agricultural technology through Australia's Rural Research and Development Corporations every year. From 2015 to 2022, the Australian government will increase its investment by USD 200 million to fund the projects of cutting-edge technology, applied research and cooperative farm research. In terms of climate change research, Australia invests USD 7.9 million in adaptation research projects in the agricultural sector.

In terms of biosecurity, the Australian government has implemented a formal biosecurity emergency agreement and cooperation arrangement, which facilitates all States, regions and sectors to collect and share information, and identify pests and diseases or weeds that may be caused by climate change in a timely and effective manner.

In terms of drought resistance capacity building and drought preparedness, the Australian government has worked closely with state and regional governments, established intergovernmental agreements (IGA), and implemented a series of national drought programs and reform measures. In 2015, the *White Paper on Agricultural Competitiveness* issued by the Commonwealth of Australia will invest USD 2.97 billion to support farmers and rural communities to fight against the drought.

In addition, in terms of global cooperation, Australia has participated in the Global Research Alliance on Agricultural Greenhouse Gases and cooperated with more than 40 member countries. In terms of natural resource management, Australia has provided USD 450 million to 56 regional natural resource management organizations for natural resource management activities, including determining the best way to achieve local sustainable agricultural priorities.

20 https://news.qq.com/a/20110711/000422.htm

21 https://www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies/international-climate-change-commitments

22 http://www.environment.gov.au/system/files/resources/bb29bc9f-8b96-4b10-84a0-46b7d36d5b8e/files/climate-solutions-package.pdf

23 Adjustment of Australia's Climate Policy and Its Impact

24 https://www.fao.org/fileadmin/templates/agphome/documents/faooecd/australia.pdf

25 https://www.farmonline.com.au/story/6884328/nff-why-australian-ag-must-be-carbon-neutral-by-2050/?cs=5373

26 Interpretation and Evaluation of Australia's Climate Change Policy

27 http://www.environment.gov.au/system/files/resources/3b44e21e-2a78-4809-87c7-a1386e350c29/files/national-climate-resilience-and-adaptation-strategy.pdf

2) R&D in Australian low-carbon agricultural technology

(1) Carbon Farming Futures (2012-2017):

In order to foster the sustainable development of Australian agriculture, the Australian government invested USD 139 million from 2012 to 2017 for purpose of the Carbon Farming Futures (CFF), which supported 350 social organizations and more than 530 farm pilots to carry out activities related to sustainable agriculture. CFF aims to create new opportunities for land managers, as well as improve agricultural productivity, gain better economic and environmental benefits, enhance the adaptability of land to climate change and protect Australia's natural environment while reducing GHG emissions and increasing carbon sequestration.

The Australian Department of Agriculture, Water and the Environment, as the competent department, is responsible for the management of CFF in the following four aspects[28]. **Firstly, filling the research gap:** the competent government departments provide USD 74 million to support the R&D and practices of new technologies, so as to help farmers reduce carbon emissions, increase soil carbon sequestration capacity, and adjust agricultural practices to cope with commercial risks arising from climate change. **Secondly, field actions:** the competent government departments provide USD 44 million to help farmers to experiment with new technologies and methods, with more than 530 farmers and 300 partner organizations participating in the experiment. **Thirdly, technology promotion and expansion:** the competent departments provide additional USD 21 million to improve farmers' professional knowledge, so that they can understand how to improve productivity while reducing emissions and sequestering carbon, and how to participate in the Australian government's emission reduction fund (ERF)[29]. **Finally, tax credit:** the R&D and manufacturing of qualified protective farming equipment (e.g., harvesters) enable to get a 15% refundable tax credit.

(2) Climate Research Strategy for Primary Industries

The Climate Research Strategy for Primary Industries (CRSPI) is a partnership established in 2017 among organizations under the Australian National Research, Development and Extension Framework (RDE), which brings together the expertise required for the Australian agricultural sector to adapt to climate change and reduce carbon emissions, and focuses on the research and technology promotion and application in the fields of agricultural climate adaptation, agricultural carbon emissions, climate change business and policies, etc.

3) Australian low-carbon agricultural market and financial mechanism

(1) *Carbon Credits (Carbon Farming Initiative) Act*

In December, 2011, the Australian Department of Industry, Science, Energy and Resources issued the *Carbon Credits (Carbon Farming Initiative) Act* (the latest revision came into effect on September 6, 2020)[30], which establishes the proposed Australia's Carbon Farming Initiative (CFI) and issues Australian carbon credits for eligible carbon offset projects. CFI aims to reduce GHG emissions through agricultural carbon sinks. CFI allows farmers and land managers to increase land carbon storage or reduce GHG emissions, as well as obtain carbon credits after being certified by designated national agencies and sell them to individuals and enterprises who want to offset their emissions according to national methodology.

(2) Australian Emission Reduction Fund

In October, 2014, the Australian Senate adopted the *Agriculture and Forestry Carbon Credit Plan Amendment 2014,* and Australia will set up an AUD 2.55 billion GHG emission reduction fund (ERF). Australia's emission reduction fund is a voluntary plan, which is promulgated based on the *Carbon Credits (Carbon Farming Initiative) Act 2011, the Carbon Credits (Carbon Farming Initiative) Regulations* 2011 and the *Carbon Credit (Carbon Farming Initiative) Rules 2015.*

Through the ERF, the government will purchase emission reductions with the lowest cost from a wide range of sources (in the form of Australian carbon credit units), and provide incentives for enterprises, families and landowners to actively reduce emissions. Participants can obtain the emission reduction of Australian carbon credit unit (ACCUs) through carbon sink or reduction of carbon emissions, and get an

28 https://www.agriculture.gov.au/ag-farm-food/climatechange/carbonfarmingfutures

29 https://www.agriculture.gov.au/ag-farm-food/climatechange/cfi

30 https://www.legislation.gov.au/Series/C2011A00101

ACCU for every ton of carbon dioxide equivalent (tCO_2e) stored or reduced. ERF can promote the development of agricultural emission reduction projects by purchasing the emission reduction of offset projects.

4) Case study of Australian carbon neutral red meat

The proportion of emissions from the Australian red meat industry in national GHG emissions has dropped from 21% in 2005 to 10% in 2017. Since 2005, the red meat industry has reduced GHG emissions by 57%, from 130.7 million tons of carbon dioxide equivalent (Mt CO_2e) to 557 billion tons of carbon dioxide equivalent in 2017[31].

The three most relevant GHGs from Australian red meat industry are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Their emission sources include cattle, sheep and goats (intestinal methane, methane and nitrous oxide emissions from manure management), fertilizers used in livestock feed production (nitrous oxide emission from fertilizers used in some pasture and crop production), land management practices (vegetation management, savanna burning), waste management in meat processing and energy use (including transportation), and other related secondary processes. Land management practices (vegetation restoration and deforestation avoidance) also represent carbon sink or carbon storage.

In 2020, the Meat & Livestock Australia (MLA) released the carbon neutral by 2030 (CN30) goal of Australian meat and livestock industry, aiming at achieving the goal of net-zero emission of GHGs in Australian red meat and livestock industry by 2030. In order to continuously advance the sustainable development of red meat production, become a world leader in this field, and provide higher-value and high-quality products for Australia and the world, the MLA released the *Australian Red Meat Industry's Carbon Neutral by 2030 Roadmap* in September 2020, based on the CN30 plan. The carbon neutral roadmap mainly includes four major initiatives:

1) Reducing GHG emissions: reducing GHG emissions from grazing management, batch feeding and meat processing operations;
2) Increasing carbon storage: increasing carbon storage in grazing land;
3) Comprehensive management: promoting the application of cross value chain technology to improve management levels;
4) Developing leadership: building leadership and competence among industry stakeholders.

1.3.3 Canadian low-carbon agricultural development

In 2016, Canada joined the Paris Agreement and promised to reduce GHG emissions by at least 30% by 2030 based on 2005 level. In order to achieve the goal of carbon reduction, the *Pan-Canadian Framework on Clean Growth and Climate Change (PCF)* was adopted at the Canada's first ministerial meeting in December 2016[32], which is Canada's first national climate plan. On the basis of PCF, Canada put forward *A Healthy Environment and a Healthy Economy – Canada's Strengthened Climate Plan*[33] in December 2020, with a view to reducing emissions to 32%-40% of 2005 levels by 2030 and achieving net-zero emissions by 2050. On April 22, 2021, when attending the Leaders Summit on Climate, Canadian Prime Minister Justin Trudeau announced that Canada, as one of the signatories of the *Paris Agreement*, would improve its emission reduction targets to reduce GHG emissions to 40%-45% of 2005 levels by 2030. In recent years, Canada has continuously improved the carbon emission reduction targets.

In 2009, Canada produced 690 million tons of carbon dioxide equivalents (Mt CO_2e) from various emission sources, mainly from carbon dioxide generated by energy use. Emissions from the agriculture account for about 8% of the total carbon emissions (56 Mt CO_2e), mainly CH_4 (about two thirds) and N_2O (about one third). With the energy consumption included, emissions from crops and the livestock industry currently account for about 10% of national emissions. The emissions from agricultural activities are CH_4 emissions from intestinal fermentation of ruminant animals, N_2O emissions from soil, CH_4 and N_2O emissions from feces, and N_2O emissions

31 The Australian Red Meat Industry's Carbon Neutral by 2030 Roadmap

32 https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

33 https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview.html

from indirect sources. In fact, since around 1990, Canada's farmlands have been a net sink of carbon dioxide. However, the carbon loss increased from the transformation from forest and grassland to farmland considering the change of land use. In fact, agricultural lands became a net sink of carbon dioxide until after around 2000[34].

1) Canadian national policy on sustainable agriculture and climate adaptation

(1) A Healthy Environment and a Healthy Economy – Canada's Strengthened Climate Plan

Canada boasts 28% of the world's boreal forests (the lungs of the earth), 24% of the global wetlands, 20% of the world's freshwater resources, as well as the longest coastline in the world. Therefore, natural-based climate change solutions are particularly important for Canada. In accordance with the *Strengthened Climate Plan,* Canada will invest USD 3.16 billion in 10 years to plant 2 billion trees, which will be planted all over Canada, including farm land; invest USD 631 million in 10 years to restore and strengthen wetlands, peatlands, grasslands and agricultural land so as to promote carbon sequestration; provide USD 98.4 million in 10 years to establish a new agricultural natural-based climate solution fund to support the actions of the agricultural sector in 2030 and 2050 to cope with climate change and other environmental priorities.[35]

(2) Agricultural climate solutions (ACS)

In March, 2021, the Agriculture and Agri-Food Canada released *Agricultural Climate Solutions (ACS),* and will invest USD 186 million in the next 10 years to help agricultural practices to cope with climate change. The ACS is aimed to establish a regional cooperation network led by farmers, including scientists and other stakeholders, who will jointly develop and share natural-based solutions and agricultural practices to maintain farm competitiveness.[36]

ACS will be implemented in two phases. The first phase will be started on April 1, 2021, with USD 100,000 provided for each project to support the provinces to put forward solutions of regional collaboration center"Living Labs". Each regional collaboration center will focus on the farms, farmers and researchers for collaborative innovation, and take measures such as planting cover crops, permanently covered marginal land, shelterbelt, nutrient management, intercropping and rotation with beans to improve soil fertility, store carbon and protect the environment. The second phase will be started this fall, and each project can be funded with a maximum of CAD 10 million.

2) Canadian (Alberta) market-based mechanism in low-carbon agricultural development

Alberta is the first Canadian province to enact laws pertaining to climate change and to develop regulations to regulate GHG emissions. In 2003, Alberta passed the *Climate Change and Emissions Management Act,* which required large industrial emission entities to report their emissions and take action to enforce emissions reductions. Since 2007, Alberta has established a carbon emission compensation system, which enables the emission enterprises to offset emissions by purchasing and using quotas or carbon emission reduction points as stated in Alberta method. A carbon credit (emission offset) indicates the reduction or sequestration of one-ton GHG gas emissions caused by project activities that are independently verified. Compensation projects includes the implementation of new management practices, technologies and/or control systems to reduce or eliminate carbon emissions in a given process.

In Alberta's carbon emission offset system, carbon offset projects must be accounted according to approved methodology and verified by qualified third parties before being given carbon credits. At present, there are more than 303 registered projects, including agricultural projects. Farmers can obtain carbon credits through no-tillage and reduced tillage of agricultural practice projects.

In order to quantify the carbon offset credit generated by agricultural activities, Alberta issued the *Protocol of Anaerobic Decomposition of Agricultural Materials* in 2007, which is aimed to quantify the methane generated from the anaerobic treatment of agricultural materials such as manure, silage, dead livestock, etc. to replace the emission reduction generated by fossil energy consumption. In 2016,

34 https://agriculture.canada.ca/en/agriculture-and-environment/climate-change-and-air-quality/greenhouse-gases-and-agriculture

35 https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/healthy-environment-healthy-economy.html

36 https://agriculture.canada.ca/en/agriculture-and-environment/agricultural-climate-solutions

Alberta issued the *Protocol on Reducing the Emission in Cattle Breeding,* which is aimed to quantify how much GHG emissions can be reduced from cattle digestion and manure storage/treatment through feeding strategies and other technologies. In the process of livestock production, GHG emissions are mainly from intestinal emissions, i.e., methane (CH_4) that is emitted while the rumen is digesting feedstuff and from methane and nitrous oxide (N_2O) emissions that are produced from the storage and treatment of cattle manure.

1.3.4 Californian low-carbon agricultural development

As a leading organization of California climate change projects, California Air Resources Board (ARB) is responsible for supervising air pollution control work in California and developing relevant plans and actions against climate change. In 2006, California issued the AB 32 *Global Warming Solutions Act of 2006,* which requires California to reduce its GHG emissions to 1990 levels by 2020.

California is the largest state in American agricultural output. According to the 2017 Agriculture Census, California boasts 12% of American agricultural sales, of which the crops account for 74% and the livestock and poultry account for 26%[37]. At present, California low-carbon agricultural development is mainly reflected in the carbon trading system.

1) Californian policy on sustainable agriculture and emission reduction

Pursuant to *AB32 Act,* ARB shall develop a comprehensive strategy to reduce emissions of short-lived climate pollutants, i.e., *SB 1383: Short-lived Climate Pollutants, published* in 2016, requiring emissions of methane and HFCs in the state to be reduced to 40 percent below 2013 levels by 2030 and anthropogenic black carbon emissions to be reduced 50 percent below 2013 levels. In accordance with *AB32 Act,* ARB shall, in consultation with the Department of Food and Agriculture, establish policies and regulations (which shall take effect as of January 1, 2024) to reduce methane emissions from the livestock and dairy manure management operations[38].

2) Californian low-carbon agricultural development market mechanism

In 2006, the ARB issued a *Cap-and-Trade Regulation* covering 80% of California's GHG emissions. In 2013, the state government officially launched *Cap-and-trade Program.* California applies the *Regulation for the Mandatory Reporting of Greenhouse Gas Emissions* (MRR) for the carbon market to collect data on enterprises' carbon emissions. More than 400 enterprises from electricity and other industries can obtain carbon quotas through free allocation or auction.

ARB has formulated the carbon market compliance offset plan, stating that carbon credits can be obtained through carbon offset for enterprises'performance. In California's carbon trading system, carbon offset projects are the only effective compliance instrument in addition to quota. In the field of agriculture and forestry, the carbon offset projects that can be developed include livestock manure projects, rice cultivation projects and urban forest carbon sink projects. *The Compliance Offset Protocol Livestock Projects*[39] provides methods to quantify and report greenhouse gas (GHG) emission reduction for livestock projects. The protocol focuses on the methane emission reduction. *The Compliance Offset Protocol Rice Cultivation Project*[40] states methods for quantifying reductions in methane emissions from flooded rice fields. *The Compliance Offset Protocol for U.S. Forest Project*[41] states methods for quantifying forest land carbon sink.

1.3.5 Low-carbon agricultural development in the UK

In 2020, UK announced that it would achieve net-zero emission by 2050. UK farms currently emit 45.6 million tonnes of carbon dioxide a year - about a tenth of the UK's GHG emissions, of which 10% are carbon dioxide, about 40% nitrous oxide (N_2O) and 50% methane (CH_4). To contribute to the UK's goal of achieving net-zero emissions by 2050, the National Farmers' Union (NFU) has set an ambitious target

37 http://www.360doc.com/content/20/0703/19/70743283_922110362.shtml

38 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1383

39 https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/livestock-projects

40 https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/rice-cultivation-projects

41 https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/us-forest-projects/2015

so that England and Wales will achieve net-zero emissions of GHG in all agriculture sectors.

In order to fulfill the goal of"net zero"emission of agriculture in 2040, the following three measures will be taken: improving farming's productive efficiency to reduce our GHG emissions – enabling farming to produce the same quantity of food, or more, with less inputs in smarter ways; increasing farmland carbon storage in soils and vegetation – improving land management and changing land use to capture more carbon; boosting renewable energy and the bioeconomy to displace GHG emissions from fossil fuels and creating GHG removal through photosynthesis and carbon capture.

1.3.6 Irish low-carbon agricultural development

Grass-fed dairy and livestock farming are the pillars of Irish agriculture, with 81% of agricultural land for grow grassland[42]. Since 2012, the carbon footprint of farms has been decreased, which is mainly due to grass-based agricultural activity. Irish Ruling Party reached a coalition agreement in June 2020, committing to cut emissions by 7% a year over the next decade. According to the 2021 Irish Farmers Journal/KPMG Agribusiness Report, it is possible to achieve carbon-neutral cultivation of Irish beef and dairy products.

Ireland's national sustainable development project"Origin Green"is the first sustainable food development project put forward at the national level in the world. The project is **committed to helping every farm and food manufacturer continuously achieve the multi-level sustainable development goals including energy use, carbon emission, water resource utilization, waste and effluent treatment, biodiversity and social welfare through independent audit,**[43] aiming at reducing the carbon emission footprint throughout the whole food production process from farm to table in Ireland and promoting the harmonious coexistence between people and nature and between science and technology and nature.

The Quality Assurance Scheme (QSA), which has been independently certified by the Ireland government, has enabled various industries to reach higher standards of excellence in the fields of food safety, animal welfare, environmental protection, traceability, sustainability and farm safety, and has been implemented for more than 20 years[44].

1.3.7 Brazilian low-carbon agricultural development

At 15th Conference of Parties in Copenhagen in 2009, the Brazilian government made a voluntary commitment to reducing the GHG (GHG) emissions by 36.1%- 38.9%[45] based on the current levels by 2020, with an estimated reduction of approximately 1 billion tons of CO_2 equivalent. In December 2020, Brazil announced that within the framework of the Paris Agreement, it would reduce its annual emissions to 37% of 2005 levels by 2025 and 43% by 2030, being carbon neutral by 2060.

Brazil is in the most advantageous position in the field of food security and natural resources protection, and it has become an important leader in the global food security field. In the past 40 years, Brazil has become one of the world's largest agricultural exporters from a food importer and its agricultural production has increased by 385% with only 32% increase in area of agricultural land. 30% of Brazil's land is used for agricultural production and 66% of its territory retains native vegetation.

1) Brazilian national policy on low-carbon agricultural climate adaptation

(1) Brazilian Low-carbon Agriculture Program and ABC+ Program

In 2009, Brazil formulated the National Policy on Climate Change (PNMC), and the administrative authorities formulated sectoral plans to migrate and adapt to climate change, aiming at consolidating low-carbon economy in economic sectors such as agriculture. In agriculture, Brazil formulated the *Program for Consolidating Low-carbon Economy in Agriculture,* and started to build a low-carbon agriculture (ABC) program working group. In 2010, Brazil released the *Low-Carbon Agricultural Economic Plan for Mitigation and Adaptation to Climate Change* (ABC Plan). The low-carbon agriculture program covers the whole country of Brazil and will be implemented from 2010 to 2020. This Plan is mainly

42 https://www.sohu.com/a/219471569_231199

43 http://www.whb.cn/zhuzhan/kandian/20160909/68898.html

44 https://www.sohu.com/a/340706529_720191

45 http://fanwen.geren-jianli.org/1180104.html

to, by 2020, restore 15 million hectares of degraded pastures through scientific management and fertilization, increase the area of 4 million hectares of agricultural and pastoral forests and agroforestry, expand the role of biological nitrogen fixation within 5.5 million hectares, promote reforestation, expand plantation area, and treat 4.4 million cubic meters of animal manure with advanced technology for energy production and organic compost production.

To build a more sustainable, resilient and competitive agricultural system, the Department of Agriculture, Livestock and Food Supply (MAPA) released the *Agricultural Adaptation and Low Carbon Emission Program* (ABC+ Program) in 2021. The ABC+ Program covers a period of 2020-2030 and will continue to promote sustainable agricultural development in three aspects:

- **Integrated landscape approach (ILA):** It holds that the management of agricultural areas must take different elements of rural landscapes of different levels and scales into consideration, and shall reflect their diversity, systematicness and dynamics. It encourages to adopt and maintain sustainable systems, practices, products and production processes, and promote comprehensive utilization of landscape components. Emphasis is placed on the effective use of areas suitable for farming, strong incentives, compliance with environmental rules, recognition of the value of local landscape, and restoration and protection of soil, water and biodiversity. It also recognizes and empowers local commodities and regional cultures, and expands the portfolio of initiatives of the Brazilian Department of Agriculture, Livestock Husbandry and Food Supply in promoting sustainable agriculture. For Brazilian territory, the establishment of this multifunctional approach can strengthen the effective protection of natural resources, without causing losses to the output of agricultural products and farmers' income. It has proved that this approach not only can enhance the economic value of ecosystem services in the process of food production, but also can help address the contradiction of land use through better land planning.
- **Promote adaptation and mitigation cooperation.** Reducing current and future carbon emissions and increasing carbon storage through ABC program mitigation strategy are effective means to deal with the threat of climate change. Facing frequent extreme incidents, it is increasingly urgent to reduce the vulnerability of the agricultural system and enhance the recovery rate of agriculture. When short-term and long-term effective public policies are implemented in local areas, the strategies, processes and tools shall focus on the climate adaptation and mitigation. Climate adaptation focuses on: (i) the adoption and maintenance of protection measures; (ii) adoption and maintenance of integrated system; (iii) genetic improvement and biodiversity restoration.
- **Promote and maintain sustainable practices, products and production processes.** Agricultural practices based on protecting natural resources are essential to the effective management of agricultural system and to strengthen its resilience and sustainability. The practice of natural resources protection can be defined as "a set of systematically arranged technologies to protect and restore natural resources through comprehensive management of soil, water and biodiversity and appropriate use of external inputs". Regardless of the production system and location, conservation agriculture follows three basic principles: reducing or inhibiting the instability of soil; (ii) retaining crop residues on the soil surface; species diversity, crop rotation, intercropping and/or cultural inheritance". These sustainable production technologies ensure the efficiency and profitability, promote the protection of ecosystems and natural resources, and enhance the resilience of agricultural systems.

(2) New Forest Law (Law 12651 /2012)

As forest carbon sink increase is one of the important measures to go carbon neutral, a solid public policy framework shall be established to ensure the coordination between environmental protection and sustainable agricultural production. On April 25, 2012, Brazilian Congress passed the newly revised national-level"New Forest Law"which requires that at least 80% of the original forest must be preserved for the development of agriculture in the original forest area, at least 35% of the original forest land must be preserved for engagement in agriculture in sparse grassland and 20% of the original forest must be retained for conducting agricultural development in other vegetation areas. Through forest land protection, priority can be given to curbing the carbon storage reduced due to irrational agricultural development.

2) Brazilian low-carbon agricultural development market conduct

(1) Carne Carbono Neutro

The GHG produced by beef production is 2-9 times that of other animal products and more than 50 times that of most plant-based food units in protein, which shows that traditional beef production has a great impact on the environment. According to a study by EMBRAPA, about 200 trees can neutralize the methane emitted by 11 adult cows every year, and planting trees between pastures can effectively absorb GHGs. To encourage this integrated management mode of agriculture, animal husbandry and forestry, the company launched the certification mark of "Carne Carbono Neutro".

In August 2020, EMBRAPA and Brazil's Mafrig jointly launched Viva beef brand, which is the first product to be certified as"Carne Carbono Neutro"and has been sold in ten supermarkets in Sao Paulo, Brazil[46]. San Virginia is the first farm in Brazil to be certified as carbon-neutral meat, located in Santa Rita do Pardo, Mato Grosso do Su. Integrated system of crop-livestock-forest (ILPF) and crop-livestock (LP) is applied to neutralize the GHGs emitted during beef production[47].

(2) Promotion of agricultural carbon neutral by other enterprises

Brazilian enterprises are gradually joining the carbon neutral and carbon emission reduction. JBS, the largest meat processing giant in the world, announced that JBS will reset the balance of its GHG emissions by 2040 by reducing the intensity of its direct and indirect emissions and offsetting the remaining emissions, including **no illegal logging** in other biological communities in Brazil by 2030. In addition, JBS is also investing in technologies and practices such as **improving renewable agricultural practices, strengthening soil carbon sequestration and targeting supplier farms** to achieve this goal[48].

Brazil's Mafrig released the ambition of carbon neutral of beef, and stated that the model of regenerative agriculture and farming-pastoral combination is the core of carbon neutral of beef. Regenerative agriculture makes use of the self-healing and resilience existing in nature, so that agricultural natural resources can be continuously reused to protect the healthy development of land, crops and human environment.

Minerva Foods has announced decisive action to combat climate change and protect ecosystems, launching a sustainability strategy and pledging to reduce emissions intensity by 30% by 2030 compared to 2020.

Minerva SA, as the largest beef exporter in South America in Brazil's meat processor, is making efforts to ensure that the pastures that provide cattle to it will not be illegally deforested, and drawing its suppliers' pastures and any areas that are known to be illegally deforested through **satellite-generated images formed by the monitoring system,** and any suppliers that overlap both will be blacklisted by the company. Minerva SA has set a target of reducing emissions by 30% by 2030, mainly from its own activities, from energy purchased by the company and from indirect emissions[49].

46 https://www.embrapa.br/en/busca-de-noticias/-/noticia/55338720/marfrig-lanca-linha-de-carne-carbono-neutro-em-parceria-com-a-embrapa

47 https://brazilianfarmers.com/news/farm-in-mato-grosso-do-sul-is-the-first-to-receive-a-carbon-neutral-meat-certification/

48 https://jbs.com.br/compromissonetzero/

49 https://www.marketwatch.com/story/brazil-s-minerva-expands-efforts-to-reach-carbon-neutrality-by-2035-271620649553?mod=mw_quote_news

II. Carne Carbono Neutro (CCN)

2.1 Concepts

Agriculture in Brazil and even around the world has been committed to meeting the growing demand of human beings for food, wood and fiber, and it is required to reduce the environmental impact while expanding the output of agricultural products. Human activities are the main cause of global warming. In order to reduce the impact of agriculture on climate change and improve the adaptability of agriculture to climate change, the Brazilian government issued the *Low-Carbon Agricultural Economic Plan for Mitigation and Adaptation to Climate Change* (ABC Plan) in 2010, which aims to reduce greenhouse gas emissions by optimizing the cattle breeding system in Brazil, combining cattle breeding with planting and forestry, and establishing a crop-livestock-forest system. The ABC plan provides the policy basis for the implementation of CCN in Brazil.

Embrapa, founded in 1973, is the largest agricultural R&D institution in Latin America, a semi-autonomous federal institution under the Ministry of Agriculture and Food Supply of Brazil, and the largest component of Brazilian agricultural research system. Embrapa focuses on developing products with economic importance in specialized fields and ecological areas, and has established full-equipped basic research facilities (such as laboratory facilities) and conducted research and development in various professional centers throughout the country.

1) Proposal of CCN

In 2015, Embrapa put forward the concept of "Carne Carbono Neutro", CCN for short, which aims to prove that under certain conditions, greenhouse gas (GHG) emissions from beef production can be offset by the carbon reserves of trees in the IPF system[50] or the ILPF system[51], and the whole offset process can be calculated and audited.

In Brazil, if fast-growing trees (e.g., eucalyptus) are planted at a density of 250–350 trees per hectare and logged after 8 years, the timber reserves per hectare can increase by 25 m^3 per year, corresponding to 5 t CO_2 carbon sink, which is roughly equivalent to the methane emission of about 12 adult cattle.

2) CCN label

The CCN label comprises Portuguese and English versions, and has been registered with the National Institute of Industrial Property (INPI). The label can be used for the domestic market and for export of fresh, frozen or processed beef.

Figure 1 CCN label in Portuguese (left) and English (right)

3) CCN label technology/production requirements

The primary objective of the CCN label is to prove that for beef produced under a given standard, **the methane emissions from the cattle intestines** in the production process **can be neutralized and offset by introducing additional carbon storage from trees into the integrated breeding system,** which comprises the IPF and ILPF systems.

The implementation of IPF and ILPF programs must follow the recommendations proposed in the Plano ABC to ensure that the established integrated system area can determine the geographical boundaries and the farmed cattle have traceability. The integrated system may be established and operated according to the instructions on farming techniques provided by Castro and Paciullo (2006), Porfírio-da-Silva et al. (2009) and Serra et al. (2012).

50 Also known as Integrated Livestock-Forestry (ILF) system.

51 Also known as Integrated Crop-Livestock-Forestry (ICLF) system.

The forestry carbon sinks generated in the integrated system must be calculated using the verified formula. The baseline scenarios of carbon sink for implementing the integrated system are: I) pastures without trees, and II) pastures with scattered native trees, and pre-existing trees will not be considered for carbon sequestration. Moreover, the timber produced must be used in high value added products (HVAP), such as timber, laminate and veneer, which can be used to produce products with longer carbon sequestration time, such as furniture and building timber. Only the fixed carbon sink of timber for HVAPs can be used for carbon offsetting of CCN label. The timber that has been awarded the integrated system certification of CCN label must be used in the production of HVAPs or furniture.

The integrated system is not a high-input system, nor does it involve the process of feedlot finishing. Before the integration of carbon emission accounting methodology, the use of nitrogen fertilizer and limestone as well as the GHG emissions from animal waste will not be considered for the time being.

During the project implementation cycle, the soil in the integrated system shall be tested every year. As the time goes by, the carbon content in the soil shall be equal to or greater than the carbon content in the initial analysis, thus proving that the beef produced in these systems has not reduced the carbon reserves in the soil. The soil carbon content will be a supplementary index for GHG emission reduction.

Minerals, protein and energy supplements can also be fed to cattle in the integrated system. In the growing period, it is recommended to use minerals and protein supplements (1–2 g/kg per live weight) or protein energy supplements (3–5 g/kg per live weight). During the fattening period, any of the above-mentioned supplements can be used, but it is recommended to use energy supplements (6–12 g/kg per live weight) to speed up the increase of carcass fat. The daily supplement shall be as high as 12 g/kg per live weight, so forage is still an important part of feed intake. When calculating the methane emission of cattle, it is assumed that the feed additives that promote growth will not affect the methane emission factor under different supplementary strategies.

2.2 Qualifications and procedures of applying for CCN label

1) Qualifications

Systematically bred cattle, whether from the process of cattle breeding to fattening, or just the process of breeding or fattening, can be eligible for label application as long as certain conditions are met.

In terms of yield, the cattle with CCN label need to be weighed at the time of being included in and excluded from the system. During breeding in the integrated system, each cattle's hot carcass shall gain at least 90 kg. For male cattle under 400 kg and female cattle under 300 kg, the increase of carcass weight is estimated to exceed 50% of the initial live weight. Besides, the male cattle should be increased to 280 kg in live weight at last, and the female cattle to at least 180 kg in live weight.

For the purpose of certification, according to Brazilian cattle carcass grading system, it is acceptable to have 0, 2 or 4 mature teeth at the time of slaughter, and female cattle with medium fat content (3–6 mm) or standard fat content (6–10 mm) and castrated male cattle are qualified to apply for CCN label. Male cattle that have not been castrated are also eligible for labeling, provided that they have 0 or 2 mature teeth at the time of slaughter and meet the above fat thickness requirements.

2) Procedures

To obtain and use the CCN label, beef products (beef and its derivatives) must meet all the following preconditions and parameters, as well as the following necessary minimum conditions or steps:

a) **Commitment to implement IPF/ILPF system projects:** Establish IPF/ILPF system based on the ABC plan of Brazilian government and Embrapa's guidance document, which must be established from pasture based on herbage (baseline);

b) **Technical assessment of carbon emissions:** Based on agricultural indicators and considering the GHG emissions of each animal, reference documents provided by the Intergovernmental Panel on Climate Change (IPCC, 2006) or PECUS network (baseline) can be consulted;

c) **Carbon sequestration calculation:** Based on the periodic (annual) forest inventory, the fixed carbon reserves in the trees of the system will be estimated according to the tree carbon sequestration methodology provided by Embrapa Forests. (Arevalo et al., 2002; Zanetti, 2008; Oliveira et al., 2011);

d) **Emission neutralization assessment:** Based on the calculation of methane carbon emission and fixed carbon in trunk of IPF/ILPF system, the carbon balance of the system (in terms of CO_2 equivalent) is assessed;

e) **Guarantee of carbon reserves:** According to the current laws and regulations, timber products from the integrated system must be fixed therein and kept in a fixed state (furniture and HVAP) for at least a few years as carbon sink for neutralizing GHG.

f) **Use of CCN label:** Embrapa itself or its legally authorized partners will only grant beef and its derivatives the CCN label.

g) **Certification:** Certification will be conducted by independent auditors from companies recognized by public or private institutions at federal, state or municipal levels.

2.3 Accounting methodology of CCN

1) Accounting method of methane emissions from cattle intestines

The methane emission from cattle intestines is calculated using the following equation:

$$E_{CH4}=M\times EF_{CH4}\times d$$

- E_{CH4}: the methane emission from cattle intestines, in tCH_4;
- M: the number of cattle;
- d: the time for cattle to be included in the integrated system, in years;
- EF_{CH4}: the methane emission factor, i.e., the methane emission per cattle per year, in t_{CH4} per cattle per year.

In order to calculate the methane emission from grazing animals, the methane emission factor is subject to the reference value provided by the IPCC (2006) for Brazil (Latin America), or the PECUS network simulation data[52] or the measured methane emission factor in ICLF system.

The IPCC report (2006) provides two simplified options (Options 1 and 2) for the estimation of intestinal methane emissions, and this method is suitable for accounting for general assessment or accounting for formulation of national inventory. For Option 1, the reference fixed value of intestinal methane emission in Latin America is 56 kg per animal per year. For Option 2, the methane emission factor of feed for medium-sized castrated cattle with digestibility of 55% to 65% is 70 kg per animal per year.

Pecus network has developed an empirical equation of methane emission based on the carbon emission data released by Brazil from 2003 to 2012. According to the equation, the methane emission factor is 66 kg per animal per year.

In 2015, Gomes et al. measured the methane emission from heifers in ICLF system, and the result showed that the methane emission factor was 66 kg per animal per year.

To sum up, the methane emission factor can be referenced by four values:

1) Fixed value based on IPCC Option 1: 56 kg CH_4 per animal per year;
2) Estimated value based on IPCC Option 2: 70 kg CH_4 per animal per year;
3) Annual average value obtained using empirical equation of Pecus Network: 66 kg CH_4 per animal per year;
4) Average value obtained from Embrapa's cattle ICLF system: 66 kg CH_4 per animal per year.

2) Accounting method of tree carbon sink

In the IPF/ILPF system, the methane emissions from cattle is neutralized by carbon reserves in forest and trees.

The calculation method of tree carbon sink is mainly based on the investigation of forest GHG inventory, to determine the actual and potential growth patterns of trees, and to estimate the accumulated carbon sequestration in trunk. The SIS series

52 http:// www.cppse.embrapa.br/redepecus/

software developed by Embrapa can be used to evaluate the biomass of trees and the amount of carbon accumulated in different parts of plants[53].

2.4 Critical analysis of CCN

The CCN provides a good practical example for sustainable development of the livestock sector in Brazil, but there are still some problems to be addressed.

1) Have not embedded all the emissions sources in the neutralized products. In the process of carbon neutralization certification, at present, only methane emissions from cattle intestines are considered, while other emission sources are not considered, such as methane emissions from animal waste, nitrous oxide emissions from land-use fertilizers, GHG emissions from meat processing, and emissions from meat transportation.

2) Unclear certification process of CCN. The CCN meat can be certified by a third party recognized by public or private institutions at federal, state or municipal levels, and the CCN logo is legally authorized by Embrapa. During the investigation, apart from the open network, we contacted Roberto, director of the Research Department of Embrapa through the Brazilian Embassy in China, and the Confederation of Agriculture and Livestock of Brazil (CNA) also provided us with technical support. However, the certification process of CCN is still unclear, which may have some influence on the promotion of CCN.

53 This software and its specific accounting method have not been made public.

III. Lessons from CCN certificate seal

3.1 Profound significance of the CCN

Agriculture is not only an important source of GHG emissions, but also an important source of carbon sink. The proposal of CCN has an important demonstration role for the sustainable development of agriculture and has profound significance.

Promoting the realization of sustainable development goals (SDG2) and boosting sustainable agricultural development. As for CCN, the cattle need to be bred in the IPF or ILPF system, and comprehensive scientific management of the breeding system is needed to improve production efficiency, effectively utilize natural resources and reduce the impact on the environment.

Providing better economic sources for agricultural development. Through the carbon neutral certification mechanism, it is possible to actively develop featured agriculture, expand the sales channels of agricultural products, enhance the export opportunities of agricultural products, and comprehensively improve the added value and comprehensive income of agricultural products by tapping resource endowments, strengthening agricultural management innovation and cultivating carbon-neutral brands.

Providing a new idea for the pathway of reaching carbon neutral agricultural products in China and the international community. The CCN certification is the earliest practice of agricultural carbon-neutral product certification in the world, which has a good demonstration effect in the international community. As far as China is concerned, since President Xi Jinping put forward the "3060" goal in 2019, all walks of life in China have been carrying out the research work of carbon peaking and carbon neutrality in an orderly manner, and the carbon peaking and carbon neutrality is also one of the important links. Up to now, China has not issued any certification documents or systems related to carbon neutrality of agricultural products. Brazil's CCN mechanism provides a good reference for China to develop carbon-neutral agricultural products.

3.2 Enlightenment to the establishment of agricultural carbon neutral system in China

3.2.1 Food-related certification system in China

China's food-related certification systems includes green food certification, organic product certification, pollution-free agricultural product certification, sustainable seafood certification and sustainable palm oil certification. Among them, sustainable seafood certification and sustainable palm oil certification are only applicable to a single category of products, and the sector of animal husbandry is not involved in such certification systems. Pollution-free agricultural products are mainly based on comprehensively solving the problem of "food contamination", which is the most basic safety problem in the quality of agricultural products. At present, pollution-free agricultural product certification is in the transitional stage to the edible agricultural product certification system.

In order to promote the sustainable development of agriculture and meet higher demand, the certification of green food and organic products emphasizes the harmonious coexistence between man and nature. The initial development motive of green food is to give consideration to both export and domestic sales, with the goal of improving production level, meeting higher demand and enhancing market competitiveness. The market share of green food is mainly among some high-income population in large and medium-sized cities, and there is also a part of export market share. Organic products are originally produced at the request of foreign traders, and the process is strictly in line with foreign organic products, with products mainly facing the international market. Organic is a rational concept and pays attention to maintaining a good ecological environment.

1) Green food certification system

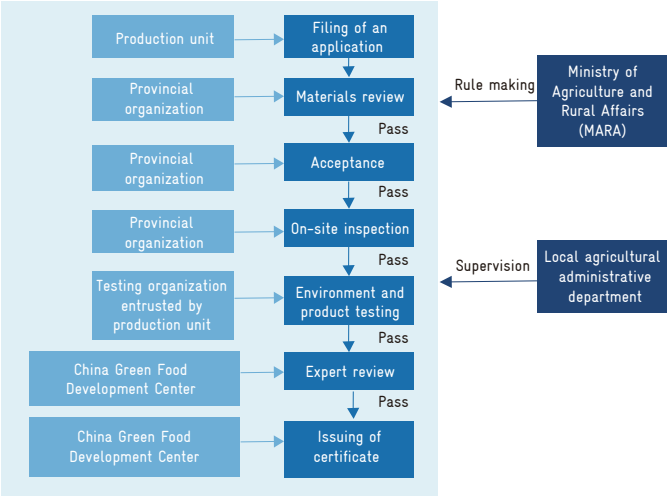
(I) Brief introduction to green food certification

Green food refers to edible agricultural products and processed products that are produced in a good environment in accordance with the specified technical specifications under full-process quality control so that they are safe and high-quality, and provided with special marks. In 1993, the Ministry of Agriculture issued the *Measures for the Administration of Green Food Marks,* which was revised in 2012[54]. China Green Food Development Center conducts a comprehensive review (including field verification) of products that have passed the quality and hygiene inspection. The Ministry of Agriculture issues the certificate and number of green food mark, which are reported to the Trademark Office of the State Administration for Industry and Commerce for filing, and announced to the public at the same time. Green food is classified into five categories: planting products, livestock and poultry products, fishery products, processed foods and other products[55]. There are 126 existing standards, such as *Green food-Livestock meat* (NY/T 2799-2015) and *Green food-Meat products* (NY/T 843-2015). In 2019, the number of green food certified units in China was 6,949, a year-on-year increase of 16.42%; the number of certified products was 6,949, a year-on-year decrease of 47.28%; the total number of certified units was 15,984, a year-on-year increase of 21.06%; the total number of certified products was 36,345, a year-on-year increase of 17.5%.

The green food mark is a certification trademark registered according to law, and the marks are as follows:

(II) Green food certification mechanism

The green food certification mechanism is shown in the figure below:



- **The responsibilities of the parties to the green food certification mechanism are as follows:**

Competent authority: The Ministry of Agriculture and Rural Affairs (MARA) is responsible for formulating and issuing standards and specifications of green food production environment, production technology, product quality, packaging, storage and transportation, etc.

Food inspectors, supervisors and administrators: Responsible for specific green food audit and green food mark supervision, etc.

China Green Food Development Center: Responsible for the review, certification and follow-up inspection after certification of the national application for green food marks.

Production unit: A production entity applying for the green food marks.

Provincial organization: The green food organization affiliated to the agricultural administrative department of the provincial people's government is responsible for the acceptance, preliminary review and follow-up inspection after certification of the application for the green food marks in this administrative region. For example, Tianjin Green Food Office, Hebei Green Food Office, Jiangsu Green Food Office, etc.

54 http://www.gov.cn/gongbao/content/2012/content_2256580.htm

55 Catalogue of Product Standards for Green Food

Testing organization: Technical organizations that undertake the environment testing of green food products and producing areas should have the corresponding testing conditions and capabilities, and have passed the qualification certification according to law. China Green Food Development Center shall select the best ones according to the principles of fairness, justice and competition, and report them to the MARA for filing.

Supervision system: Agricultural administrative departments of people's governments at or above the county level shall supervise and manage green food and green food marks according to law.

- **The relevant documents of green food certification are as follows:**

Relevant documents for license review: *Measures for the Administration of Green Food Marks, Procedures for License Review of Green Food Marks, Standards for License Review of Green Food Marks, Standards for On-site Inspection of Green Food, Standards for Expert Review of Green Food, Administrative Measures for Registration of Green Food Inspectors, Measures for Performance Assessment of Green Food Inspectors, and Implementation Measures for Renewal Review of Provincial Green Food Organizations.*

Main technical standards: Product standards: Requirements for green product quality; **Criteria:** specifying the requirements for environmental quality, medicine/fertilizer/additive/feed, product inspection and sampling, packaging, storage and transportation, sanitation and epidemic prevention, etc.; **Production operation rules:** Requirements for green product production.

Management documents of marks: *Management Standard for the Use of Green Food Marks (Trial), Green Food Certification Procedure, Management Measures for the Certificate of Green Food Marks, New Numbering System of Green Food, etc.*

Quality supervision documents: *Management Standard for Safety Precaution of Green Food Quality (Trial), Standard for Annual Inspection Work of Green Food Enterprises, Administrative Measures for Annual Sampling Inspection of Green Food Product Quality, Implementation Measures for Market Supervision of Green Food Marks, Administrative Measures for Registration of Green Food Mark Supervision Administrator, Implementation Measures for Performance Assessment of Green Food Mark Supervision Administrator, etc.*

2) Organic product certification system

(I) Introduction to organic product certification

Organic agriculture refers to a kind of sustainable agriculture that does not use synthetic fertilizers, pesticides, growth regulators or feed additives in the production process, but emphasizes the importance of the virtuous circle of natural life and the biodiversity. Organic products refer to the products that are produced, processed and sold for human and animal consumption, which meet the Chinese national standards of organic products. Organic product certification refers to the conformity assessment activity conducted by certification authority in accordance with the provisions of the *Measures for the Administration of Organic Product Certification* and the rules for organic product certification, in which the production, processing and sales activities of related products meet China's national standards for organic products. The development and certification of organic products in China began in 1995, and the *Regulations of the People's Republic of China on Certification and Accreditation* was officially promulgated and implemented in 2002. The certification of organic products was uniformly managed by the National Certification and Accreditation Administration Committee authorized by the State Council. So far, the certification of organic products in China has entered a standardized stage. The state implements a unified certification system for organic products, and a unified certification catalogue, unified standards and certification implementation rules, and unified certification marks. At present, the certification of organic products has involved 46 categories of products, 135 subcategories and more than 500 varieties[56], such as plants and edible fungi, aquatic products, livestock and poultry, processed food, etc. In 2019, there were 1,184 certified enterprises of organic food in China, and the number of certified products was 4,381. The certified area of organic food in China was 68.0874 million mu (1 mu = 0.0667 hectares) for animal husbandry, a year-on-year increase of 83%; 7,377,400 mu for processing industry, a year-on-year increase of 40.15%; 3,884,800 mu for fishery industry, a year-on-year increase of 28.5%; 3,301,200 mu for wild collection, a year-on-year increase of 8.88%; and 3,041,200 mu for planting industry, a year-on-year decrease of 25.8%.[57]

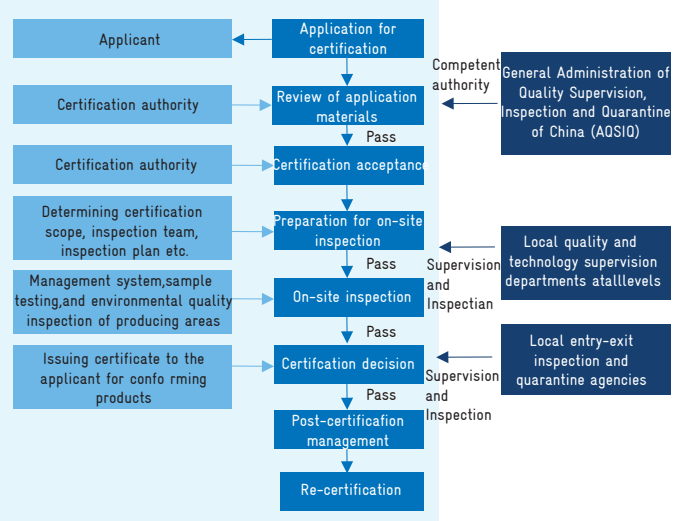
56 Organic Product Certification Catalogue (published in 2019)

57 Research Report on Market Demand Analysis and Investment Development of China's Organic Food Industry from 2021 to 2027

The organic product mark is a certification trademark registered according to law, and the mark is as follows:

(II) Organic product certification mechanism

The organic product certification mechanism is shown in the figure below:



- **The responsibilities of all parties to the organic product certification mechanism are as follows:**

Competent authority: General Administration of Quality Supervision, Inspection and Quarantine of China (AQSIQ), The Certification and Accreditation Administration of the P.R.C (hereinafter referred to as CNCA) is responsible for the unified management, supervision and comprehensive coordination of the national organic product certification. CNCA is responsible for developing. adjusting and issuing the certification catalogue and certification implementation rules of organic products. CNCA organizes international cooperation in organic product certification according to the principle of equality and mutual benefit. The international mutual recognition of organic product certification is carried out within the international cooperation agreement signed by the country.

Organic products certification authority: The certification authority should satisfy the conditions stipulated in the *Regulations of the People's Republic of China on Certification and Accreditation,* have the technical capability to conduct organic product certification, and be approved by CNCA. The certification authority is responsible for the acceptance, on-site inspection preparation, on-site inspection and certification decision of organic products, on-site inspection after annual certification, and re-certification inspection.

Organic products inspector: The inspector should obtain the practicing registration qualification issued by China Certification & Accreditation Association.

Applicants: Organic producers and processors (hereinafter referred to as the "applicants") voluntarily entrust a certification authority for organic product certification.

Testing organization: It should meet the national conditions and be responsible for sample inspection and environmental monitoring.

Supervision system: Local quality and technical supervision departments at all levels and local entry-exit inspection and quarantine agencies (hereinafter referred to as "local certification supervision departments") are responsible for the supervision, inspection and administrative law enforcement of organic product certification activities within their jurisdiction according to the division of responsibilities.

- **Relevant documents for organic product certification include:**

Certification related documents: *Regulations of the People's Republic of China on Certification and Accreditation, Measures for the Administration of Certification Authorities, Measures for the Administration of Organic Product Certification, Implementation Rules for Certification of Organic Products,* and *Organic Product Certification Catalogue.* Among them, the implementation rules clarify the requirements of organic product certification authorities, personnel requirements, certification basis, certification procedures, post-certification management, re-certification, certificate and certification mark management, etc.

Main technical standard: GB/T 19630 *Organic products—Requirements for production, processing, labeling and management system*

3.2.2 Suggestions on the establishment of China's carbon neutral beef system

China has not carried out any certification mechanisms concerning agricultural carbon neutrality. Based on the CCN mechanism and the certification system of agricultural products in China, the suggestions on the establishment of China's CCN system consist of two approaches:

(I) Approach I: Establishing China's carbon-neutral agricultural product certification system by referring to the green food certification mechanism

MARA has the chance to lead the establishment of a carbon neutral beef certification system through:

1) MARA can issue the *Administrative Measures for Cabon-Neutral beef Certificate,* which specifies, as the comprehensive measures, the registration, acquisition, management requirements, use, supervision, individual responsibilities and penalties of the *Cabon-Neutral beef Certificate.* To issue the standards and specifications of producing environment, production technology, quality, packaging, storage and transportation of the *Certified products.*

2) Management documents of the *Cabon-Neutral beef Certificate:* including use requirements, numbering system and management specifications, etc.

3) To Issue the relevant documents for *Cabon-Neutral beef Certificate* review, including review procedures, review specifications and inspector management measures, etc.

4) Technical documents: requirements for certified products, carbon-neutral technology requirements and relevant specifications for cattle breeding, etc.

5) To establish the certification channel of carbon neutral beef seal. It is suggested to employ China Green Food Development Center affiliated to the Ministry of Agriculture as the management department and standardize relevant testing institutions.

(II) Approach II: Establishing China's carbon-neutral agricultural product certification based on the national certification and accreditation system

Based on the existing certification and accreditation system, China's *Cabon-Neutral beef Certificate* can be incorporated into the existing product certification system. As a result, the following tasks should be carried out:

1) The General Office of the AQSIQ can specify the management requirements of achieving the *Cabon-Neutral beef Certificate* in the *Measures for the Administration of Cabon-Neutral Product Certification,* including the certification process, certificates and certificate seals, supervision and management, and penalties.

2) *Implementation Rules for Cabon-Neutral beef Certificate:* The *Implementation Rules for Cabon-Neutral beef* can be developed and issued by relevant public stakeholders in the system. The implementation rules should specify the requirements of CCN certification process, including the purpose and scope of certification, requirements of certification authority, certification personnel requirements, certification basis, certification procedures, post-certification management, re-certification requirements, certificates, certification mark management, and certification fees as a minimum.

3) Technical documents of *Cabon-Neutral beef products:* technical documents concerning carbon-neutral research and development by relevant scientific research institutions, at least including requirements for carbon netural products and technology and relevant specifications for cattle breeding. Relevant technical documents can be published in the forms of national standards, professional standards and group standards.

3.3 Analysing domestic marketing channels

1) Understanding the organic products' promotion system:

Memorandum management of organic products: The competent authorities of organic products in countries or regions that export organic products to China may apply for the equivalence evaluation of organic product certification

system to CNCA, which will accept the application and organize relevant experts to evaluate the submitted applications. If the organic product certification system of the countries or regions that export organic products to China is equivalent to that of China, the CNCA may sign the relevant memorandum with the competent authorities. Organic products exported from such countries or regions to China shall be managed according to the requirements of relevant memorandum.

Carrying out product certification according to the requirements of China's organic product certification: The products imported from the countries or regions that have not signed the relevant memorandum on the equivalence of organic product certification system with CNCA should meet the requirements of China's relevant laws and regulations and national standards on organic products if such products are to be exported to China as organic products. Manufacturers, sellers, importers or agents of imported products to be certified as organic products in China shall submit certification entrustment to the certification authority approved by CNCA. They should also carry out organic product certification according to requirements of the rules for organic product certification. For inbound inspection and quarantine, submissions of imported organic products should include the copies of China's organic product certificates, copies of organic product sales certificates, certification marks and product identification, etc. Local entry-exit inspection and quarantine agencies should carry out inbound verification for the imported organic products under declaration, and where necessary, may conduct sampling inspection supervision to verify whether the products meet the requirements of China's national standards for organic products.

2) Financing for green products

On February 2, 2021, the State Council issued *Guiding Opinions on Accelerating the Establishment and Improvement of a Green and Low-carbon Circular Development Economic System,* which put forward to strengthen the certification and management of green food and organic agricultural products, and encourage the development of ecological planting and breeding. It also proposed to develop circular economy in the sector of forestry, implement the construction of forest eco-products, emphasize the vigorous development of green finance, promote green credit and direct financing, and support eligible green industrial enterprises to **go public for financing.**

3.4 Conclusions

Currently, China's understanding on the adaptability of agriculture to climate change is still in its infancy. According to the international practice of adaptability to climate change and the CCN certificate, we could receive new ideas of promoting the transformation of the agricultural sector in line with China's "3060" goal:

1) Improvement of the adaptability of agriculture to climate change is an important aspect of promoting sustainable agricultural development, ensuring food security and fulfilling the second international sustainable development goal (SDG 2 for short). It is also the direction of how the sector of agriculture develops.

2) Agricultural GHG emissions cannot be ignored, but currently, among all the industries, agriculture is the only sector that can achieve independent net-zero emissions, which sets a good foundation for China's future carbon neutrality.

3) It is operational to promote agricultural carbon emissions reduction through market-based mechanisms such as carbon trading and certification. Promoting carbon credits for agricultural carbon emissions reduction is one of the means to fulfill carbon offsetting by key emission entities and units. Establishing China's carbon-neutral agricultural product certification system will also be of significance to promote China's agricultural sustainable development.

4) Marketing and mutual recognition between markets. Currently, China's demand for carbon-neutral agricultural products is in the incipient cultivating period. It has no strong requirements for imported agricultural products to be sustainable. China has not developed supporting mechanisms for importing sustainably featured products or clear marketing channels or practices. Nevertheless, organic product certification and green food certification have laid a solid foundation for carbon-neutral agricultural products in terms oof both certificating mechanisms and international market integration.

Annex I
Agricultural policies and practices in response to climate change in agriculturally dominant countries

Country	Relevant laws, policies and practices
New Zealand	• **National policies:** In November 2019, the New Zealand Parliament passed the ***Zero Carbon Bill,*** and put forward the goal of net-zero emissions by 2050. In 2020, He Waka Eka Noa, the Primary Sector Climate Action Partnership, released the ***HWEN Five-year Work Plan,*** and put forward the goal of agricultural GHG reduction. • **Carbon trading market:** In 2002, the *Climate Change Response Act* was issued, and the carbon trading market was established. In June 2020, the *Emissions Trading Reform Bill* was issued, which set an upper limit on the total emissions allowed in the carbon trading system. In 2008, the forest was included in the carbon trading system. Up to now, the carbon pricing for agricultural GHG emissions is still under discussion. • **R&D:** The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) was established in 2009, and the Global Research Alliance on Agricultural Greenhouse Gases (GRA) was established in New Zealand in the same year. • **Certifications:** In the 1990s, New Zealand started sustainable wine certification. In recent years, Toitū Envirocare has launched the first carbon certification project specially designed for farms in New Zealand.
Australia	• **National policies:** The *National Greenhouse Strategy* was established in 1998, the *Council of Australian Government National Adaptation Framework* was issued by the Australian government in 2007, and the *National Climate Resilience and Adaptation Strategy* was released in 2015. In 2019, the Australian government officially published the Climate Solution Package and planned to invest 3.5 billion Australian dollars to deal with climate change. • **R&D:** From 2002 to 2017, the Australian government has invested US$ 139 million to carry out the Carbon Farming Futures (CFF) Program. In 2017, the Climate Research Strategy for Primary Industries (CRSPI) was established. • **Market and financial mechanism:** The *Carbon Credits (Carbon Farming Initiative) Act* was promulgated in 2011, and the Emissions Reduction Fund (ERF) for greenhouse gases, totaling 2.55 billion Australian dollars, was established in 2014. • **Carbon neutral case of red meat industry:** In 2020, the Meat & Livestock Australia (MLA) released the carbon neutral target by 2030 (CN30) for meat and livestock industry in Australia.

Country	Relevant laws, policies and practices
Canada	• **National policies:** In December 2016, the first ministerial meeting of Canada adopted the *Pan-Canadian Framework on Clean Growth and Climate Change* (PCF); in December 2020, the *Strengthened Climate Plan: A Healthy Environment and a Healthy Economy* was promulgated, and the goal of net-zero emissions by 2050 was put forward. In March 2021, the Agriculture and Agri-Food Canada (AAFC) issued the *Agricultural Climate Solutions* (ACS). • **Carbon trading market:** In 2003, Alberta passed the *Climate Change and Emissions Management Act.* Since 2007, Alberta has established a carbon emission offset system. In addition, Alberta issued the *Anaerobic Decomposition of Agricultural Materials Protocol* in 2007 and the *Emissions Reductions from Dairy Cattle Protocol* in 2016, so agricultural carbon emission reduction can enter the carbon trading market.
California, USA	• **National policies:** In 2006, California issued the *Global Warming Solutions Act* (AB32 Act), based on which, the *Senate Bill No.1383 on Short-lived Climate Pollutants* was promulgated in the same year, putting forward the emission reduction targets of methane and hydrofluorocarbons. • **Carbon trading market:** In 2006, the *Regulations on Cap and Trading* was issued, and in 2013, the California government officially initiated the Cap-and-Trade Program to start the carbon market. The carbon credits developed according to the *Compliance Offset Protocol for Livestock Projects, Compliance Offset Protocol for Rice Cultivation Projects and Compliance Offset Protocol for U.S. Forest Projects* can be used for performance offset of carbon market.
UK	• **National policies:** In 2020, the UK announced that it would achieve net-zero emissions by 2050; the National Farmers Union (NFU) has set an ambitious goal that by 2040, all agriculture in England and Wales will achieve net-zero emissions of greenhouse gases.
Ireland	• **National policy:** The "Origin Green" Program, a national sustainable development project in Ireland, is the first food sustainable development program put forward at the national level in the world.
Brazil	• **National policies:** In 2009, Brazil formulated the *National Policy on Climate Change* (PNMC). In the aspect of agriculture, in 2010, the *Low-Carbon Agricultural Economic Plan for Mitigation and Adaptation to Climate Change (ABC Plan)* was released, and in 2021, the *Climate Change Adaptation and Low Carbon Emission in Agriculture Plan (ABC+ Plan)* was released. On April 25, 2012, the New Forest Law was promulgated. • **Carbon-neutral practices:** In 2020, EMBRAPA introduced the certification mark of "Carne Carbono Neutro (CCN)". The JBS Company of Brazil, the world's largest meat processing giant, announced a global commitment to achieve net-zero emissions by 2040. Mafrig, Minerva Foods and Minerva SA, the largest food companies in Brazil, have also taken actions in response to climate change.