

Case Studies and Insights: Transforming the Agri-Food Sector under the Biodiversity Conservation Agenda

ABSTRACT

Agri-food systems contributed to 40% of the global land-use change and biodiversity loss, with an implicit loss of \$1.7 trillion/year to global natural capital. In China, where agricultural land occupies 56% of the land area, the negative impact of agricultural activities to biodiversity and ecosystems has been substantial. Since acceding to the Convention on Biological Diversity in 1993, the Government of China has instituted a series of strategies and policies at the national level to promote biodiversity conservation and sustainable agricultural development.

Through case studies, this paper demonstrates the agri-food industry's exploration of sustainable paths in protecting and utilizing traditional varieties of resources, developing ecological circular agriculture, and weighing land use methods. The case of Guzhai Village in Mashan County, Guangxi, which is based on the development of women's cooperatives, introduces the story of active conservation, improvement and utilization of traditional varieties and resources based on the participation of women farmers, and the gradual development of circular eco-agriculture on this basis, and the realization of economic, ecological and social benefits through cooperation with multi-stakeholders, i.e. "three good harvests". In the case of sustainable landscape management of the Maasai grasslands in Tanzania, the team assessed and found that the current key ecological services of the grasslands provide benefits to local farmers and local authorities at approximately \$91 million/year, but that the high rate of agricultural expansion and encroachment on pastoral areas, if left unchecked, could result in a future loss of internal natural capital of up to \$1.3 billion (compared to the low rate-of-conversion scenario), depriving grassland development of its sustainability, while the carbon dioxide released from land conversion could result in a loss of external natural capital of \$15–24 billion, threatening the global population.

What the two cases have in common is that they both demonstrate: 1) the dependence on and impact of the private sector (individual farmers, agricultural cooperatives and related enterprises) operations in the agri-food sector on biodiversity and ecosystems and their important role in the sustainable transformation of agriculture; and 2) the importance of systemic thinking, emphasizing synergies between biodiversity conservation, ecosystem restoration and other environmental and social objectives such as climate change, poverty alleviation and women's empowerment. Recommendations on how to more effectively promote sustainable transformation of the agri-food sector also include: promoting the development and empowerment of agricultural cooperatives through multi-stakeholder participation; promoting technological and institutional innovation, technical support and capacity-building based on broad rural development; using new analytical tools to change unsustainable development paradigms and encouraging the introduction of economic mechanisms (e.g. payments for ecosystem services, PES) aimed at promoting internalization of externalities.

The aim of this paper is to demonstrate, with vivid examples and relevant data, possible pathways for the agri-food industry to become more sustainable, to inspire the industry to improve natural resource management, risk aversion and seize opportunities, and in turn to support transformation.

BACKGROUND

The agri-food industry is a key interface between human and nature. Agricultural activities produce crops and livestock on the basis of ecosystems (specifically land, water and biodiversity) and have impacts on ecosystems (1). The development of modern agriculture has contributed significantly to food security and poverty alleviation, but the negative effects on biodiversity and ecosystems, such as changes in land use patterns and the use of fertilizers and pesticides, are also considerable. Data show agricultural land now accounts for 50% of the natural habitat (2), and agricultural systems contributed 25% of the greenhouse gas emissions (3), 40% of the land-use change and biodiversity loss (4), and 70% of the freshwater consumption (4). Their implicit losses to global natural capital amounted to USD 1.7 trillion/year (2018 benchmark) (5). Meanwhile, biodiversity loss and ecosystem degradation continue to increase, with up to one million species currently on the verge of extinction globally (6) and 15 of the 24 agro-ecosystem services listed by the Millennium Ecosystem Assessment in an unsustainable or degraded state (7). The agri-food industry urgently needs to rethink its strategy on meeting the food demands of the planet's 9 billion people on the road to 2050 within the natural resource constraints.

China is the most biodiverse country in the northern hemisphere, with 56% of its terrestrial land occupied by agricultural use (data as of 2017) (8). Data show that as of 2000, land use and related activities have caused about 30% biodiversity loss in certain areas of China, of which agriculture is one of the main factors (9); air pollution from agricultural systems has caused economic losses equivalent to 32 billion yuan (10). To conserve biodiversity and develop sustainable agriculture, the Chinese government has issued a series of national-level strategies and policies: it officially joined the Convention on Biological Diversity (CBD) in 1993, and proposed a national biodiversity conservation strategy in 1994; in 2013, the Chinese government began to implement the development strategy of "ecological civilization", embedding the concept of ecological protection into every level of economic, political, cultural and social development. The protection and sustainable management of agricultural ecosystems is one of the key points of the strategy.

Since agricultural production, processing and consumption involve multiple value chains and various stakeholders, the sustainable transformation of agriculture cannot be successfully completed solely by government efforts, but requires the joint participation and efforts of all parties in society. Governments, farmers, cooperatives, enterprises, scientific research institutions, social organizations, and the public are all important contributors. The Economics of Ecosystem and Biodiversity (TEEB) Business Report states that the role of the private sector will become increasingly important in the management, conservation and sustainable use of natural resources (11). Being a major contributor to such transformation, the private sector interacts closely with other parties to form joint-forces through the fiscal and taxation and financial support systems, technological R & D, and consumption orientation.

In the future, the challenges and opportunities faced by enterprises, cooperatives and individual farmers pertaining to agricultural and food sector will coexist. The current top five

business risks in the world are all related to the environment, of which the risk of biodiversity loss ranks fourth (12). How to greening the business model in an environment constrained by biodiversity loss and ecosystem degradation will be crucial. Among them, the synergistic effect of biodiversity conservation and other environmental and social goals (such as combating climate change, poverty alleviation, rural women empowerment, etc.) will be a path worth exploring.

This article introduces two cases in the agri-food sector from the perspectives of identifying its dependence and/or impact on biodiversity, business models, and multi-stakeholder participation. It aims to bring inspirations to, with vivid examples and relative date, the process of improving the level of natural resource management in the agri-food sector, avoiding risks and seizing opportunities, and ultimately to provide support for the sustainable transformation of the agri-food sector.

CASE STUDY. Living conservation of traditional agricultural varieties and sustainable community development under circular agriculture: a story from the women's cooperative in Guzhai Village, Mashan County, Guangxi

Guangxi is one of the most biodiverse and culturally diverse provinces in China. In the long-term adaptation to changes in the natural environment and to the dietary and cultural needs, farmers have selected rich germplasm resources, which occupy a very important part in the livelihood of farmers and improvement of crop varieties. In the late 1990s, the International Maize and Wheat Improvement Center (CIMMYT) published an assessment report on the impact of smallholder farmers on maize (*Zea mays*) varieties in southwest China, which concluded, among other things, that there was a systematic separation between the formal and the farmers' seed systems, and that in situ germplasm resources were rapidly disappearing and the breeding base was narrow. Since 2000, the Participatory Plant Breeding (PPB) project has been implemented in six villages in Guangxi under the coordination of the Participatory Action Research Project Team (hereafter referred to as "Project Team") of the Chinese Academy of Sciences, in collaboration with the Crop Research Institute of the Chinese Academy of Agricultural Sciences and the Maize Research Institute of the Guangxi Academy of Agricultural Sciences, in which the scientists and breeders, together with the farmers, began piloting the use and research of "Participatory Breeding"¹. Guzhai Village in Ma Shan County was one of the first project communities. After 20 years of development, Guzhai Village has officially registered a professional cooperative under the leadership of a woman leader, and nearly 100 cooperative members now work together to carry out ecological circular farming, while preserving and utilizing local traditional varieties, increasing the economic income of farmers, protecting the local ecological environment, developing and passing on the traditional culture of the Zhuang people, and promoting community-level sustainable development.

Community Profile and Women's Cooperative Development History

¹Participatory Plant Breeding (PPB) is a breeding method that combines the formal national breeding system with the informal breeding of farmers. China's first PPB program began in 2000 and was implemented in six communities in Guangxi. It aims to address the decline of genetic biodiversity in farmers' fields, improve farmers' livelihoods, and develop improved crop varieties for farmers. The programme facilitates the negotiation of local agreements where farming communities can benefit by sharing their genetic resources and associated traditional knowledge with breeding institutions (13).

Mashan County Guzhai Village Community (administrative village community, hereinafter referred to as the "community") is located in a remote mountainous area of Guangxi, about 150 kilometers from Nanning City, where steep karst mountain terrain and rushing creeks are the main natural feature. This is a Zhuang and Yao ethnic community with 26 natural villages under its jurisdiction, and in 2018, the community had 1,515 households with 3,987 members. The proportion of elders in the community was 30%, making aging a serious issue. Of the 3,987 members, 1,800 were labour-capable, in which 700 worked in agriculture. Seventy percent of the farm work was undertaken by women, leading to the feminization of agriculture. The community had a total of 2,052 mu (appr. 128 ha) of cultivated land, with an average household land area of 1.35 mu (0.08 ha), all of which dry lands without irrigation facilities. Farmers grow maize (86% of the area sown), vegetables and a variety of grains on steep slopes between rocks and flat narrow lands. The per capita income in 2018 was CNY 6,500 Yuan, of which agricultural income constituted only 20%.

Starting in 2000, the project team began by guiding farmers on local resources, experimenting with community germplasm collection and registration, and working with local women's cooperatives on participatory breeding activities. In 2008, out of concern for ecological environmental protection, food health, conservation and utilization of agro-biodiversity, a woman leader led five elderly women in the Upper Gulatun (a natural village under Guzhai Village) to carry out ecological farming, specifically planting-breeding circular agriculture. With the support of the project team, the Community Supported Agriculture (CSA)² model was used in partnership with NGOs to increase farmers' income through the sale of ecological products in an organic restaurant in Nanning (14). Gradually, the circular eco-agricultural model of "maize, pig and vegetable" was formed, and the development of small-scale agriculture suitable for the local area was discovered.

After four years of development, in March 2012 the women's group was officially registered as a professional cooperative for ecological farming (hereinafter referred to as "the cooperative"), with 28 members, mainly women and the elderly. By the end of 2019, the cooperative has been extended to 17 tun (natural village) in the surrounding 5 administrative villages, the development of members to 96 households, a total of more than 150 mu (9.4 ha) cultivating 26 ecological vegetables.

Integrated benefits analysis of women's cooperatives

(1) Progressively optimize and expand the scope of production and operations to increase the participation and economic benefits of farmers

The scale of the cooperative has grown from 28 to 96 households, and the number of community mobilized has also increased. In 2013, the cooperative had 57 households, and the total annual income of ecological vegetables and pigs was 605,000 yuan, with an average household

² The concept of Community Supported Agriculture (CSA) was originated in Switzerland in the 1970s and was initially developed in Japan. CSA brings a closer relationship between consumers and producers, shortens the agricultural sales channels, improves quality of the agricultural supply, and promotes the integration of urban and rural development. It was considered as an ecological agriculture model with a humanistic spirit. CSA was introduced in Southwest China (Guangxi, Guizhou, Yunnan and Sichuan) by a Hong Kong civil organization Partnerships for Community Development (PCD) in 2005, and since then, the CSA concept and relevant practices have developed rapidly in China.

income of about 10,000 yuan. As the cooperative continued to grow and develop, in 2019 it began to expand cooperation with the public sector, gaining access to 800,000 yuan from the Guzhai community village level collective economic project support funds for the construction of vegetable cold storage, the purchase of refrigerated trucks, the acquisition of ecological pollution-free Buddha hand melon seedlings, etc., which promoted the further development of the cooperative. It is expected to achieve vegetable sales revenue of 1.57 million yuan in 2020, with an average annual household income of 15,000 yuan. At the same time, cooperatives actively assume social responsibility for poverty alleviation and encourage the inclusion of poor households.

(2) Local adaptation of eco-cyclic agriculture to protect biodiversity and community ecology

The "maize, pig and vegetable" circular eco-agriculture model developed by the cooperative was to feed the pigs with maize meal and leftover vegetable leaves, and the manure of the pigs was treated in a biogas digester and subsequently used to fertilize the fields and produce biogas for family use. In the process, farmers continue to explore ecological planting techniques to prevent diseases and pests, such as planting scallions with other vegetables to prevent insects, and using insect light to control pests. The whole production process does not use chemical fertilizers and pesticides, and no feed is added for the pigs, reducing the pollution of the soil and water by chemicals, saving energy and effectively protecting the environment, improving the rural farming and living environment. Meanwhile, the high-quality ecological agricultural products free of pollutants has been well recognized by consumers.

(3) Active conservation and sustainable use of local crops and traditional varieties

With the support of multiple partners, including the project team, the farmers' seed network, and the Maize Research Institute of Guangxi Academy of Agricultural Sciences, the cooperative carried out long-term conservation and improvement of traditional varieties, such as community resource registration, establishment of rural seed banks, conducting variety trials, community seed production, etc.

Rural seed bank: In 2018, a rural seed bank was established, which currently holds 27 traditional species and/or varieties (15 beans, 2 maize, 10 melons and vegetables). It also linked up with government germplasm banks, and in 2019, provided three local germplasm resources, namely Mexican white maize, local yellow maize and local glutinous maize, to the researchers from the Guangxi Academy of Agricultural Sciences Maize Research Institute for preervation in the National Germplasm Bank and the Guangxi Academy of Agricultural Sciences Germplasm Bank.

Community resource registration: By the end of 2019, 124 traditional types (species and/or varieties) of resources (including 9 maize, 11 beans, 8 melons, 24 vegetables, 53 herbs, etc.) have been registered by the community. The cooperative currently focuses on the development of agricultural products such as vegetables, corn and dry roots, which are mainly sourced from traditional varieties.

Improvement, selection and technology dissemination of traditional varieties: Since 2000, women in the community have been carrying out a series of conservation, purification and breeding

activities involving traditional species and/or varieties of maize, soybean and other crops to ensure the continuation and development of traditional varieties in the community. From 2006 to 2008, they worked with breeders to carry out PPB breeding trials and successfully bred the "Guinuo 2006" variety, the buds of which have been welcomed by consumers both inside and outside the community and continue to this day. The women of Guzhai have also taught the women of Baoshan Stone Village in Yunnan Province the techniques of breeding in the exchange activities organized by the farmers' seed network in 2014.

Wild vegetable domestication: The president of the cooperative has taken the lead in the domestication of wild vegetables and is trying to domesticate wild tassel flower (*Emilia sonchifolia*), goji (*Lycium chinense*), jueming (*Cassia tora*) and hemp leaves (*Apoeynum venetum*), in the hope of developing local resources and expanding community vegetable varieties.

(4) Protection of traditional knowledge and practices and transmission of ecological and cultural carriers

Women's cooperatives play an important role in the preservation of traditional culture. They established a troupe to revive and pass on the traditional ethnic dance, the hammering dance. Hammering dance is the Zhuang ancestors's celebration of the harvest, they do it to pray for good weather in the coming year, and to "entertain the gods". The dance has more than 1,300 years of history, and is listed as Guangxi intangible cultural heritage. The troupe currently has 25 people and is capable of organizing public performances of up to 2-3 times a month in 2019.

(5) Enhancing rural women's leadership capacity and capacity building for community-level sustainable development

For 20 years, the leader has been leading community women in the conservation and improvement of traditional varieties, upholding the concept of circular agriculture and equitable and sustainable development, and actively participating and assisting in the organization of training and exchange activities with the project teams. Under her leadership, the number of women participants has gradually increased, slowly transforming a women's collective group into a cooperative, and the capacity of the key women farmers has been greatly enhanced through active participation in cooperative management and administrative activities. At present, the backbone of the cooperative's management and operation is mainly women, and the majority of those who carry out ecological farming are also women. In this process, the rural women involved in the cooperation are awakened to a sense of ownership and their integrated capacities are enhanced, contributing to the sustainable development of the community.

Analysis and summary

From the participatory breeding activities in 2000 to the sustainable use of agro-biodiversity, and from the collective group of nine women to the cooperative of nearly 100 households, their actions not only increased the farmers' overall income, but also improved the ecological environment of the community, altogether achieving a "triple harvest" of economic, ecological and social benefits. In terms of economic benefits, the sale of eco-agricultural products through the CSA

model has directly increased the income of local farmers, especially the poor. In terms of ecological benefits, the promotion of eco-circular agriculture has improved the local ecological environment by reducing the use of pesticides and fertilizers; and the improvement and use of traditional varieties has promoted the conservation of agricultural biodiversity. In terms of social benefits, the cooperative has increased the inclusiveness and sustainability of local development by bringing in women and the elderly, as well as by actively engaging young people. It also promoted the development of traditional dance troupes to pass on the cultural heritage of the community, and improved the ecological and health values of the community members. As one villager said, "we are healthier than before, because we grow and eat healthy ecological products every day".

CASE STUDY. Sustainable grassland landscape management under TEEBAgriFood framework: an example from Tanzania Maasai Steppe³

To be added.

TEEBAgriFood in China

To promote sustainable development in agriculture, TEEB launched the project "Economics of Ecosystems and Biodiversity: Promoting Sustainable Development of Agriculture and Food Systems" in 2019, with China as one of the seven pilot countries. The core objective of the project was to promote biodiversity conservation and the provision of ecosystem services in agriculture and to avoid unfair competition due to low environmental standards. During the four-year implementation period, guided by the systemic thinking of the TEEBAgriFood framework and President Xi Jinping's development philosophy that "green water and green mountains are mountains of gold and silver", the project will assess and identify the invisible impacts of agricultural policies on natural, human, social and produced capitals through case studies, and support the development of sustainable agricultural policies to preserve biodiversity and restore degraded landscapes.

IMPLICATIONS

The growth and prosperity of the agri-food industry relies on biodiversity and ecosystem support, but the effect work both ways. Transforming unsustainable agricultural development in the looming threat of global biodiversity loss and ecosystem degradation requires a change in mindset, innovative institutional approaches and tools, and the full engagement of all stakeholders. This work illustrates possible paths for the agri-food industry to shift towards sustainability from the perspectives of resource conservation and utilization of traditional varieties, the development of ecological circular agriculture, and the weighing of land use practices, and from it these following key messages emerge:

³ This work is supported by the project "The Economics of Ecosystem and Biodiversity (TEEB): Promoting a Sustainable Agriculture and Food Sector"; the Maasai case study was recommended by the UNEP TEEB Office, and was re-narrated by Jiyuan Chen and Willam Speller from the UNEP.

(1) Based on the conservation, improvement and utilization of traditional varieties and resources with the participation of farmers, the strong combination of "diversified and integrated development of farmers' cooperatives" and "multi-functionality of agriculture" can become an important path of rural development in China. It has the potential to improve the local production and consumption of sustainable agricultural products, and achieve "three good harvests" of economic, ecological and social benefits.

(2) Multi-participation is an important means of advancing sustainable agricultural practices, and farmer professional cooperatives as a special form of enterprise can play a linking and empowering role. In the case of Guangxi, the process of cooperative development is a process of women's leadership and community capacity building and empowerment under the coordination of the CAS Participatory Action Research Group, where all levels of CAS institutes, civil society organizations, hotels, government agricultural extension services, etc. are linked to communities.

(3) The "dual combination" of technological and institutional innovation, technical support and capacity-building is an important prerequisite for promoting sustainable agricultural development, which should be motivated by a focus on broader rural development and not just on serving business needs.

(4) Although farming might be more resource-efficient in arid grassland areas in the short term compared to grazing, the expansion of farmland and encroachment on pastoral areas often do not bring better returns to the local people in the long run, but rather leads to high losses. In the case of the Maasai Grasslands, the rapid conversion of rangeland to cropland accelerated land degradation, lowered long-term yields, and fragmented wildlife habitat, ultimately leading to a reduction in the value of internal natural capital within the region.

(5) Changes in land use patterns resulting from agricultural activities will lead to changes in regulating services, with implications for a wider range of stakeholders. In the case of the Maasai Grasslands, the high rate of conversion of pastureland to cropland will release carbon dioxide that would result in a loss of external natural capital of up to \$24 billion, threatening the global population.

(6) The application of the TEEBAgriFood framework for assessment will help to understand the benefits and losses to nature, people and society from relevant decisions, and encourage the introduction of economic mechanisms to promote the internalization of externalities (e.g. payment for ecosystem services). TEEB's objective of "mainstreaming the values of biodiversity and ecosystem services into decision-making at all levels" is highly consistent with the development concept of "green water and green mountains are gold and silver mountains" promoted by China in recent years.

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