Scoping and Scenario Setting Report

The Economics of Ecosystem and Biodiversity (TEEB): Promoting a Sustainable Agriculture and Food Sector

Implementation in China

【Deliverable 1.2】

January, 2021

International Ecosystem Management Partnership
国际生态系统管理伙伴计划

This report is the scoping and scenario setting document for the "Economics of Ecosystems and Biodiversity: Promoting Sustainable Agriculture and Food Systems (TEEBAgriFood)" project in China. In July 2020, the first Project Steering Committee meeting decided to implement the project in Tengchong City of Yunnan Province. In October of the same year, the project implementation team, in coordination with the Tengchong Branch of the Baoshan Ecological and Environmental Bureau, visited Tengchong and conducted expert interviews and data collection with representatives from more than ten government branches. This report is based on the information collected from said trip.

The project focuses on the agri-food system in Tengchong and aims to explore the impact of the whole system on natural, produced, human and social capitals in the region under different development scenarios within the TEEBAgriFood evaluation framework. This report mainly includes a regional overview of Tengchong City, an overview of the agricultural system, national policies and local transformation needs, the time scale of scenario design and specific scenario settings.

1.1 Project area

Tengchong is located in the western part of Yunnan Province, with a land area of 5,848 square kilometres, 11 towns and 7 townships, inhabited by 25 ethnic groups including Han, Hui, Dai, Wa, Lisu and Achang, with a total population of 689,000. Tengchong achieved a gross domestic product of RMB 25.27 billion in 2019, of which RMB 4.69 billion (18.6%) came from the primary sector, RMB 9.92 billion (39.2%) came from the secondary sector, and RMB 10.66 billion (42.2%) from the tertiary sector. The GDP per capita was RMB 37,536.

Tengchong is located in a subtropical monsoon climate zone, governed by the North Indian Ocean Monsoons. It combines the advantages of continental and oceanic climates. The weather is sunny and warm in winter and spring, and cool and pleasant in summer and autumn, with the minimum temperature not lower than 0°C in winter and the maximum temperature not exceeding 30°C in summer. The average annual rainfall is 1,531 mm, with 85% of the year's precipitation in the rainy season (May-October) and 15% in the dry season (November-April), and an average annual relative humidity of 77%.

Tengchong is located at the junction of the Eurasian and Indian plates, where intense volcanic movements have occurred during the geological history, forming a typical volcanic-geothermal coexistence zone. Three major water systems, the Binglang River, Longchuan River and Daying River, cut through Tengchong from north to south, providing Tengchong with an annual water production of 8.1 billion cubic metres, and forming mountain ranges and river basins of varying heights, with elevations ranging from 930 metres to 3,780 metres. The terrain is high in the northwest and low in the southeast, with the dam area (river valley) covering 16% of the total area and the mountainous and semi-mountainous areas covering 84%. The soils are rich in variety, mostly red, yellow-red and yellow loam as well as volcanic ash soils, with deep layers and mostly medium to upper fertility levels of soil quality.

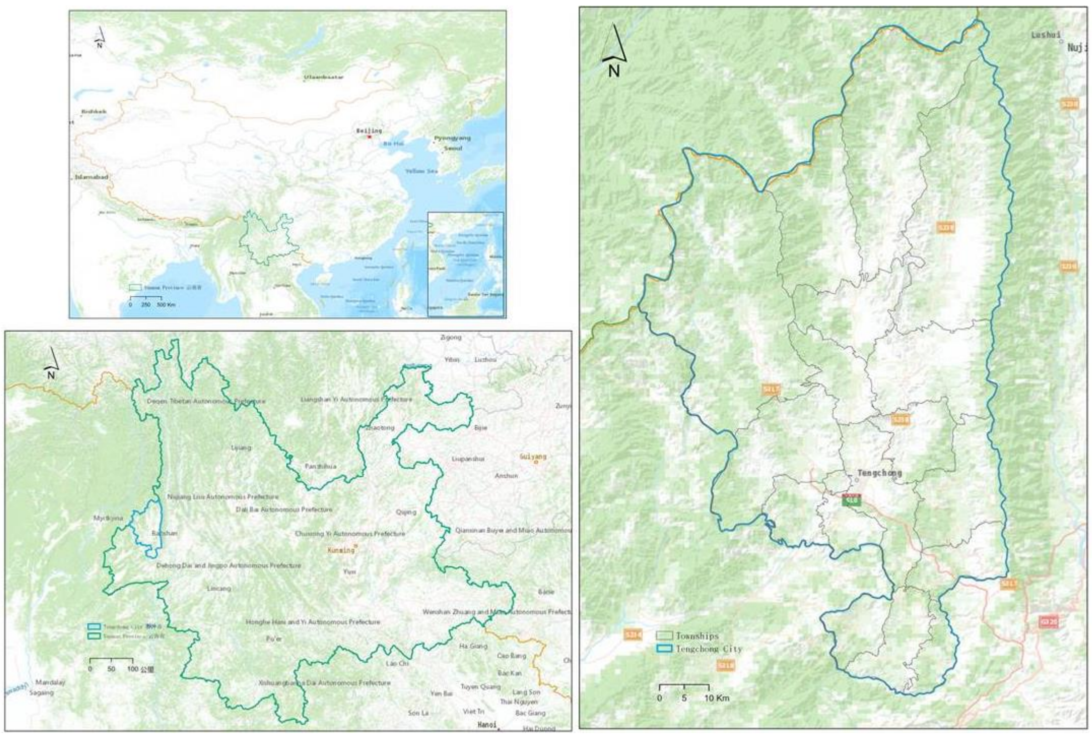

Figure 1 Geographic location of Tengchong

The area is rich in forest resources. With a forest cover of 75%, Tengchong is an important eco-function zone of the nation. The Gaoligong Mountains, which run across the entire territory as part of the Transverse Mountains, are dominated by old-growth forests with over 5,000 plant species and over 3,000 animal species. It is one of the most biodiverse regions in China, and are known as a "gene bank of species".

The Gaoligong Mountain Nature Reserve was established in 1983 with the approval of the Yunnan Provincial People's Government, and the Gaoligong Mountain National Nature Reserve was established in 2000 with the approval of the State Council. Over the past thirty years since the establishment of the reserve, the number of species has increased restoratively. These include about 434 endemic plant species in the Gaoligong Mountains, about four species of plants protected at the national level, about 20 species of animals protected at the national level, about 30 species of plants protected at the national level, about 47 species of animals protected at the national level, as well as the white-browed gibbon (*Hylobates* *hoolock*), the antelope (*Budorcas taxicolor*), the Nujiang golden monkey (*Rhinopithecus strykeri*) and other endangered species.

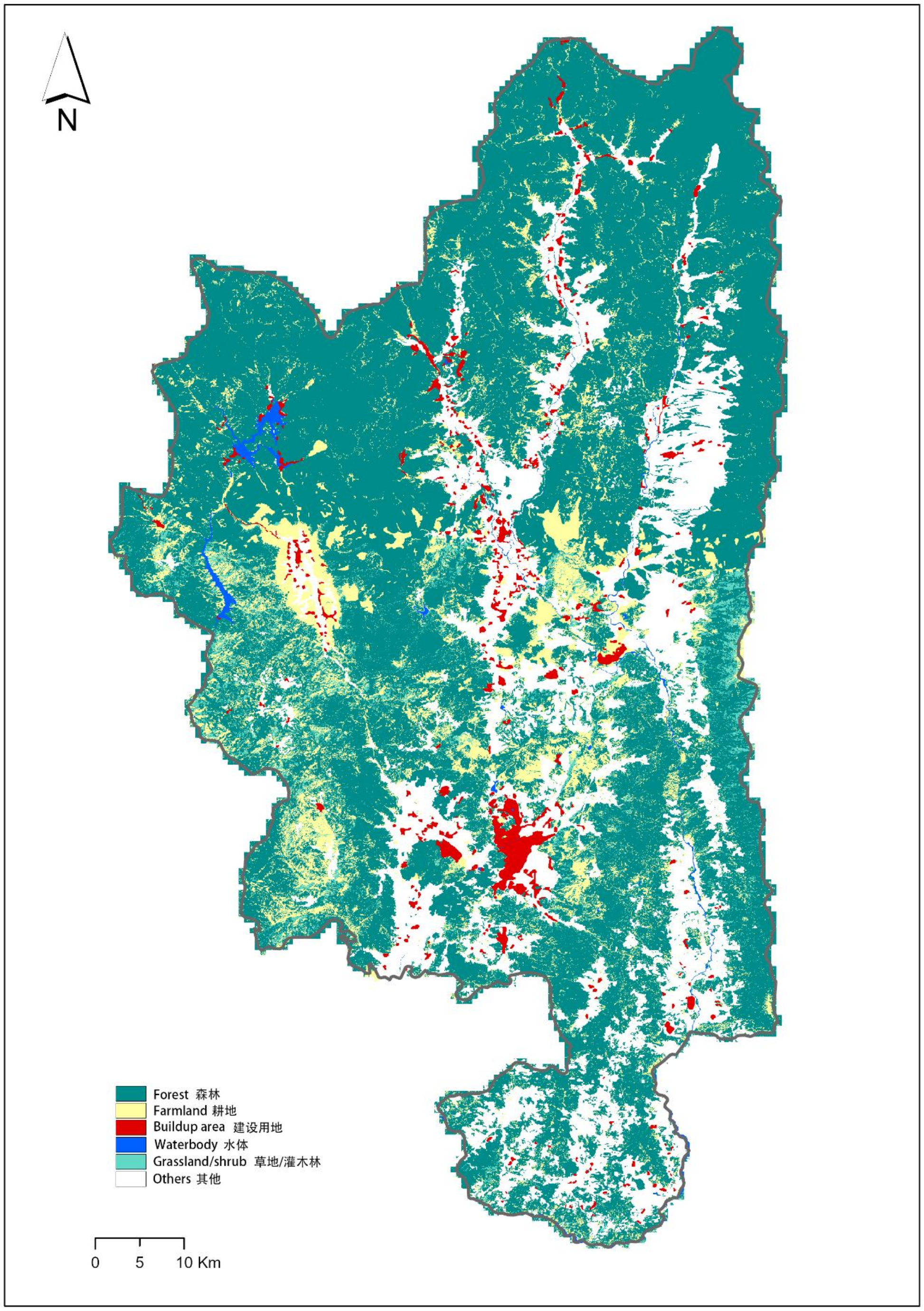

Figure 2 Land use and land cover status of Tengchong City (2020)

The degree of coordination between agriculture and ecology in Tengchong affects regional sustainable development. According to the General Land Use Plan of Tengchong, the city has 1,021,400 mu (appr. 68,093 ha) of arable land, of which

999,800 mu (appr. 66653 ha), or 81.4%, is basic farmland. The Ecological Protection Red Line covers an area of 1675.97 square kilometres, accounting for 28.63% of the city’s total area (Figure 2). Among them, basic farmland refers to the arable land that cannot be occupied in compliance with China's overall land use planning, which is in accordance with the demand for agricultural products for a certain period of time for population and socio-economic development. The ecological protection red line refers to the spatial boundaries and management limits of areas that need to be strictly protected in terms of ecosystem services, environmental quality and safety, and natural resource use, in order to maintain national and regional ecological security and sustainable economic and social development.

Tengchong is also an important demonstration area for practising the concept of ecological civilisation. In 2018, Tengchong City was chosen for the second batch of national "lucid waters and lush mountains are invaluable assets" practice and innovation bases (referred to as the "Two Mountains" bases) by the Ministry of Ecology and Environment. The establishment of the "Two Mountains" base is to encourage areas with good ecological resources and a good foundation for green development to continue exploring effective ways to transform the idea that "lucid waters and lush mountains are invaluable assets" into practice (the “Green is Gold” transformation). Tengchong City was selected because of its excellent ecological environment and its active vision to develop of healthy food, healthy medicine, healthy sports and healthy tourism industries, which have achieved good results.

1.2 Tengchong's agricultural system

Tengchong has a diverse and multi-functional agricultural system, with plantation (including economic forestry) and animal husbandry being the pillars of local agricultural development. As of the third quarter of 2020, the total agricultural output value was RMB 6.4 billion, of which the value of the plantation sector was approximately RMB 4 billion (62.5%), and the value of the animal husbandry sector was approximately RMB 2.4 billion (37.5%). In terms of plantation, as of 2019, 1,241,500 mu (appr. 82,767 ha) of grain crops were sown, achieving a total output of 430,000 tonnes; 320,000 mu (appr. 21,333 ha) of oilseed rape (*Brassica napus*) was planted, producing 49,000 tonnes; 252,000 mu (16,800 ha) of medicinal herbs were planted, producing 16,000 tonnes; 180,000 mu (12,000 ha) of vegetables were planted, producing 190,000 tonnes; 150,000 mu (10,000 ha) of tea was planted, producing a total output of 13,600 tonnes; 12,000 mu (800 ha) of fruit was planted, producing 18,000 tonnes. In terms of animal husbandry, an output of 780,600 pigs, 60,600 cattle, 90,000 sheep and 3,362,000 poultry were achieved in 2019, with a total meat production of 92,200 tonnes (Table 1). Furthermore, many of Tengchong’s agricultural products have high genetic and cultural value, such as the er-si rice (a subspecies of *Oryza sativa*) and the Binglang River buffalo (*Bos bubalus*), of which the latter has been selected for the National Agricultural Cultural Heritage List.

Table 1 Main agricultural production of Tengchong City in 2019

Plantation			
	Produce	Area (10,000 mu)	Yield (tonnes)
1	Grains (rice, wheat, maize)	124.15	430,000
2	Oilseed rape	32	49,000
3	Medicinal herb	25.2	16,000
4	Vegetable	18	190,000
5	Tea	15	13,648
6	Fruit	1.2	18,000
Animal husbandry			
	Produce	Stock (head)	Output (head)
7	Pig	595,000	780,600
8	Cattle	143,000	60,600
9	Goat	73,400	90,000
10	Poultry	2,015,000	3,362,000

Rice (*Oryza sativa*), wheat (*Triticum aestivum*), maize (*Zea mays*), oilseed rape (*Brassica napus*).

The continued development of the medicinal herb industry boosted production value of the agricultural land. At present, Tengchong has more than 60 varieties of medicinal herbs under artificial cultivation, mainly local species, including cao-guo (*Amomum tsaoko*), chong-lou (*Rhizoma paridis*), ginkgo (*Ginkgo biloba*), hou-pu (*Magnolia officinalis*), marigold (*Tagetes erecta*), tian-ma (*Gastrodia elata*), huang-jing (*Polygonatum sibiricum*), dendrobium (*Dendrobium nobile*), hong-dou-shan (*Taxus chinensis*), etc, many of which are medicinal food products. In terms of planting methods, some herbs are planted in the forest (e.g. cao-guo), some in greenhouses (e.g. marigold), or both (e.g. dendrobium), and the output value of herbs accounts for approximately 30% of the total output value of the plantation industry. In 2019, Tengchong successfully landed the "one county, one industry" demonstration for medicinal herbal medicine in Yunnan Province.

The beef cattle industry is the leading subsector in Tengchong's livestock production, but its development has accumulated certain environmental side effects, such as non-point source pollutions in the watershed. With about 500,000 mu (appr. 33,333 ha) of scattered grassland, Tengchong is a dominant beef cattle region in Yunnan Province and one of the 237 beef cattle base counties (cities) in China. The Binglang River buffalo is the only riverine buffalo found in China, it has been reared in Tengchong for more than 200 years and has been selected for the "National Agricultural Cultural Heritage List" due to its high economic and cultural value. But so far, the development of the beef cattle industry has been dominated by smallholder free-range farming, leading to a certain degree of grassland degradation and pollution.

1.3 National policy and the need for local transformation

1.3.1 National and provincial level

Emphasizing Biodiversity conservation. Agricultural activities have had the highest impact on terrestrial biodiversity to date (Dudley & Alexander, 2017), and has been linked to 40% of the global land use change (Clark & Tilman, 2017). In order to protect biodiversity, China instituted the China Biodiversity Conservation Strategy and Action Plan (2011-2030) in 2010, which clearly sets out to reduce the impact of environmental pollution, such as agricultural surface pollution, on biodiversity. Yunnan Province is the richest province in terms of biodiversity in China and is also one of the most critical areas for biodiversity conservation. In response to the China Biodiversity Conservation Strategy and Action Plan (2011-2030), Yunnan Province released the Yunnan Biodiversity Conservation Strategy and Action Plan (2012-2030) in 2013, providing a platform for biodiversity conservation in the country.

Setting clear goals for pesticide and chemical fertilizer reduction and efficiency rise. Green development in agriculture and rural areas is an important aspect in the development of Chinese rural. According to the "Highlights of Green Development Work in Agriculture and Rural Areas in 2020", China continues to promote the reduction and increase the efficiency of chemical fertilizers, strengthening relevant action plans and ensuring that the utilization rate of chemical fertilizers rises to more than 40% by 2020, and at the same time maintaining the negative growth of chemical fertilizer use. Similar action plans have also been carried out for agricultural pesticide use. In 2020, the efficiency of fertiliser and pesticide use in China reached 40.2% and 40.6%[1], respectively, exceeding the 2020 target. According to the No. 1 central document of 2021 issued in February 2021, the reduction of fertilisers and pesticides will still be a major element in the nation’s green-agriculture development in the future, and an important approach to improving product quality, reducing agricultural surface pollution and protecting biodiversity in China. National policy requirements have prompted the agricultural system to shift to more sustainable production and business practices.

Implementing and promoting measures for agricultural resources conversion and utilization. China's resource-based agricultural waste has been large and widespread, and yet it has been handled and utilised in a crude manner, causing great environmental pollution. During the "Thirteenth Five-Year Plan" period, the Ministry of Agriculture and Rural Affairs issued the "Plan for the Construction of Demonstration Projects of Combined Farming and Raising Circular Agriculture (2017-2020)" under the trend of green and characteristic development of agriculture and rural areas. This plan addresses the problems of imbalance in the

[1] http://news.china.com.cn/txt/2021-01/18/content_77127646.htm

structure of farming and poor waste recycling, and promotes the integration of farming and raising with the aim of "optimising the structure and promoting the use", covering the construction of standardised forage bases, the transformation of standardised farms, the recycling of waste from standardised slaughterhouses and the recycling of livestock manure. It covers the construction of standardized forage bases, the transformation of standardized farms, the recycling of waste from standardized slaughterhouses, the recycling of livestock and poultry manure (returning digestate to the fields, deep processing of organic fertilizer), and the comprehensive utilization of crop straw.

Yunnan's pursuit of green food brands. To further promote the implementation of the rural revitalisation strategy, Yunnan set out to improve the organisational structure, scale and marketability of the province's agricultural industry, and promote the high-quality development of modern agriculture with highland characteristics in the province. This programme in Yunnan Province focuses on eight advantageous industries: tea, flowers, fruits, vegetables, nuts, coffee, Medicinal herbs and beef cattle. The aim is to integrate green concepts into all aspects of the agricultural value chain, with the development of agricultural processing and manufacturing as the key. Measures to be taken include accelerating land transfer, agricultural non-point source pollution control, expanding green and organic food certification, placing processing and manufacturing industries close to production areas, and improving processing technology. In 2019, Yunnan proposed the creation of a "one county, one industry" demonstration plan to accelerate the creation of a world-class "green food programme", and to promote the development and transformation of green agriculture in the province. It involves the establishment of 20 pilot counties each with one leading food industry. The government will allocate RMB 30 million per year (for three years) to each county to support the construction of green food.

1.3.2 Tengchong City level

During the 14th Five-Year Plan period, the overall developmental agenda of Tengchong City is to transform itself into a world-class health and wellness destination and a modern park city. The concept of green development will be implemented, and the concept of "Lucid Waters and Lush Mountains are Invaluable Assets" will be applied to all aspects of the economic and social development. These include the promotion of the health industry's development following the "scaled breeding, scaled processing, scaled sales" and "integrated development of the primary, secondary, and tertiary sectors of economy" guidelines, and the establishment of modern agricultural industries, most notably large-scale production bases, deep processing bases, and logistics nodes in the agricultural demonstration areas, with complete chains and cycles, so as to make the primary sector better, the secondary sector stronger and the tertiary sector more active. Tengchong will also consolidate and upgrade the agricultural traditional industries, focus on the key industries with regional characteristics, and improve the green-supply level and market competitiveness of agricultural products. These include the development of green and organic agriculture, strengthening the construction of green food bases, expanding the scale of production and promote large-scale and standardised production. The construction of green food bases emphasizes the building of good agricultural production environment to prevent and control agricultural non-point source pollution, the promotion of agricultural film recycling and straw comprehensive development, the efficient reuse of livestock and poultry manure, and the strengthening of the construction of local green agriculture and food processing industry standards.

Guided by the national zero-growth action on pesticides and fertilisers, Tengchong has gradually replaced chemical fertilisers with organic fertilisers or agricultural manure, and adopted biological control and other measures to prevent and control pests and diseases. For example, the use of chemical fertilisers in Tengchong has been reduced from 32,000 tonnes in 2018 to 30,000 tonnes in 2020, achieving negative growth. The implementation of green pest-and-disease control techniques have been vigorously promoted, covering an area of 745 square kilometres. These are areas prioritizing environmental-friendly techniques such as ecological control, biological control and physical control to minimise the use of chemical pesticides. The local government has also encouraged organic production, with a number of organic production bases for tea, medicinal herbs and oil tea now established.

Tengchong seeks to address livestock and poultry manure pollution issues by adopting scaled production methods. At present, Tengchong has 62,000 free-range livestock households and more than 300 large farms (mostly swine and poultry), with a scale rate of only 20%. To prevent livestock pollution, in 2017, the local government designated 70 restricted farming areas and 60 no-farming areas, covering a total area of 1,207 square kilometres. At the same time, the local government strongly encourages the construction of large farms equipped with waste treatment facilities and the resourceful use of livestock and poultry manure.

According to the "Tengchong City’s Plan To Develop Meat Cattle Industry Following the 1+3+6 Model to Consolidate and Improve the Effectiveness of Poverty Alleviation", an increase of more than 60,000 head in stock is to be achieved by 2022, which means that in principle, each of the city's administrative villages should build at least one standardised cattle farm (the 1), fitted to carry no less than 300 head (the 3). An accompanying forage and feed base of 600 mu (40 ha; 2 mu per head) will be established around each farm (the 6). According to the "Tengchong City’s Work Implementation Plan to Create Green Food Brand", two highland ecological pastures, 10,000 mu (appr. 667 ha) each, will be built in 2021 specifically for the high-quality crossbred beef and dairy production of Binglang River buffalo, which will combined with tourism development of buffalo meat products.

1.4 Time scale of scenario setting

On 29 October 2020, the Fifth Plenary Session of the 19th Central Committee of the Communist Party of China adopted the "14th Five-Year Plan and Proposed Visionary Goals for 2035", which states that the "14th Five-Year Plan” period is the first five years after China has built a moderately prosperous society and achieved the first century-goal (since CCP foundation in 1921), when it will start a new journey to build a modern country and march towards the second century-goal (since PRC foundation in 1949). In the “14th Five-Year Plan” period, China proposes to give priority to the development of agriculture and rural areas and to promote the revitalisation of the countryside, of which improving the quality, efficiency and competitiveness of agriculture is an important goal.

The document also pictures the basic realisation of modernisation by 2035, of which agricultural modernisation is an important component, as well as the widespread formation of a green production and lifestyle in China, the steady reduction of carbon emissions after reaching the peak, and the basic realisation of the goal of building a beautiful China.

The year 2050 is the closing year of China's second century-goal, which is when the country will be built into a strong nation with an overall improvement in ecological civilization, while achieving the goal of strong agriculture and rich farmers, and further strengthening the green production and consumption of agricultural food systems.

With these significant milestones in mind, the project proposes to set the short-term time point for scenario analysis at 2025, the completion year of China's 14th Five-Year Plan, which is also the first five years to achieve quality and efficiency in agriculture for a moderately prosperous society. The mid-term time point for scenario analysis will be 2035, which is the target year for the basic realisation of modernisation in China and an important point for the basic realisation of modern green production and sustainable consumption. Year 2050, the target year for China’s second century-goal, will be set as the long-term time point.

1.5 Scenario setting

1.5.1 Driving forces analysis

The driving forces affecting agri-food systems can be broadly classified into two main categories, namely natural environmental factors and socio-economic factors. Natural environmental factors mainly consider changes in agri-food systems under different climate change scenarios. Socio-economic factors include changes in population, urbanization processes, agricultural farming policies, etc. The basic logic of the impact of the different drivers on agricultural biosystems is as follows:

Climate change: Future regional temperature and precipitation conditions under two representative concentration pathways from the IPCC Fifth Assessment Report , namely RCP4.5 and RCP8.5, were selected as indicators to characterise future climate change scenarios affecting natural capital for this study. Where RCP4.5 is a climate scenario under government intervention, which assumes reduced fossil fuel use and significantly lower greenhouse gas emissions, RCP8.5 is a baseline scenario in the absence of climate change policy intervention, characterised by increased fossil fuel consumption and increasing greenhouse gas emissions and concentrations.

Demographic change: This is mainly reflected in the two aspects of total population and population structure. With the implementation of China's new child-birth policy, China's total population has had no explosive growth, but adopted a steady growth trend. We forecast that the population of the study area will continue to grow at the average rate of past years in the medium to long term. As China's per capita age continues to rise, the ageing phenomenon will become increasingly serious and the elderly population is forecast to be key to the changing characteristics of the population structure, which may affect the supply of rural labour to some extent.

Urbanisation: Urbanisation brings about multi-dimensional changes in agricultural production and food consumption. Firstly, the expansion of urban land during urbanisation changes the type of land use, resulting in a reduction in agricultural and ecological land, thus affecting natural capital; secondly, urbanisation causes a large number of young labourers to move to cities for employment and a loss of young and middle-aged rural labourers, especially male labourers, while also providing opportunities for female and older labourers to be employed, thus affecting changes in human capital. Finally, urbanisation changes the dietary structure of the population and affects the matching of the food consumption structure with the production structure.

Agricultural policies: Agricultural policies mainly refer to relevant agricultural policies implemented or planned locally to promote local agricultural restructuring and development, as detailed in 1.3.2.

1.5.2 Factors of scenario setting

The green development and transformation of agricultural systems, as the main production unit of agriculture and rural areas, has various functions such as economic, social, ecological, cultural and political. The green development and transformation of agricultural systems aims to improve the quality of agriculture and provide better functions and services to local residents and society. In this project, three agricultural farming policy scenarios (baseline scenario, optimistic policy scenario and pessimistic policy scenario) were set up and crossed with two climate change scenarios (medium greenhouse gas emission scenario RCP4.5 and high greenhouse gas emission scenario RCP8.5) to obtain six future scenarios (Table 2).

Table 2 Scenarios adopted in this study

Scenario 1	Scenario 2	Scenario 3
Medium greenhouse gas emission scenario RCP4.5 + baseline policy scenario	Medium greenhouse gas emission scenario RCP4.5 + optimistic policy scenario	Medium greenhouse gas emission scenario RCP4.5 + pessimistic policy scenario
Scenario 4	**Scenario 5**	**Scenario 6**
High greenhouse gas emission scenario RCP8.5 + baseline policy scenario	High greenhouse gas emission scenario RCP8.5 + optimistic policy scenario	High greenhouse gas emission scenario RCP8.5 + pessimistic policy scenario

According to the basic situation and future development needs of the agricultural system in Tengchong City, the plantation scenarios encompass three main modes of conventional cultivation, including conventional crops, endemic species, and under-canopy plantation. The breeding scenarios encompass four main modes of the beef cattle industry, including ecological pasture, standardized breeding, combined planting-breeding, and conventional free-range. Specific definitions are as follows.

- Plantation

Conventional crops: mainly refers to the cultivation of food crops (rice, wheat and maize), but also includes oilseed rape, non-forest herbs, vegetables, fruit and tea cultivation.

Endemic species: cultivation of endemic germplasm resources with significant genetic and cultural value. Locally favourite is er-si rice, which is assumed to have no competition for land with conventional rice due to their its small planting area.

Under-canopy plantation: mainly Chinese medicinal herbs, but also includes other species such as mushrooms.

- Beef cattle breeding

Ecological pasture: the construction of ecological pastures for the breeding of beef cattle (including Penang River buffalo and crossbred beef cattle) on concentrated and contiguous grasslands, as well as the development of tourism to enhance multiple economic, cultural and ecological benefits. Based on the primary productivity of Yunnan's grasslands and the weight of beef cattle, this model requires a matching 5.5 mu of grassland resources to raise one beef cow.

Standardized breeding: refers to enterprises that concentrate on raising beef cattle at a scale of 300 head/farm. Feed is mainly sourced from pasture grass, purchased commercial feed and agricultural and forestry residues, etc.; according to the plan, one beef cattle needs to be equipped with 2 mu of grass resources, which are grown in rotation with forage from non-basic farmland idle planting season. The beef cattle manure is treated by anaerobic fermentation to produce industrial-grade gas, which is used to replace natural gas for local cooking or for industrial power generation, and the digestate is professionally treated to produce organic fertiliser for return to the fields to replace traditional chemical fertilisers and pesticides, contributing to agricultural carbon peaking and carbon neutrality.

Combined planting-breeding: refers to small farmers combining farming and livestock breeding. Small farmers feed their beef cattle with agricultural and forestry residues, planting fodder and finely chopped grass pasture, and the manure produced by the cattle is simply composted and returned to the fields to achieve the recycling of nutrients such as nitrogen and phosphorus. For mountainous areas where farmers live in scattered areas, the "combined farming" model can achieve the full use of local grass resources, agricultural and forestry waste resources, and the recycling of livestock manure, and promote farmers' income and sustainable growth of the agricultural economy.

Conventional free-range farming: small farmers raise beef cattle by grazing or penned breeding, with feed mainly coming from pasture or agricultural and forestry residues, and animal manure is discharged into the surrounding environment without treatment.

At present, Tengchong City's beef cattle mostly comes from conventional free-range and combined planting-breeding modes, with a total breeding scale of 140,000 head.

1.5.3 Specific scenario settings

Specific scenario settings are as follows:

1. <u>Business as usual</u>

This scenario builds on pre-existing policies and initiatives (as of 2020) and ones to be implemented in the 14th Five-Year Plan (2020-2025). Total beef cattle breeding grows from 140,000 head in 2020 to 200,000 head in 2025 and remains unchanged in 2035 and 2050. The use of pesticides and fertilisers in the plantation sector is gradually increasing, the proportion of traditional species cultivation and forestry cultivation is gradually increasing, and the degree of integration of primary, secondary, and tertiary sectors of economy is gradually increasing.

Under this scenario, it is expected that:

- Beef cattle breeding

Ecological pasture: by 2025, 20,000 mu (appr. 1333 ha) of new ecological pastures and 3,640 beef cattle will be added, development of ecological tourism and integrated development of primary, secondary, and tertiary sectors of economy is to remain unchanged in 2035 and 2050.

Standardized breeding: By 2025, 200 new standardised farms, 60,000 new beef cattle and 120,000 mu (8000ha) of new supporting forage land will be present[2], which will remain unchanged in 2035 and 2050.

Combined planting-breeding: By 2025, 10,000 small farmers will be guided to shift from the conventional free-range mode to the combined planting-breeding mode, with a conversion scale of 20,000 beef cattle head; the same will be maintained in 2035 and 2050.

Conventional free-range: by 2025, the number of free-range beef cattle will be reduced by 23,600; the number will remain unchanged in 2035 and 2050.

- Plantation

Conventional crops: (i) the efficiency of fertiliser and pesticide use will increase from 40.2% and 40.6% respectively (2020) to an equal 45% by 2025 (to be determined by the 14th Five-Year Plan), and then both to 50% by 2035 and 2050; (ii) the use of chemical fertilisers will be reduced from 30,000 tonnes at present to 26,700 tonnes in 2025[3], and the use of farmyard manure and organic fertilisers will be increased by 3,300 tonnes, which will remain unchanged in 2035 and 2050; (iii) the area planted remains unchanged and forage required for large-scale beef cattle breeding is rotationally cropped during idle seasons on farmlands, with no impact on the area and production of grain.

Endemic species: By 2025, the er-si rice planting area will increase by 30% from 2020 to 2,600 mu (appr. 173 ha), by 2035 and increase of 50% to 3,000 mu (200 ha), and by 2050 an increase of 100% to 4,000 mu (appr. 267 ha).

---

[2] Based on a calculation of 300 head per farm and 600 mu (40 ha) of forage land in close proximity.

[3] The daily emissions of nitrogen and phosphorus from one beef cattle's manure are 126 g/d and 26.66 g/d, respectively, and the annual emissions of nitrogen and phosphorus are 46 kg/ and 9.7 kg/a, respectively. At 70% efficiency, the annual returns of nitrogen and phosphorus per beef cattle head are 32.2 kg and 6.8 kg, respectively (i.e. the amount of fertiliser replaced). In the baseline scenario, a total of 83,600 head of beef cattle can provide annual equivalents of 2,690 and 565 tonnes of nitrogen and phosphorus, respectively, under the ecological pasture, standardized breeding, and conventional free-range modes. Refer to Sun, C., Pan, Y., Liu, Y. 2017. Study on the current situation of livestock manure resources and the potential of chemical fertilizer substitution: an example from Guzhen County, Anhui Province. J. of Ecol. & Rrl. Env., 33(4): 324-331.

Under-canopy plantation: area under plantation will increase from 6,000 mu (2019; 400 ha) to 30,000 mu (2025; 2000 ha), to 50,000 mu (2035; appr. 3,000 ha), and to remain unchanged by 2050.

- Industrial integration development

Foster agricultural product processing enterprises, accelerate product quality and brand certification, develop rural tourism and agricultural tourism based on modern agriculture, enhance the integration of agriculture and culture, and promote the integration of one, two and three industries.

2. Optimistic Scenario

The scenario assumes good progress towards agricultural modernisation targets during the 14th Five-Year Plan period and continued progress towards green production methods in the agricultural system, with a high level of green production in the agricultural system by 2050. Total beef cattle breeding increases from 140,000 head in 2020 to 200,000 head in 2025, and remains constant in 2035 and 2050. The plantation industry has achieved higher efficiency in the use of pesticides and fertilisers, the proportion of endemic species cultivation and under-canopy plantation has increased, and the degree of integration of the development of primary, secondary, and tertiary sectors of economy has increased.

- Beef cattle breeding

Ecological pasture: by 2025, 20,000 mu (appr. 1333 ha) of new ecological pastures and 3,640 beef cattle will be added, development of ecological tourism and integrated development of primary, secondary, and tertiary sectors of economy is to remain unchanged in 2035 and 2050.

Standardized breeding: By 2025, 200 new standardised farms, 60,000 new beef cattle and 120,000 mu (8000ha) of new supporting forage land will be present, which will remain unchanged in 2035 and 2050.

Combined planting-bredding: By 2025, 10,000 small farmers will be guided to shift from the conventional free-range mode to the combined planting-breeding mode, with a conversion scale of 20,000 beef cattle head; in 2035, 10,000 more small farmers will be guided on the basis of 2025, with a new conversion scale of 20,000 head; in 2050, another 5,000 small farmers will be further guided on the basis of 2035, with a new conversion scale of 10,000 head.

Conventional free-rang: by 2025, the number of free-range beef cattle will be reduced by 23,600, and by 2035 by a further 20,000, and by 2050 an additional reduction of 10,000.

- Plantation

Conventional crops: (i) the efficiency of pesticide use will increase from 40.6% in 2020 to 45% by 2025, 55% by 2035, and 60% by 2050. (ii) The use of chemical fertilizers will be reduced from the current 30,000 tonnes to 26,700 tonnes in 2025, and the use of farmyard manure and organic fertilizers will increase by 3,300 tonnes; the use of chemical fertilizers will be reduced to 25,000 tonnes in 2035, and the use of farmyard manure and organic fertilizers will increase by 4,000 tonnes; the use of chemical fertilizers will be reduced to 20,000 tonnes in 2050, and the use of farmyard manure and organic fertilizers will increase by 10,000 tonnes. (iii) The area under cultivation remains unchanged.

Endemic species: By 2025, the er-si rice planting area will increase by 50% from 2020 to 3,000 mu (200 ha), by 2050 an increase of 100% to 4,000 mu (appr. 267 ha), and by 2050 an increase of 300% to 8,000 mu (appr. 534 ha).

Under-canopy plantation: area under plantation will increase from 6,000 mu (2019; 400 ha) to 30,000 mu (2025; 2000 ha), to 50,000 mu (2035; appr. 3,000 ha), and to cover all available under-canopy areas (specific range to be determined by later research and GIS analysis).

- Industrial integration development

Foster agricultural product processing enterprises, accelerate product quality and brand certification, develop rural tourism and agricultural tourism based on modern agriculture, enhance the integration of agriculture and culture, and promote the integration of one, two and three industries.

3. Pessimistic Scenario

The scenario assumes the emergence of irresistible factors that constrain the modernisation and green development transition of Tengchong's agricultural system and causes extreme scenarios of land use change. Total beef cattle breeding grows from 140,000 head in 2020 to 200,000 head in 2025 and remains unchanged in 2035 and 2050. The pesticide and fertiliser utilisation rate in the plantation sector remains unchanged, endemic species plantation and under-canopy plantation are reduced to 0, and the degree of integration of the primary, secondary, and tertiary sectors of economy are low.

- Beef cattle breeding

Ecological pasture: no development of ecological pastures.

Standardized breeding: No development of large-scale breeding.

Combined planting-breeding: No development of combined planting-breeding.

Conventional free-range: By 2025, 200,000 beef cattle head will all be raised in conventional free-range mode, with no centralised treatment of livestock manure.

The 60,000 increase in beef cattle will require 330,000 mu (22,000 ha) of forest around the villages to be converted into grassland[4]. In 2035 and 2050 these numbers will remain unchanged.

- Plantation

Conventional crops: (i) the efficiency of pesticide use will remain at the current level of 40.6% (2020) in 2025, 2035, and 2050; (ii) the use of chemical fertilizers will remain at 30,000 tonnes in 2025, 2035, and 2050, and the use of organic fertilizers and farmyard manure will be reduced to zero; (iii) the area under cultivation will remain unchanged.

Endemic species: By 2025, the planted area of er-si rice will be reduced by 50% compared to 2020 (1,000 mu, appr. 66.67 ha), and by 2035 the planted area will be reduced to 0, which is to remain unchanged by 2050.

Under-canopy plantation: by 2025, the under-canopy plantation area will be reduced to 0, and by 2035 and 2050 it will remain unchanged.

- Industry integration development

This scenario assumes no new agricultural product processing enterprises, no product quality and brand certification, and a low level of integrated development of primary, secondary and tertiary industries.

The changes in the scale of each agricultural sector under different scenarios are shown in Table 3.

[4] Based on the calculation that 5.5 mu (appr. 0.37 ha) of grassland is required for one free-range beef cattle.

Table 3 Changes in different agricultural sectors in Tengchong under different scenarios

		Animal husbandry (10,000 head)				Deforestation (10,000 mu)	Conventional crops (10,000 mu)		Fertilisers & pesticides			Endemic species (10,000 mu)	Under-canopy plantation (10,000 mu)
		Standardized breeding	Ecological pasture	Combined planting-breeding	Conventional free-range		Pasture	Crops	Fertilizers (10,000 tonnes)	Organic fertilizers & farmyard manure (10,000 tonnes)	Pesticide efficiency (%)		
Now	2020	0	0	X	14-X	0	12	120.14	3	Y	40.6	0.2	0.6
BAU	2025	6	0.36	X+2	11.64-X	0	12	120.14	2.67	Y+0.33	45	0.26	3
	2035	6	0.36	X+2	11.64-X	0	12	120.14	2.67	Y+0.33	50	0.3	5
	2050	6	0.36	X+2	11.64-X	0	12	120.14	2.67	Y+0.33	50	0.4	5
Optimistic	2025	6	0.36	X+2	11.64-X	0	12	120.14	2.67	Y+0.33	45	0.3	3
	2035	6	0.36	X+4	9.64-X	0	12	120.14	2.5	Y+0.5	55	0.4	5
	2050	6	0.36	X+5	8.64-X	0	12	120.14	2	Y+1	60	0.8	Z
Pessimistic	2025	0	0	0	20	33	0	120.14	3	0	40.6	0.1	0
	2035	0	0	0	20	33	0	120.14	3	0	40.6	0	0
	2050	0	0	0	20	33	0	120.14	3	0	40.6	0	0

X denotes the current scale of beef cattle breeding under the combined farming model (10,000 head); Y denotes the current amount of organic/farmyard manure used (10,000 tonnes); Z denotes the area of under-canopy plantation development to all suitable forest land in 2050 under the optimisation scenario (10,000 mu), with specific areas to be determined by later research and GIS analysis.