Revisiting China's agricultural green-box subsidy policies to promote the coordinated development of agriculture and ecology post the COVID-19

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1.Introduction

While the world is focusing on controlling COVID-19 and mitigating its negative influence on food security and economy worldwide, evidence points at the biodiversity crisis as a leading factor in its emergence. Agriculture is a major driver of biodiversity loss globally. It is imperative to revisit the relation between agricultural production and ecosystem protection to prevent the next COVID-19. To feed a growing human population in ways that minimize harm to ecosystem, supportive agricultural policies are needed to facilitate the transformation of the current agricultural production.

COVID-19 and many past emerging infectious diseases are highly associated with the biodiversity loss. Outbreaks of infectious diseases are on the rise (Smith et al., 2014), and COVID-19 is just the last in a long list of zoonoses, which are spread from animals (the majority originates from wildlife) to humans. Biodiversity loss resulted from landscape change especially deforestation has been the leading driver in the emergence of zoonoses caused by a pathogen with a wildlife origin (Baudron & Liégeois, 2020). On one hand, deforestation brings wildlife and people (and their livestock) into greater contact, increasing the risk of zoonoses (Morse et al., 2012). On the other hand, pathogens may be more prevalent in animal communities with reduced diversity. Therefore, it is essential to safeguard biodiversity to prevent future pandemic zoonotic diseases.

Agricultural land use to meet the demands of a growing population, changing diets, lifestyles and biofuel production is a significant driver of biodiversity loss globally. The expansion and intensification of agricultural and food systems increasingly pressure biodiversity through its role in habitat conversion and degradation, habitat fragmentation, climate change, harvesting and pollution (Tittensor et al. 2014; Koch et al., 2019). About 22% of the land area represented by biodiversity hotspots is threatened by agricultural expansion (Veach et al., 2017). The conversion of natural vegetation and pasture to cropland is also linked to serious declines in biodiversity, as well as the loss of other important ecosystem services (Marques et al., 2019; Usubiaga-Liaño et al., 2019).

Solutions exist, but the burden of implementing them should not be left to farmers alone, who are mainly small-scale family farmers worldwide. Agricultural subsidies are crucial in reshaping the agri-ecology relationship to facilitate the transformation of the current agri-food system. Many previous studies on the agricultural subsidies mainly target their research on the amber box policies and their effects on agricultural production (Huang et al., 2011; Liang et al., 2019; Wang et al., 2020). Only a small proportion of studies examine the green box measures, but most of these research focus on the evaluation of single subsidy such as returning farmland to forest and grassland program or grassland ecological compensation policy (Hu et al., 2019; Lü et al., 2012; Uchida et al., 2009). With no or minimal trade distorting effect, the green box measures are under less pressure from the WTO and thus have big potential in reshaping the agri-food system through supportive subsidies. However, the current literature lacks a holistic review of agricultural green-box subsidy policies to provide comprehensive insights on the structure and efficiency of such policy instruments. To fill the gap, the paper aims to provide a review on agricultural green box subsidy policies in China with a focus on its dual effects of environmental restoration and rural development, identify low-efficiency segments and further propose the improvement approaches.

The paper is structured as follows. The next section reviews the literature on mutual influence between agricultural system and resource/environmental pressure. The third section presents major instruments of Chinese agricultural green box subsidies. The fourth section investigates the effects of major green box instruments on the ecological restoration and rural development. To conclude, the last section presents findings, limitations, and associated implications for the further design and development of agricultural green box subsidies in China and other developing or developed countries to better promote the coordinated development of agriculture and ecology.

2 Agricultural production and resource/environmental pressure

2.1 Effects of agricultural production on resource depletion, diversity loss and environmental degradation

Agricultural expansion and intensification will influence human infectious diseases and also human infectious diseases might likewise affect food production and distribution. Feeding billions of people will require substantial increases in crop and animal production that will expand agricultural use of antibiotics, water, pesticides and fertilizer, and contact rates between humans and both wild and domestic animals, all with consequences for the emergence and spread of infectious agents.

Food production and consumption is amongst the major drivers of environmental degradation (Notarnicola et al., 2017). The increase in world population increases the pressure on soil resources and triggers land degradation, agricultural environments are one of the most vulnerable ecosystems to this process (Bogunovic et al., 2019). The rapid expansion of agriculture and its disruption of wild ecosystems become one of major forces reshaping the biosphere. The vast monocultures that dominate 80% of the 1.5 billion hectares of arable land are one of the largest causes of global environmental changes, leading to soil degradation, deforestation, depletion of freshwater resources and chemical contamination (Altieri & Clara I. Nicholls, 2020). The main causes of degradation include depletion of organic matter and biological diversity, structural stability, erosion, compaction, crusting, acidification, alkalization and salinization, each process has negative impacts on agriculture activities (Bogunovic et al., 2019).

Biodiversity faces growing pressures from human actions which includes habitat conversion and degradation, habitat fragmentation, climate change, harvesting and pollution (Tittensor et al., 2014). It is predict that as anthropogenic climate change continues the risks to biodiversity will increase over time and indicates a potential catastrophic loss of global biodiversity (Trisos et al., 2020). It has been estimated that agricultural activities negatively impact 53% of threatened terrestrial species (Tanentzap et al., 2015). In addition to crop land use, the production and consumption of animal-sourced food products by humans is one of the most powerful negative forces affecting the conservation of terrestrial ecosystems and biological diversity, both livestock and feedstock production are increasing in developing tropical countries where the majority of biological diversity resides (Machovina et al., 2015). Animals at industrial operations are genetically similar, that are more susceptible to viral infections but also sponsor the conditions by which pathogens can evolve to more infectious types (Altieri & Clara I. Nicholls, 2020; Wallace, 2016). Since 1940, agricultural drivers were associated with >25% of all — and >50% of zoonotic — infectious diseases that emerged in humans, proportions that will likely increase as agriculture expands and intensifies (Rohr et al., 2019). A large list of deadly pathogens, including H5N1-Asian Avian Infl uenza, H5N2, multiple Swine Flu variants (H1N1, H1N2), Ebola, Campylobacter, Nipah virus, Q fever, hepatitis E, Salmonella enteritidis , foot-and-mouth disease, and a variety of influenzas emerged due to the ways in which human practice agriculture especially (Weiss, 2013). It is linked to large-scale animal production that may create opportunities for many viruses to mutate and spread. Animals at industrial operations are genetically similar, that are more susceptible to viral infections but also sponsor the conditions by which pathogens can evolve to more infectious types (Altieri & Clara I. Nicholls, 2020; Wallace, 2016). As climate change and deforestation forces wild bird populations into closer proximity with industrial farms, it is increased that the likelihood of broiler populations contracting low-pathogenic strains (Wallace, 2020). It is crucial to feed a growing human population in ways that minimize harm to ecosystem.

With one quarter of harvested cropland under irrigation, the agriculture sector is the world's largest consumer of water (Ferrant et al., 2014). Roughly 60%, 30%, and 20% of the harvested areas for the dominant crops, i.e., rice, wheat, and maize are irrigated, respectively, and half of the citrus, sugar cane, and cotton areas (Portmann et al., 2010). A significant social welfare loss of using groundwater for agriculture is found in terms of both groundwater quantity and quality deterioration costs and which is likely to increase over the long run (Athukorala et al., 2017). A third of global crop production and 44% of total cereal production were determined to come from irrigated agriculture (Portmann et al., 2010).

It is important to consider environmental impacts of agricultural activities and support given to agriculture, because agricultural production and land use contribute a disproportionately large share of GHG emissions relative to their share in global GDP. Emissions from agriculture and land use change have contributed up to a third of total greenhouse gas emissions, with beef, milk and rice production accounting for more than 80% of agricultural emissions (Mamun et al., 2021).

2.2 Effects of resource and environmental pressure on agriculture

It is warned that industrial agriculture became too narrow ecologically, highly dependent on off-farm inputs, and extremely vulnerable to insect pests, diseases, climate change (Altieri et al., 2015). Agricultural production is highly dependent on climate conditions and is therefore subject to climate change and variability. IPCC (2017) provided authoritative assessment of climate change on agriculture and food production. Direct impacts of climate change on agriculture productivity are through changes in mean climate, climate variability and extreme weather events (extreme temperatures, drought, heavy rainfall and flooding, tropical storms), while climate change may also impact indirectly on crops through effects on pests and diseases, water availability, mean sea-level rise, CO2 fertilization, Ozone, and so on (Elliott et al., 2014; Gornall et al., 2010).

Terrestrial biodiversity fulfills important functions such as pollination, pest control, nutrient cycling and its loss has economic as well as human health implications. Agrobiodiversity is crucial for delivery of a wide range of agroecosystem products and services, which greatly enhances carbon sequestration, reduces soil erosion risk, improves production and food security (Kazemi et al., 2018; Mburu et al., 2016). Each species has its role in food system while the nature of the agricultural environment is dependent on crop diversification (Bongers et al., 2015). The expansion and intensification of agricultural land are among the major causes of biodiversity loss across the world, due to the conversion of natural ecosystems and the increasing use of pesticides and fertilizers (Koch et al., 2019). When assessing the impacts on biodiversity, the focus is generally on the transformation of natural land and its occupation for agricultural purposes, as habitat change represents one of the main sources of biodiversity loss (Barnosky et al., 2011). The conversion of natural vegetation and pasture to cropland is also linked to serious declines in biodiversity, as well as the loss of other important ecosystem services (Marques et al., 2019; Usubiaga-Liaño et al., 2019). It is identified that agricultural products such as wheat, rice, and maize (due to high land occupation), as well as sugarcane, palm oil, coconut, cassava, rubber, and coffee (due to high species richness in the places where they are cultivated, although low land occupation at global level) are among the major impacting products on the potential loss of habitats and the decline on biodiversity (Chaudhary et al., 2016; Kwatrina et al., 2018; Middendorp et al., 2018). It is noted that embodied land area is not a good proxy for embodied biodiversity impacts, as crops occupying little global area such as sugarcane, palm oil, rubber and coffee have disproportionately high biodiversity impacts (Chaudhary et al., 2016).

The production and consumption of animal-sourced food products by humans is one of the most powerful negative forces affecting the conservation of terrestrial ecosystems and biological diversity, both livestock and feedstock production are increasing in developing tropical countries where the majority of biological diversity resides (Machovina et al., 2015). Deforestation is found to be negatively associated with children diet diversity, as well as recent consumption of legumes and nuts, flesh foods, and fruits and vegetables in the West Africa region (Galway et al., 2018). It is found that 83% of total species loss is incurred due to agriculture land use devoted for domestic consumption whereas 17% is due to export production, and in general, industrialized countries with high per capita GDP tend to be major net importers of biodiversity impacts from developing tropical countries (Chaudhary et al., 2016).

The outbreaks of diseases lower the crop production, have negatively effect on food processing, distribution, and transportation, and reduced household income which will further influence the food security. It has been posing a challenge for the ability of the system to provide sufficient, affordable, and nutritious food for everyone (Bakalis et al., 2020).

3. Structure of agricultural green-box subsidies

3.1 Agricultural subsidy level in China

Since 2006, the agricultural tax had been completely abolished in China. At the same time, the central government has also implemented a series of policies to strengthen the agricultural sector with price support measures, direct and indirect subsidy policies, and general service support. The agricultural support increased from 32.4 billion US$ in 2004 to 196.7 billion US$ in 2019. The substantial increase in agricultural support has played a huge role in promoting agricultural production, increasing farmers' income, narrowing the gap between urban and rural areas, and improving the livelihood.

As a whole, the OECD has stabilized agricultural subsidies over the past 19 years, which are between 250 billion US$ to 300 billion US$ (Figure 1). China, on the other hand, continues to spend a large amount of money on agricultural support, peaked at 240 billion US$ in 2015 and decreased over the past 5 years. However, in terms of farm receipts, the level of agricultural subsidy in China is still very low (Figure 2). During 2015-2019, the producer support in China only accounts for 12-15% of farm receipts, while the producer support in Japan and South Korea are about 40 and 45% of farm receipts, respectively.

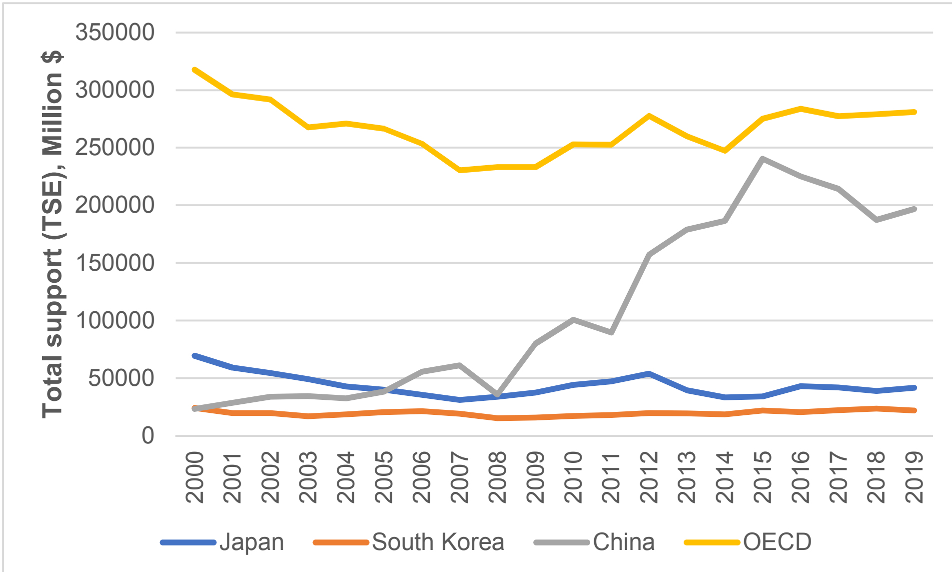

Figure 1. Total support

Source: OECD (2021), Agricultural support (indicator). doi: 10.1787/6ea85c58-en

(Accessed on 13 April 2021)

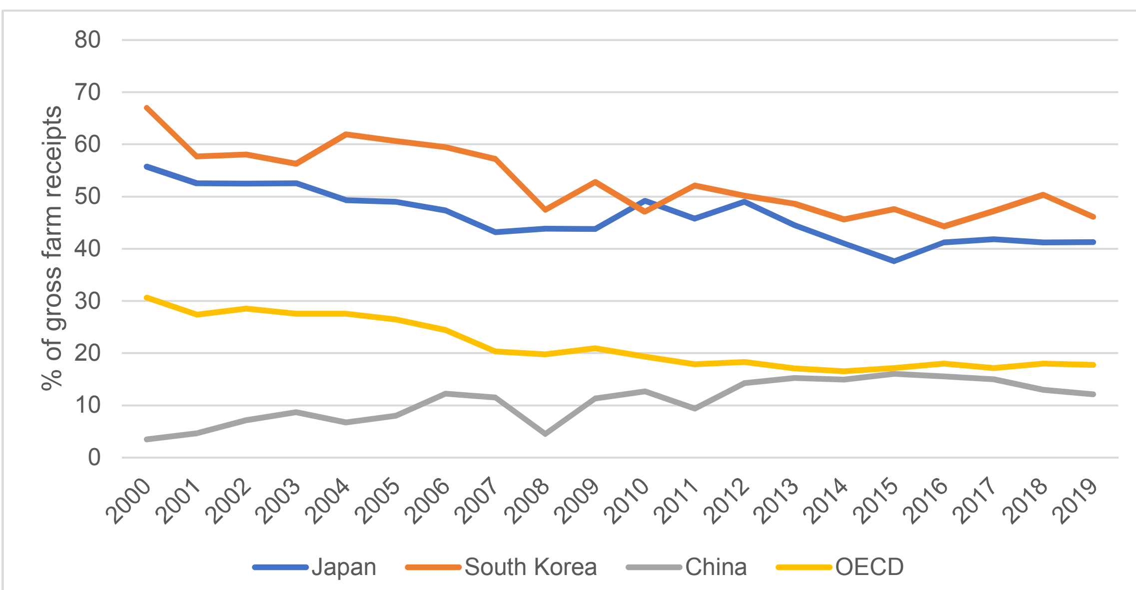

Figure 2. Producer support

Source: OECD (2021), Agricultural support (indicator). doi: 10.1787/6ea85c58-en (Accessed on 13 April 2021)

3.2 Structure of agricultural subsidies

The year 2021 is the 20th university of China being accepted as a member of World Trade Organization (WTO). It not only records the process of the gradual establishment and improvement of China's market economic system, but also reflects China's integration into economic globalization. Under the Uruguay Round Agreement on Agriculture (URAA), domestic support is classified into three categories according to their potential impact on international trade: the Amber Box, the Blue Box, and the Green Box. The subsidies in the Blue and Green Boxes are excluded from all World Trade Organization (WTO) disciplines and are expected to have no, or at most minimal, trade-distorting effects on production. Green Box subsidies are defined as programs that are not targeted at particular products, and include direct income supports for farmers that are not related to (are decoupled from) current production levels or prices. Since they are exempt from WTO disciplines, Green Box payments have been providing a growing and important share of the total support to agriculture provided by governments.

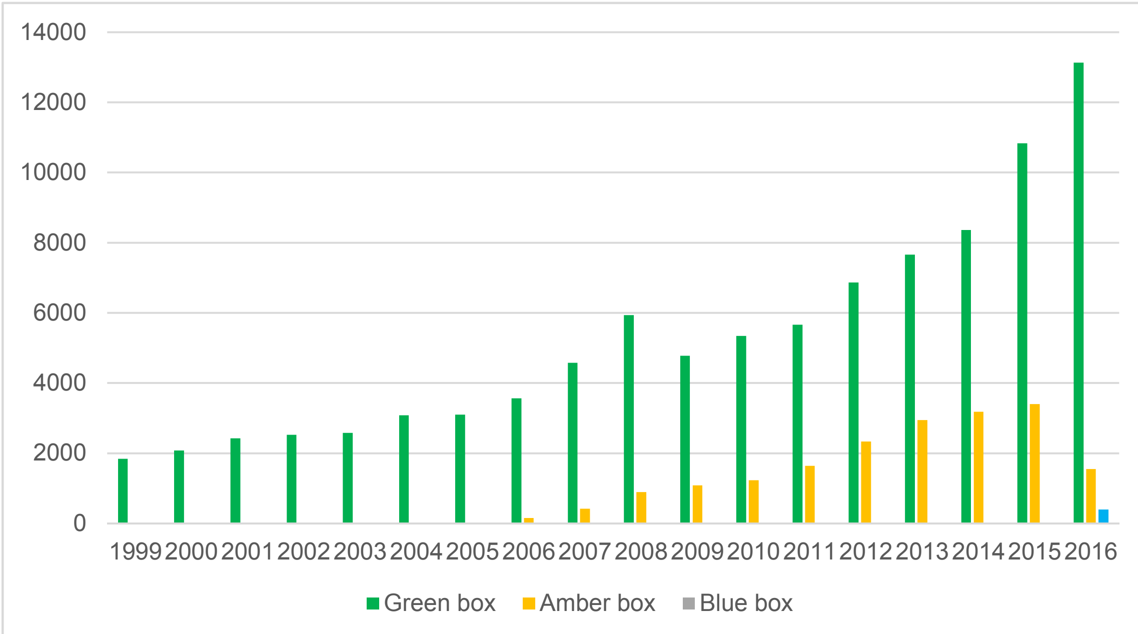

Figure 3. Agricultural subsidies under the WTO framework (Unit 100 million RMB)

Source: WTO documents

The green box measures dominate the agricultural subsidies in China, which account for 87.1% of the total support (Figure 3). The subsidy level increased from 207.9 billion yuan to 1313.15 billion yuan in 2016, with an average annual growth of 13.9% in the past 10 years. The green box measures are the most important policy tool to support agricultural development. The amber box policy support level was 154.76 billion yuan in 2016, accounting for 10.3% of the total domestic support of WTO. The blue box policy was used for the first time in 2016, and the support level was 39 billion yuan, which mainly identified corn producer subsidies as blue box.

3.3 Structure of agricultural green box subsidies

According to the WTO standard, China currently uses eight measures in the green box, i.e., general government services, public food security reserve, domestic food aid, unconnected income payment, natural disaster relief, environmental protection plan, regional assistance and structural adjustment assistance for resource withdrawal. However, the three types of support policies, such as insurance and income safety net plan, structural adjustment assistance for producer retirement plan and structural adjustment for investment aid plan are not used.

The spending on the government's general service accounted for the largest proportion of the green box policy, which was 606.541 billion yuan in 2016, accounting for 46.19% of the green box. Among the government's general service subsidies, agricultural infrastructure construction ranked the top, with 160.209 billion yuan in 2016, accounting for 26.41%. It followed by the support on technology promotion and consulting services, which was 69.81 billion yuan, accounting for 11.51%. Moreover, agricultural scientific research and pest control was 22.351 billion yuan and 14.08 billion yuan, accounting for 3.68% and 2.32%, respectively.

The spending on the government's general service is followed by the spending on vulnerable areas of regional aid (220.378 billion yuan) and decoupled income support

(163.259 billion yuan), accounting for 16.78% and 12.43%, respectively. The subsidies on food security reserves, payment under the environmental plan, and natural disaster relief was 114.919 billion yuan (8.75%), 1234.63 million yuan (4%) and 80.646 billion yuan (6.14%), respectively. Domestic food aid and structural adjustment aid for resource exit were relatively small, with 62 million yuan and 3.884 billion yuan in 2016, accounting for only 0.005% and 0.30% respectively.

China has initially explored and formed a policy system aiming at promoting sustainable utilization of resources, curbing environmental degradation and sustainable development of agriculture, adjusting and optimizing the agricultural structure and transforming the mode of agricultural development by controlling the total amount of agricultural water, reducing the amount of chemical fertilizers and pesticides, and promoting the basic realization of resource utilization of crop straw, livestock manure and agricultural film residues. The No.1 government document of 2017 proposed that the state will explore the pilot of farmland rotation and fallow and other support subsidies for crop structure adjustment, support zero growth action of chemical fertilizer and pesticide, implement subsidies for farmland protection and quality improvement, continue to carry out grassland ecological protection awards and subsidies, support a new round of returning farmland to forest and grassland, and encourage all regions to increase support for comprehensive utilization of crop straw.

The agricultural subsidies directly linked with the resource and environmental protection in the green box include subsidies for soil testing and formulated fertilization, subsidies for cultivated land protection and quality improvement, grassland ecological compensation, agricultural resources ecological protection and non-point source pollution prevention. In addition, it supports agricultural disaster prevention and relief (including agricultural production disaster relief, animal disease prevention and control, agricultural insurance premium subsidies), etc. After the reform of the three subsidies, the subsidy of cultivated land productivity protection is uncoupled from production level and has become a "green box" policy.

4. Major agricultural green-box subsidies

A major part of Chinese green-box subsidy policies belongs to payments for ecosystem service (PES). These incentive-based programs provide financial incentives to those who “supply” ecosystem services, including farmers who agree to set aside sensitive land or adopt farming technologies that generate ecosystem services such as wildlife habitat protection, carbon sequestration, and protection of watershed functions (Uchida, Rozelle, and Xu, 2019). This research focus on major agricultural green-box measures which are directly aiming the restoration of the ecosystem in China. They include Returning farmland to forest program, grassland ecological compensation, subsidy for cultivated land productivity protection, and fallow rotation subsidies.

4.1 Returning Farmland to Forest and Grassland Program

China's Returning Farmland to Forest and Grassland Program (RFFGP) (also called the Grain-for-Green Program) is one of the world's most ambitious afforestation programs and the largest payments for ecosystem services program in the developing world. This program aims to meet both ecological and development goal. By compensating farm households for the conversion of erodible or otherwise environmentally fragile land from grain production to forestland or grassland and financing the afforestation of barren mountainsides, the program, aims to expand forestland in the upper reaches of the Yangtze and Yellow River basins to prevent soil erosion, and also to alleviate poverty and restructure agricultural production into more environmentally and economically sustainable activities in some of the poorest parts of rural China.

RFFGP has been presented as a great success in terms of both generating ecosystem services, including increasing the forest and grassland coverage, enhancing the soil conservation and improving the carbon sequestration. According to the report issued by the Chinese State Forestry and grassland Administration (SFGA, 2020), since the implementation of the program in 1999, the central government in China has invested 517.4 billion RMB in 2435 counties (autonomous regions and districts) across 25 provinces (autonomous regions and municipalities) and Xinjiang production and Construction Corps to implement the project. By 2019, this program has returned farmland to forest and grassland of 515 million mu, and the forest coverage rate of the program area has increased by more than 4 percent on average. The afforestation area in this program has accounted for 40.5% of the total afforestation area of the Chinese national key ecological forestry projects in the same period, and its forest area accounts for the largest proportion (4%) in the world. The total value of ecological benefits (in the price level of 2016) generated in the year of returning farmland to forest is 1.38 trillion yuan, which significantly improves the ecological environment and is a landmark project of ecological civilization construction in China. Moreover, a case study was conducted as an assessment of key ecosystem services at the regional level in the ecologically vulnerable region of the Loess Plateau, China, it shows that significant conversions of farmland to forest and grassland were found to have resulted in enhanced soil conservation and carbon sequestration (Lü et al., 2012).

RFFGP has also achieved a positive influence on rural development (including off-farm labor, livelihood diversification and income mobility) indicated by large-scale studies (Z. Liu & Lan, 2015; Lü et al., 2012; Uchida et al., 2009). According to the program's rules, each participating farmer receives three types of compensation: in-kind grain, cash, and free seedlings. In-kind grain and cash are given out annually after a farmer's program plot passes an inspection; seedlings are provided only in the first year. The program can potentially affect household wealth, both directly and indirectly. Grain-for-Green directly affects household incomes through the grain and cash compensation, which can be used for other productive activities and for consumption. The conservation set-aside program also can indirectly induce structural change in household wealth by reducing the demand for labor for cultivating crops. How the freed-up labor time gets reallocated may critically depend on the other resources possessed by the household, the household's stock of human capital, and the conditions of land, labor, and credit markets. As shown in the official report, about 41 million farmer households in China participated in the implementation of the program by 2019, the total amount of subsidies for farmers was more than 9000 yuan per household. The average annual growth rate of per capita disposable income of farmers in 2007-2016 was 14.7%, 1.8 percentage points higher than that of rural residents in China nationwide. From 2016 to 2019, a total of 39.23 million mu of farmland was returned to forest and grassland in poverty areas, accounting for 75.6% of the total tasks in these four years. By the end of 2017, in the new round project the coverage rate of registered poverty-stricken household was 31.2%.

On average, the RFFGP program has a positive effect on off-farm labor participation, participating households are increasingly shifting their labor endowment from on-farm work to the off-farm labor market (Uchida et al., 2009). Using a longitudinal household survey data set spanning the overall implementation of the RFFGP program, results show that the program works as a valid external policy intervention to increase rural livelihood diversification (Z. Liu & Lan, 2015).

However, regional case studies on the RFFGP shows how local governance and environmental conditions enable different land use patterns and substantial heterogeneity (Zinda and Zhang, 2019). It is argued that to achieve a win-win outcome by meeting both ecological and development goals, local government may need to provide additional support to vulnerable populations through job training programs or other means, low-income farmer group since they are more affected by the program in terms of income Diversification (Liu & Lan, 2015; Uchida et al., 2009). Although some positive policy results have been achieved over the last decade, large uncertainty remains regarding long-term policy effects on the sustainability of ecological rehabilitation performance and ecosystem service enhancement, to reduce such uncertainty, studies calls for an adaptive management approach to regional ecological rehabilitation policy to be adopted, with a focus on the dynamic interactions between people and their environments in a changing world (Lü et al., 2012).

4.2 Grassland Ecological Compensation Policy

To reduce grazing pressure and recover grassland productivity, the Chinese government initiated he Grassland Ecological Compensation Policy (GECP), which is a large-scale ecological compensation program using subsidies to motivate herders to reduce grazing.

The main goals of GECP program are to alleviate grassland degradation and increase herders' income.

The first round of the GECP (2011-2015) was implemented in eight major pastoral provinces of China, including Inner Mongolia, Xinjiang, Tibet, Qinghai, Sichuan, Gansu, Ningxia and Yunnan. Grassland in these provinces was divided into grazing ban zones or forage-livestock balance zones, based on their condition and quality. In the grazing ban zones, herder households are subsidized to cease all grazing since the grassland degradation was severe. While in the forage-livestock balance zones in which the grassland conditions were relatively good but also overgrazed， herders were subsidized to graze below a given intensity. Subsidies were also provided for forage seeds and other production materials for the herders. In the second round of GECP (2016-2020), five more provinces were added, which are Hebei, Shanxi, Liaoning, Jilin, and Heilongjiang. The policy changes in the send round period include increasing the general compensation standards, enhancing rewards to areas with remarkable grassland condition improvement, and improving the policy implementation mode in semi-agricultural-and-semi-pastoral areas. The current subsidy standard is 7.5 yuan per mu per year for grazing forbidden grassland and 2.5 yuan per mu per year for balanced grassland. During 2011-2018, more than 132.6 billion yuan were invested.

The GECP has shown a significant positive influence in enhancing the grassland conditions indicated by the macro data. The comprehensive vegetation coverage of grassland reached 55.3% in 2017, which is 4.3 percentage points higher than that in 2011. Also in 2017, the total output of fresh grassland grass in China was 1.065 billion tons, an increase of 2.53% over the previous year, which showed a steady growth. Most previous studies focus on the ecological effects of the GECP, such as the improvement of the height, coverage, and biomass of natural grassland. Some studies showed that grassland condition has recovered to some extent since implementation of the GECP (Liu et al., 2018; Yang et al., 2016). The impact of GECP on protecting the grassland condition was stronger in counties with worse initial grassland condition (Liu et al., 2018).

Total income of herd households increased though net household income extremely significantly decreased, but the overall stocking rate marginally significantly increased indicated by Inner Mongolia survey data (Yin et al., 2019). Since income from animals still formed the major proportion of household income, and off-farm income only played a complementary role in household income. Herdsmen were not satisfied with the program to some extent, while value perception, environmental regulation and their interaction played a positive role on improving the satisfaction (Li et al., 2021).

However, due to the complex effects of climate and socioeconomic factors, some studies argue that overall grassland condition has continued to deteriorate (Hu et al., 2016; Wei and Hou, 2015). Using county-level panel data，Liu et al. (2018) show that the GECP has succeeded in improving the grassland condition; however, the effectiveness was offset to some extent by climate and socioeconomic factors. The market price of livestock and the off-farm jobs also affect the livestock production and grazing decisions among herders significantly. Higher mutton prices increased the number of sheep but decreased the number of cattle. Herder households with off-farm jobs raised fewer livestock and grazed lighter (Hu et al., 2019). Studies advocate that increase the compensation level per households, design a more market-based instruments, and providing more off-farm employment opportunities can provide much incentive for herders to stop or reduce their herd sizes, and should help to reduce over-grazing (Hu et al., 2019).

Table 1: Review summary on the major instrument of agricultural green box subsidies

Subsidy name	Ecosystem effect	Welfare effect	Identified problems
Returning Farmland to Forest and Grassland Program	- Increased the forest and grassland coverage - Enhanced the soil conservation - Improved the carbon sequestration	- Promoted off-farm labor - Increased livelihood diversification - Increased income	Effects shows substantial heterogeneity across different land use patterns, local governance and environmental

		mobility	conditions at regional level
Grassland Ecological Compensation Policy	- Improvement of the height, coverage, and biomass of natural grassland	-Total income of herd households increased - Net household income extremely significantly decreased - Stocking rate marginally significantly	The effectiveness was offset to some extent by climate and socioeconomic factors

4.3 Other agricultural green-box subsidies

4.3.1 Subsidy for cultivated land productivity protection

Since 2016, the "three subsidies" reform of agriculture has been carried out nationwide in China. The "three subsidies" (i.e., direct subsidies for grain farmers, improved crop varieties subsidies, and comprehensive subsidies for agricultural materials) of agriculture are merged into agricultural support and protection subsidies, and the policy objectives are to support cultivated land fertility protection and to moderate scale operation of grain production. The support for cultivated land fertility protection (CLFP) belongs to the green-box subsidies.

Funds for cultivated land productivity protection are used to subsidize farmers who adopt comprehensive agricultural technologies and management operations that can effectively strengthen the protection of agricultural ecological resources and consciously improve the productivity of cultivated land. It includes improving the comprehensive utilization level of crop straws, encouraging the adoption of straw returning, deep loosening and soil preparation, reducing the amount of chemical fertilizer and pesticide, applying organic fertilizer, etc. The subsidy standard is determined by the local government based on to the total amount of subsidy funds available and the subsidy basis. It can be different due to the heterogeneity in crop planting and available fund amount. For example, the CLFP subsidy was 71.78 yuan per mu in Heilongjiang, but 91.55 yuan per mu in Anhui Province; the subsidies for the cultivated land rotate planted with peas or corn was 100 yuan per mu in Pinggu District, Beijing in 2018. No subsidies are given to the cultivated land that have been converted into animal husbandry farms, facility agricultural land, non-agricultural land for requisition (occupation), or the cultivated land that has been abandoned for a long time and whose area and quality cannot meet the conditions of cultivation.

4.3.2 Support for animal disease prevention and control

The support policies for animal disease prevention and control mainly include compulsory immunization subsidy, compulsory killing subsidy and harmless treatment subsidy for breeding. First, the compulsory immunization subsidy is used to carry out the purchase, storage, injection (feeding) and immune effect monitoring and evaluation, personnel protection and other related prevention and control work of the compulsory immunization vaccine (anthelmintic drugs) against foot-and-mouth disease, highly pathogenic avian influenza, peste des petits ruminants, brucellosis, echinococcosis and other animal diseases, as well as subsidies for the implementation and purchase of animal epidemic prevention services. Second, compulsory killing subsidy is used to compensate the owners of the animals that have been forcibly exterminated in the process of preventing, controlling and exterminating animal epidemics. The diseases included in the current scope of central financial subsidies include foot-and-mouth disease, highly pathogenic avian influenza, h7n9 influenza, peste des petits ruminants, brucellosis, tuberculosis, hydatidosis, equine anthrax and equine transmitted poverty. Third, harmless treatment subsidy for breeding is used to subsidize the implementers of the collection, transfer and harmless treatment of sick and dead livestock and poultry.

4.3.3 Agricultural insurance premium subsidy

China launched subsidy programs for agricultural insurance premium. The subject matter of agricultural insurance subsidized is the major agricultural products related to the national economy and livelihood, food and ecological security. Subsidies are provided for the insured farmers and operation organizations conducting agricultural production. Corn, rice, wheat, cotton, potato, oil crops, sugar crops are insured against weather-related natural disasters and pest and rodent damage. Livestock insurance covers diseases for breeding sows, dairy cattle and fattening hogs, as well as losses from natural disasters. Public welfare forest and commercial forest are under the forest insurance coverage. Highland barley, yak, Tibetan sheep, natural rubber and other crop or breeding varieties are also included. It is noted that where conditions permit, the insurance liability can be steadily explored with the changes of price, output, weather, etc., and the resulting insurance premium can be subsidized by the local government in a certain proportion. Farmers pay only 40 percent of crop insurance premiums and 30 percent of breeding insurance premiums. The share of central government is higher in central and western provinces and lower in the eastern provinces.

4.3.4 Compensation for banning fishing

Banning fishing and relevant compensation is promoted by classification and stages in key waters of the Yangtze River Basin. The areas are grouped into four categories: aquatic life protection areas in the Yangtze River Basin, water areas of the main stream and important tributaries of the Yangtze River except for the protection areas, water areas of large-scale Tongjiang Lake except for the protection areas, and other related water areas.

The central government adopts a combination of one-time subsidies and transitional subsidies to support the work of banning fishing in key waters of the Yangtze River Basin, so as to promote the recovery of aquatic biological resources and the restoration of water ecological environment. The one-time subsidy fund is comprehensively calculated according to the number of fishing boats returned from each province, the type of prohibited water area and the arrangement of work tasks, which are used by local governments to recall fishing rights and to scrap special production equipment, and to compensate fishermen. During the transitional period, the subsidies will be used by all localities for publicity and mobilization, reward for early withdrawal, strengthening law enforcement and management, emergency response and other work directly related to the ban.

5. Conclusion and discussion

Raised by novel zoonotic coronavirus, COVID-19 has severe negative effects on food security worldwide, and it puts urgent pressure to revisit the relation between agri-food production and ecosystem protection. Agricultural subsidies especially agricultural green box subsidy policies are the key in reshaping the agri-ecology relationship. The paper examines the structure of agricultural subsidies under the WTO framework, reviews major instruments in the agricultural green box subsidy policies and their identify low-efficiency segments, and further propose the optimization approaches.

Agricultural green-box subsidy policies in China have been important instruments in enhancing resource and environmental protection in terms of increasing the forest and grassland coverage, reduce breed grazing and crop planting pressure, and recover cultivated land productivity. In addition to the positive influence on the ecosystem, green box subsidy policies also increase the livelihood of farm households in rural areas, including stabilize income levels, promoting off-farm jobs and income diversification.

Though Chinese agricultural green-box subsidy policies have shown as an important step moving forward to reshape the agri-food system in a more environmental and sustainable way. However, many problems reported offsets the effectiveness of these policies. First, the subsidy rate as a compensation is still not enough to motivate a high farm and herdsman participation. The market-based standards for compensation should be designed and developed to better prompt the decision and behavior change among farm households. Second, policy effects in certain crops or household groups are often mixed at a regional level. The heterogeneity across regions, farm groups, crop and livestock varieties need to be fully considered during the formulation and implementation of subsidies. Third, the current policy goals are still at pollution control and environmental degradation recovering. The targets shall be more active in terms of reshaping the agri-food and ecosystem relation by considering mitigating and adaptation of climate change, recovering the agricultural diversity and restoring ecosystem services, promoting cycling agriculture and regenerate agriculture to achieve a cycling of agri-food-energy-plants-animal-biology.

The relation between agricultural production and ecosystem protection needs to be reshaped to prevent the next COVID-19. Agricultural subsidy policies in China, and as well as other countries worldwide need to be reformed from the perspective of policy goals, instruments, working mechanism and evaluation to better promote the coordinated development of agriculture and ecology and therefore facilitate the transformation of the current agri-food system.

Acknowledgments

This research was funded by the National Natural Science Foundation of China (NSFC-CGIAR Grant # 72061147002), "Optimizing Chinese Agricultural Subsidies to Transform Agro-food Systems under the Global Context ".

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