Changes in indigenous natural resource utilization regimes and land uses in Dong ethnic minority villages in southwest China

（中国南西部のドン少数民族の村落における先住民の天然資源利用体制と土地利用の変化）

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Chapter 1 Introduction

1.1 The Dong ethnic minority in China

Ethnic minorities in China are the non-Han Chinese population in the People's Republic of China (PRC). In addition to the Han majority, the PRC recognizes 55 ethnic minority groups in China. In 2010, the population of officially recognized minority groups in mainland China accounted for 8.49 percent of the total population (Www.gov.cn, 2014).

Due to historical factors, disadvantaged ethnic minorities tend to distribute in remote areas (Skutsch, 2005). The Dong ethnic minority people, also referred to as the Kam people, one of the fifty-five recognized ethnic minorities in China with a population of 2.88 million according to the 2010 census, are distributed in the mountainous area in Guizhou Province, Guangxi Zhuang Autonomous Region and Hunan Province in Southwestern China.

The Dong people are famous for their grant song, which is listed on UNESCO's Representative List of the Intangible Cultural Heritage of Humanity since 2009 (Unesco.org., 2009). As an ethnic minority without writing characters, the Dong people use grand songs to pass the knowledge of their interaction with nature (Yang, 2015). They are also famed for their unique architecture built by fir wood, especially the drum tower ("*Gulou*" in Chinese) and the roofed bridges called wind and rain bridge ("*Fengyuqiao*" in Chinese). Twenty-two villages are listed on the Tentative Lists of States Parties published by the World Heritage Centre (Unesco.org., 2013). The Dong nationality also possesses unique costumes, festivals, and cuisines (Skutsch, 2005). In history, there were conflicts between the Dong nationality and Han Chinese people and other ethnic minority groups like the Miao nationality (Skutsch, 2005). Today urbanization has pushed large rural Dong population to move into urban areas, resulting in a merge of national culture and loss of cultural identity (Geary and Pan, 2003).

The Dong people tend to reside along rivers in mountainous areas. They developed unique natural resource management regimes for self-subsistence within their environment with limited natural resources and few connections with the outside world. They created a unique landscape by applying long-standing agricultural practices (Yuan et al., 2012). The Dong's Rice-Fish-Duck System in Guizhou is a recognized Globally Important Agricultural Heritage Systems (GIAHS) in China (fao.org., 2011). They have a long tradition of cultivating Kam fragrant glutinous rice, one of the sticky rice varieties (Lei et al., 2017a; Lei et al., 2017b), and their forest management regimes of fir plantations also received some research interest (Yuan et al., 2012; Yuan and Wu, 2010; Xu and Wang, 2021; Yang, 2007).

1.2 Research review

1.2.1 Importance of traditional ecological knowledge of ethnic minority groups

Agricultural landscapes are shaped and maintained by human activities (Naveh, 1995; Ellis, 2015; Nassauer, 1995). Traditional agricultural management regimes, particularly those pertaining to the agricultural use of natural resources, create and preserve landscape heterogeneity responsive to the needs and demands of residents (Kamada and Nakagoshi 1997). Natural resource management (NRM) refers to the sustainable utilization of major natural resources, such as land, water, air, minerals, forests, fisheries, and wild flora and fauna (Muralikrishna and Manickam, 2017). NRM is concerned with the interaction of human and natural landscapes, which includes the utilization and conservation of natural resources. Past

research shows that traditional landscapes that are managed by indigenous people using traditional ecological knowledge (TEK) they gain from long-term interacting with the surrounding environment are resilient to disturbances and maintain ecosystem services (Gómez-Baggethun et al., 2013).

TEK stands for all types of knowledge concerning the environment that a particular people derived from experience and traditions (Houde, 2007). Previous research indicates three aspects of traditional ecological knowledge: knowledge system, system of practice, and moral and spiritual values (Berkes, 1995 & Reo and Whyte, 2011). For ethnic minority groups, since TEK comprises all types of knowledge, it is expressed indirectly in the ethnic minority people's knowledge, practice, respect, value, et. (Yuan et al., 2014). Houde identified six TEK manifestations: factual observations, management systems, past and current uses, ethics and values, culture and identity, and cosmology (Houde, 2007). Past research demonstrated the potential contribution of TEK in conserving biodiversity (Berkes et al., 1995), making sustainable resource management plans (Inglis, 1993), monitoring and adapting to climate change (Hosen et al., 2020), alleviating poverty (Parrotta et al., 2007), and strengthening socio-ecological resilience (Erik et al., 2012; Gu et al., 2012). Faced with today's global environmental problems and human well-being issues, the United Nations General Assembly initiated 17 Sustainable Development Goals (SDGs) in 2015 to be completed by 2030 (Un.org., 2015). Recent research highlighted the role of TEK in meeting SDGs (Kumar et al., 2021; Das et al., 2021), which pointed out the new direction of the application of TEK and traditional natural resource management (NRM) so that they can continue benefiting human society.

There was some fascinating research on the TEK of the ethnic minority groups in southwestern China in the past decade, results from which reveal a decline in the transfer of TEK (Yuan et al., 2012; Yuan et al., 2014; Zhou et al., 2018). Although past research on the Dong ethnic minority people already identified some of their TEK in managing forest resources and water resources (Yuan et al., 2012), there is a research gap of analyzing TEK and NRM of the Dong people from a landscape perspective, integrating the management of natural resources in the farmland, forest, and settlement.

Japan launched the Satoyama Initiative (SI) in 2010 to realize "societies in harmony with nature" through landscape approaches to arouse interest in biodiversity and ecosystem conservation and to rebuild a healthy human-nature relationship both in Japan and internationally. It highlighted the importance of traditional ecological knowledge. In the SI, the concept of Socio-ecological production landscapes and seascapes (SELPS) is developed as Satoyama-like landscapes that are "managed via interactions between ecosystems and human to create various ecosystem services for human well-being" and "characterized by a mosaic of different ecosystem types: secondary forest, timber plantations, farmlands, irrigation ponds, wetlands, grasslands, beaches, and coastal zones, as well as human settlements" (Saito et al. 2020). Research on SELPS across the globe can provide models for making sustainable management plans (Saito et al. 2020).

1.2.2 Rural land-use change problems in southwestern China

The past century has witnessed tremendous agricultural landscape changes for various reasons, including agricultural intensification, urbanization and related land abandonment, the rise of natural conservation awareness, and the potential impacts of climate change (Plieninger et al., 2016; Millennium Ecosystem Assessment, 2005). These changes have led to and will

continue to cause declines in ecosystem services (Millennium Ecosystem Assessment, 2005). China experienced such landscape changes due to urbanization, which induced problems such as depopulation and changes in land use in rural areas (Yan et al., 2020). Various factors, including political, socio-economic, and cultural factors, interact with each other to create this issue, rather than a single factor, which makes the characteristics, conditions, patterns, and processes of agricultural landscapes and their changes difficult to understand, although such knowledge is crucial and urgently needed to develop sustainable management plans (Plieninger et al., 2016; Antrop, 1997; Kamada and Nakagoshi, 1997).

The goal of 'rural revitalization' that was announced in the CCP's 19th Congress in late 2017, which aims to build rural areas with thriving businesses, ecologically sound living environments, social civility, effective governance, and prosperity, provides not only developing opportunities into rural areas in China, but may also bring about challenges, i.e., rural revitalization emphasize the revitalization of rural land resources via the market, which may increase the property income of villagers, but might also detach villagers from their land (Yan et al., 2020). Therefore, there is an urgent need to research the land-use changes in indigenous ethnic minority villages to understand the status of their landscape so that we can make a preservation plan of the traditional landscapes and make suggestions for implementing the Rural Revitalization Strategy.

Research on land-use change in China has attracted much interest, while accelerated urbanization has brought about urban growth and cropland loss in China. The processes, driving factors, and ecological effects of rural land-use change in the mountainous areas of western China require more research compared to the flourishing research in the metropolitan area in eastern and coastal China (Peng et al., 2008) since rural China is experiencing land-use problems including the abandonment of farmland, non-agriculturalization, and non-grain preference (Su et al., 2020).

1.2.3 Loss of cultural identity in ethnic minority groups

As is argued by Poole in her research, there is a neglect of protecting TEK and cultural heritage (Poole, 2018), especially in the current situation when urbanization has driven large population from traditional and cultural rural landscapes to become migrant workers in urban areas, resulting in loss of cultural identity, especially in the young generation of ethnic minority children born in the cities (Geary and Pan, 2003).

1.3 Research objectives

The Dong people practice natural resource management for self-subsistence within their environment with limited natural resources and few connections with the outside world and create a unique landscape by applying long-standing agricultural practices. However, urbanization and industrialization have changed the needs and lifestyles of the Dong people, resulting in land-use changes in the Dong region. Wooden houses changed into brick houses, paddy fields are left unused, forests are disappearing, and roads have fragmented the village and the landscape. Past research analyzed the Dong people's TEK in the management of forest resources, water resources, or agricultural systems. However, there is a lack of research from the landscape's perspective. In addition, Guangxi Zhuang Autonomous Region is one crucial area where the Dong people are distributed. However, most of the research on the Dong people was taken in Guizhou Province. There is a research need to understand the tradition and current

conditions of the Dong people's knowledge in managing natural resources and the changes in their land-use systems.

Based on these backgrounds, the following research questions were raised:

- What TEK of the Dong people is maintained, and what is lost?
- What are the drivers of changes in TEK manifested by their NRU regimes and land-use systems?
- How can this research help for sustainable development?

The objectives of this research are:

- To understand the current status of TEK manifested by their agricultural activities;
- To understand the changes and driving factors of their TEK manifested by changes in NRU regimes, land use, and landscape pattern in Dong villages;
- To provide suggestions for sustainable development plans.

The structure of this thesis is shown in Figure 1.1.

Chapter 1 is the general introduction part. Chapter 2 analyses the current condition of the agricultural activities in three Dong villages in a Dong region called Sanjiang County using interview data taken in 2017. Chapter 3 used interview data collected during 2017 and 2018 to analyze a case study in one Dong village from chapter 2 describing the changes in natural resource utilization regimes from 1949 through 2018. Chapter 4 uses the same research site as chapter 3 to conduct a case study using GIS analysis from 2009 to 2020 and demonstrate the spatio-temporal change of land-use and landscape patterns and their driving forces. Chapter 5 gives a general discussion, and Chapter 6 provides the conclusions of this research.

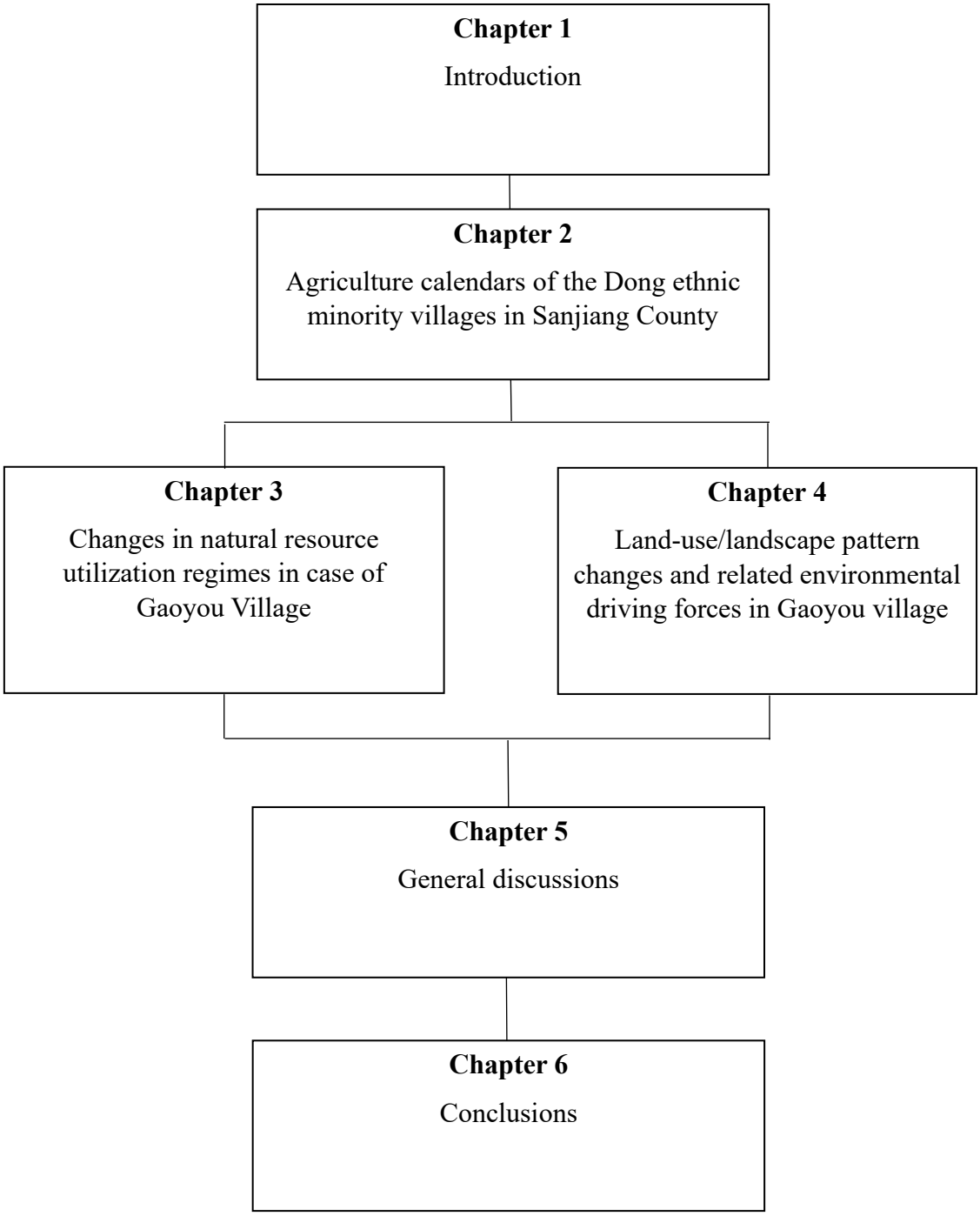

Figure 1.1. Structure of the thesis

1.4 Research site

The research site is Sanjiang Dong Autonomous County (25°21′ ~ 26°03′N, 108°53′ ~ 109°47′E). It is located in Liuzhou city, Guangxi Zhuang Autonomous Region, southwest China, as is shown in Figure 1.2. Because of the lack of farmland and bad topographic conditions to build roads and big urban areas, the county was identified as a critical poverty-stricken county to be aided by the state (and the poverty alleviation succeeded in 2020).

Sanjiang County covers an area of 2429.72 km^2, with 1976.76 km^2 of forest and 235.93 km^2 of farming area. Located in the transition zone between Yunnan-Guizhou Plateau and Southern China Hilly Area and on the watershed of Pearl River Basin (consisting of 74 rivers with a total length of 68 km), an old saying describes this area as '九山半水半分田' (90% mountains, 5% river, and 5% farmland). The region is covered with red loam. The parent material is mainly sand shale. Sanjiang region is in the subtropical monsoon mountain climate zone, with an annual average temperature of 17 to 19°C and annual rainfall of more than 1100 mm. The climate and soil are suitable for timber forests and economic forests. The dominant forest type of Sanjiang County is subtropical evergreen broadleaf forest. The Dong minority people make up more than 50% of the population in this region. Sanjiang has a UNESCO's World Heritage Site called Chengyang Fengyu Bridge, and five Dong villages are listed as the Tentative UNESCO's World Heritage Sites. The traditional food source is glutinous rice, and the forestry primarily consists of Chinese fir, camellia, and bamboo. As a critical poverty-stricken county to be aided by the state, the local government developed a series of poverty alleviation policies, and poverty alleviation was succeeded in 2020.

Figure 1.2. Location of Sanjiang County

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Chapter 2 Agricultural calendars of the Dong ethnic minority villages in Sanjiang County

2.1 Introduction

Nassauer (1995) portrays culture and landscape as interacting in a feedback loop in her studies on culture and landscape structure. Landscapes are shaped by cultural factors such as the political system, economic use, aesthetic preferences, and social traditions, and culture influences the landscape. This culture-landscape feedback loop is connected by incorporating natural resource management operations such as planting, subdivision, harvesting, and construction into the land's underlying biological structure (Nassauer 1995). Traditional natural resource management regimes that incorporate generations of local experience and practice can provide vital information for sustainable resource management and the development of environmental conservation plans based on indigenous knowledge acquired through close and long-term involvement in local ecosystems (Menzies, 2006). Past research shows that traditional landscapes managed by indigenous people using traditional ecological knowledge (TEK) are established by long-term interaction with the surrounding environment, are resilient to disturbances, and maintain ecosystem services (Gómez-Baggethun et al., 2013). However, industrialization, urbanization, and several significant changes in the Chinese state's rural development strategy have changed the lifestyles of the indigenous people and the rural landscapes (Yan et al., 2020). The agricultural calendar, which represents the agricultural activities farmers conduct throughout the year, links farmers to their environment presented by farmers reacted differently to the cosmographical, meteorological, and bioclimatological aspects of the calendar with their TEK (Daldjoeni, 1984). Therefore, changes in the agricultural calendar show how farmers responded to the changing natural, socioeconomic, and political factors (Yegbemey et al., 2014; Iskandar and Iskandar, 2016; Beetstra et al., 2021).

The Chinese Dong nationality, one of the fifty-five national minorities in China, has been using TEK to manage their land for a long history and created a distinguished traditional landscape. The Dong's Rice-Fish-Duck System in Guizhou is a recognized Globally Important Agricultural Heritage Systems (GIAHS) in China (Fao.org, 2022). As a nationality without letters, the Dong minority people recorded their life and feelings in songs that passed through the generations. Knowledge about the indigenous natural resource utilization (NRU) regime that includes various activities can be obtained from the traditional Dong songs sung in the Dong language. The months used in this song refer to the Chinese lunar calendar, which is usually one month later than the solar calendar.

"January collecting firewood in the mountains, February plowing on the flats, March adding manure into the fields, April plowing with a buffalo, May transplanting rice seedlings, June weeding everywhere, July sharpening the scythe for mowing, August harvesting glutinous rice, September harvesting rice and restoring rice, October no working, November mountains froze, December reclaiming farmlands with hoes and guns in the mountains…."

Objectives of this research: (1) To understand the general agricultural calendars of the Dong people in Sanjiang County; (2) To find out the differences of agricultural calendars of the Dong people in different villages; (3) To understand the TEK that was manifested in the agricultural calendars.

2.2 Methodology

2.2.1 Research site

Research in this chapter was conducted in three Dong villages in Sanjiang Dong Autonomous County. The location of these villages, Gaoyou village, Kuangli village, and Liangli village, is shown in Figure 2.1.

Sanjiang Dong Autonomous County (25°21′ ~ 26°03′N, 108°53′ ~ 109°47′E) in Guangxi Province in southwest China covers an area of 2429.72 km^2, with 1976.76 km^2 of forest and 235.93 km^2 of farming area. Located in the transition zone between Yunnan-Guizhou Plateau and Southern China Hilly Area and on the watershed of Pearl River Basin (consisting of 74 rivers with a total length of 68 km), an old saying describes this area as '九山半水半分田' (90% mountains, 5% river, and 5% farmland). The region is covered with red loam. The parent material is mainly sand shale. Sanjiang region is in the subtropical monsoon mountain climate zone, with an annual average temperature of 17 to 19°C and annual rainfall of more than 1100 mm. The climate and soil are suitable for timber forests and economic forests. The dominant forest type of Sanjiang County is subtropical evergreen broadleaf forest. The Dong minority people make up more than 50% of the population in this region. The traditional food source is glutinous rice, and the forestry primarily consists of Chinese fir, camellia, and bamboo. Because of the lack of farmland and bad topographic conditions to build roads and urban areas, the county was identified as a critical poverty-stricken county to be aided by the state (and the poverty alleviation succeeded in 2020).

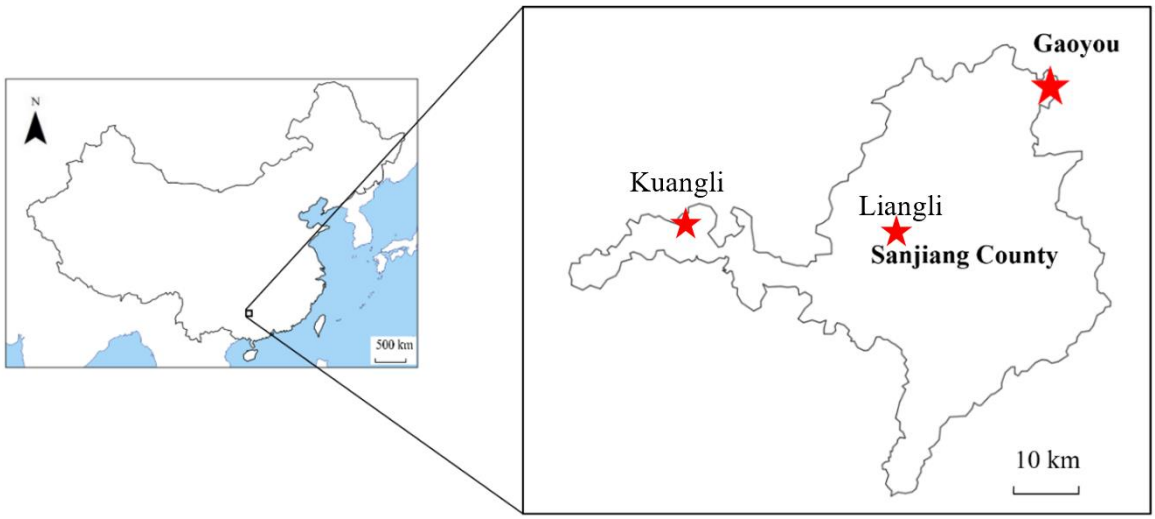

Figure 2.1. Location of study sites

The basic information about these study sites is listed in Table 2.1. Please note that there are five village committees in Kuangli Town, and the study site Kuangli is one of the five village committees. Since the official information about this village committee is not available, the official information of Kuangli Town is used in the table.

The first research site is Gaoyou village (N 25°59′02″, E 109°52′35″). Gaoyou village is located on the top of a mountain. As is shown in Figure 2.2(a), Gaoyou village preserves a traditional Dong landscape with delicate wooden houses and diverse land-uses. It is one of the Dong villages that are on the Tentative Lists to the World Heritage (Unesco.org., 2013).

The second research site is Kuangli village (N 25°46′27″, E 109°27′41″). As is shown in Figure 2.2(b), Kuangli is a village located on the riverbank. After a road was constructed on the other bank of the river in 1998, some villages moved to the other bank and built brick houses. The old village was left with traditional wooden houses.

The third research site is Liangli village (N 25°42′57″, E 109°52′35″). Liangli used to be located on the mountain top. In 2009 the local government helped build a new village in the flat area near the road, so the whole village moved to the new village from the old village on the mountain, and the new village is shown in Figure 2.2(c).

Table 2.1. Baseline information about the villages

Village	Population	Households	Area (ha)	Farmland area (ha)	Forest area (ha)	Other areas (ha)	Average elevation (m)
Gaoyou	1820	488	460	100	270.4	89.6	500
Kuangli	2574	654	1070.77	245.89	446.57	378.31	200
Liangli	89	22	82.4	4.53	No data	77.87	200

Data source: Provided by Liuzhou Agriculture Bureau in 2017.

(a) **(b)** **(c)**

Figure 2.2. The present landscape of (a) Gaoyou village (b) Kuangli village (c) Liangli village. (photographed in 2017)

2.2.2 Data collection

The method of interview was used in this research. Interviewees' information is summarized in Table 2.2.

The respondents were randomly selected for general discussion in the first step, and other respondents were subsequently selected and introduced by a village chief, a cooperative chief, or a primary school teacher for in-depth interviews. All respondents lived in the village for more than 20 years and had a good understanding of the landscape and agricultural activities. In the general discussion part, residents were mainly asked about baseline information about each village and the general agricultural calendar. In the personal interview, interviewees were asked about household information about the interviewee and the major agricultural activities in their residential area, farming area, and forest area throughout the year. Groups of 4-10 residents of general discussion were taken in each village. In each general discussion, three hours were taken, and over 2 hours were taken in each in-depth interview. In each interview, the researcher was accompanied by a translator, a local governor, and an agriculture expert. The interviews were conducted during four visits to the villages during 2017.9.20 and 2017.11.5.

Table 2.2. Interviewees' information

Aspects		**No. of respondent**		
		Gaoyou	**Kuangli**	**Liangli**
Gender	**Male**	19	13	4
	Female	3	6	6
Average age		63	61	60
Education	**Elementary school**	17	12	8
	Junior High School	2	3	1
	Senior High School	3	2	1
	University	0	2	0
Occupation	**Agriculture**	22	18	10
	Others	0	1	0
TOTAL RESPONDENT		22	19	10

2.3 Results

2.3.1 Backgrounds of changes of Dong people's lifestyle in Sanjiang County

The information derived from inventory data and governmental data in Sanjiang County was synthesized in Figure 2.3 to illustrate the backgrounds of changes in lifestyles in Sanjiang county. Political backgrounds, demographic backgrounds, socio-economic backgrounds, ecological backgrounds, and cultural backgrounds are all included in this figure.

China has undergone significant political changes over the past hundred years, affecting and interacting with other backgrounds. One fundamental change caused by political factors is the change of the land system. Before the liberation of China in 1949, the land belonged to households who reclaimed it, and poor farmers worked for these landlords through farming and forest work in exchange for food or money to buy necessities. In 1950, the central government of China published a Land Reform Law to abrogate ownership of land by landlords and redistributed the land confiscated from former landlords to all peasants. Later the government began organizing the peasants into teams, which subsequently were combined into producer cooperatives and communes that managed the land, taking orders from the government after the government took control of the land in 1956. After the Reform and Opening Up Policy in 1978, the implementation of the Family Production Responsibility System gave the freedom to manage the land back to the peasants.

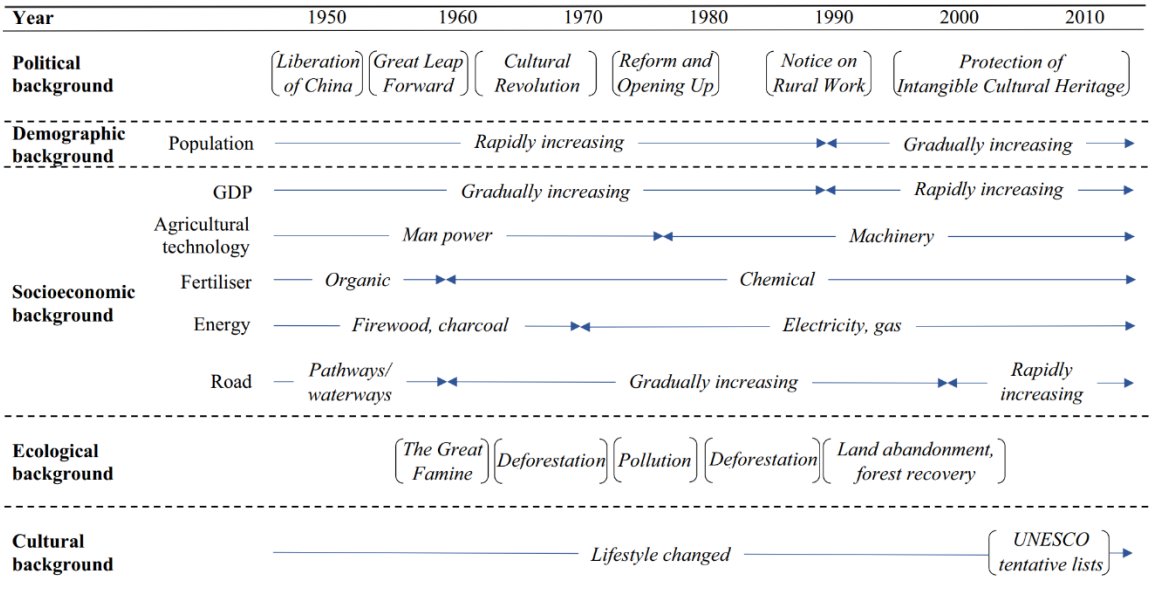

Figure 2.3 Backgrounds (Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2018)

Regarding the demographic background, the population increased rapidly after the liberation of China, slowing down in the 1990s, which resulted in resource over-exploitation to fulfill the increasing needs for self-sustainability. The rapid urbanization and industrialization occurring after the Reform and Opening Up created huge economic profits in the cities that attracted millions of farmers to migrate into cities to pursue higher income. The outflow of the population from rural areas into urban areas occurred after several notices on rural work that facilitated the new lives of farmers in the cities were implemented in the early 1990s. Figure 2.4 and Figure 2.5 show that small children accounted for less of the population in 2010 than in 1982, which indicates a slowdown in population growth in Sanjiang County. These two figures also suggest that young laborers made up less of the population in 2010 than in 1982, suggesting that young farmers left the village and became migrant workers. Table 2.3 summarizes data from several censuses that explain the trends of migrant workers in recent years.

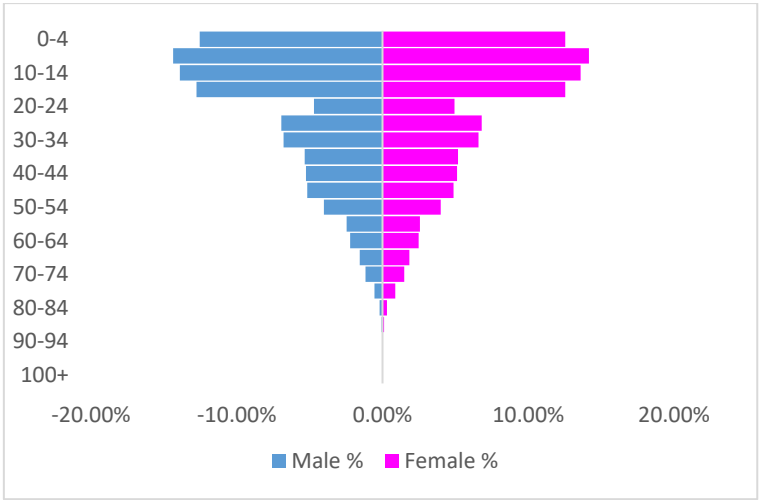

Figure 2.4. Permanent resident population structure in 1982

Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2017

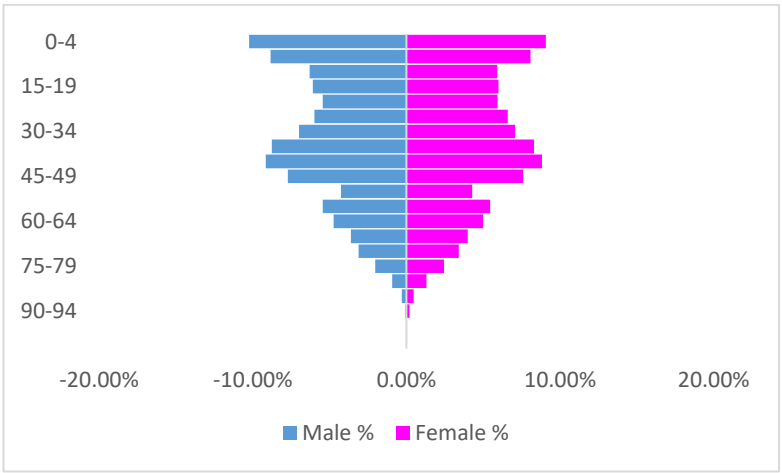

Figure 2.5. Permanent resident population structure in 2010

Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2017

Table 2.3. Percentage of migrant workers for more than six months each year in the whole population in Sanjiang County (Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2018)

Year	Male (%)	Female (%)	Total (%)
1990	0	0	0
2000	11.17	10.66	10.93
2010	26.53	22.14	24.46

Industrialization brought new agricultural technology, fertilizer, and pesticides into traditional farming, increasing crop production and the GDP in this region and introducing water and land pollution problems. The GDP growth in Sanjiang is shown in Figure 2.6. Regarding the ecological background, the Great Leap Forward campaign negatively impacted agriculture. A three-year natural disaster deteriorated the situation and led to the Great Famine in the early 1960s. Deforestation occurred when numerous trees were clear-cut to provide energy for industrialization. Another period of severe deforestation occurred in the early 1980s when the market started to open, and the regulations were not complete, so farmers sold timber from their newly redistributed forest in exchange for quick money. The shift in energy sources from firewood to electricity and gas allowed the forest to recover. In Sanjiang, the electricity consumption increased from 38,670 thousand kWh in 2000 to 55,090 thousand kWh in 2013. The outflow of young laborers into cities caused land abandonment problems in some areas.

The Dong people developed and maintained their characteristic culture before the liberation of China as it was scarcely connected with the outside world since their resident area was restricted by the geographical environment. The transformation of production modes due to political changes, industrialization, the Cultural Revolution, and more communication with the mainstream culture gradually changed the lifestyle of the Dong people. The country pays great attention to the conservation of ethnic minority culture when it is mentioned in the Protection of Intangible Cultural Heritage in the 21st century. Using the cultural resources in the Dong villages, tourism was developed and grew stronger after several Dong villages were listed as World Heritage sites by UNESCO. (UNESCO, 2013)

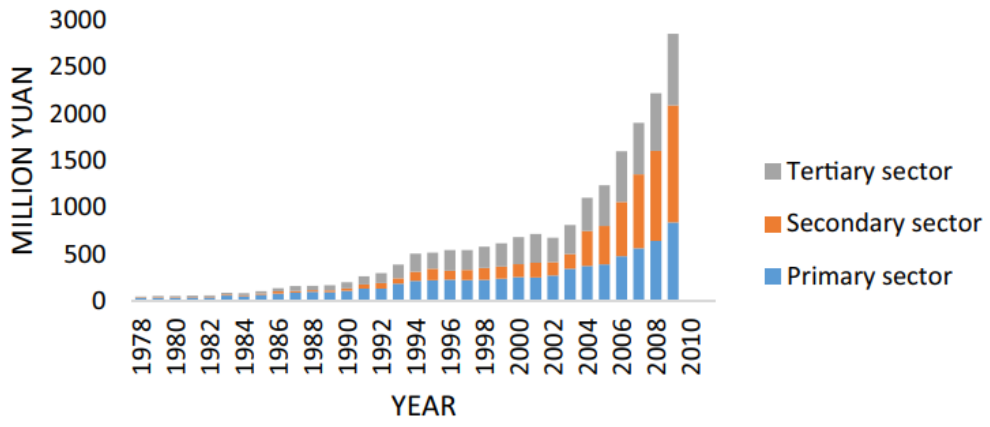

Figure 2.6. GDP by sector of Sanjiang in 1978-2010 (at current prices). (Data source: the official statistics provided by the Agricultural Bureau of Liuzhou, 2018)

The land use and NRU regime changes in Sanjiang during the modern period in China under these backgrounds. Figure 2.7 illustrates some critical changes in grain area, rice area, grain production, and rice production between 1950 and 2018. Although several fluctuations are evident in this figure, grain and rice production show an upward change in total. Cultivated and rice area decreased gradually after the 1990s when some farmlands were changed into other land uses or left unmanaged because villages were losing their labor. Governors of the Sanjiang Agricultural Bureau estimated the percentage of abandoned farmland in the Sanjiang region is about 5%, and most of the abandoned farmlands are located on slopes where water accessibility is difficult. For example, garden fields in Sanjiang, including fruit and tea plantations, increased from 3328 ha in 2003 to 15,206 ha in 2019. However, the rice area decreased while the rice production increased due to the increase in yield.

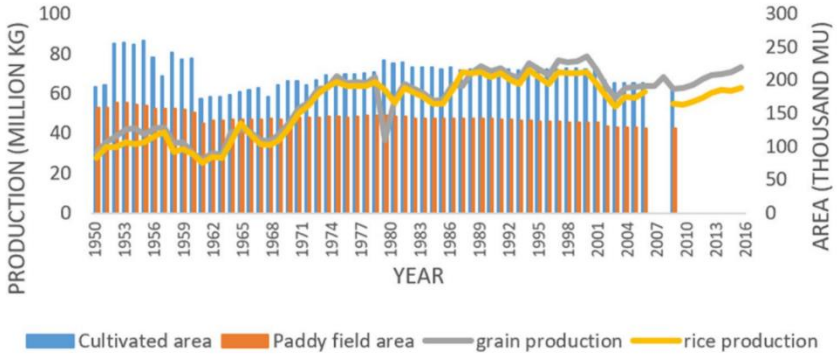

Figure 2.7. Changes in area and production of grain and rice in Sanjiang, 1950 – 2017

Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2018

2.3.2 Agricultural calendars of three villages

I used information derived from interviews and drew Table 2.4, Table 2.5, and Table 2.6 to show the present annual agricultural activities in Gaoyou village, Kuangli village, and Liangli village in Sanjiang county, respectively. Figure 2.8 was illustrated to summarise the agricultural activities of the Dong people in Sanjiang county. Table 2.7 shows the annual festival calendar in Sanjiang county.

Table 2.4. Agricultural calendar of Gaoyou village (a village on the mountain)

Place **Month**	**Forest area**	**Farming area**	**Resident area**
January	Planting trees[1]	Direct sowing on dry field[2], applying animal manure, harvesting tea leaves	
February	Planting trees	Weeding and preparing paddy fields, direct sowing, and harvesting on dry field, catching fish, harvesting tea leaves, harvesting green manure	
March	Planting trees	Seeding, preparing paddy fields, harvesting and direct sowing on dry field, rearing fry[3], harvesting tea leaves, harvesting green manure	
April	Harvesting satoyama products[4]	Seeding, transplanting rice seedlings, direct sowing and harvesting on dry field, harvesting tea leaves, catching fish, stocking of fish seed, growing vegetables[5]	
May	Harvesting satoyama products	Transplanting rice seedlings, harvesting tea leaves, stocking of fish seed, growing vegetables	
June	Weeding, logging	Direct sowing and harvesting on dry field, harvesting tea leaves, growing vegetables	Weaving and dyeing cloth
July	Weeding, logging	Direct sowing on dry field, weeding, catching fish,	Weaving and dyeing cloth

		harvesting tea leaves, growing vegetables	
August	Weeding, logging	Harvesting rice, threshing, direct sowing and harvesting on dry field, catching fish, harvesting tea leaves	Dyeing cloth
September	Collecting camellia seeds	Direct sowing and harvesting on dry field, planting green manure, stocking of fish seed, harvesting tea leaves	Pickling meat and fish
October	Collecting camellia seeds, applying fertilizer	Harvesting glutinous rice, harvesting on dry field.	House building, oil squeezing from camellia seeds, weaving and embroidery, pickling meat and fish
November	Collecting camellia seeds	Harvesting glutinous rice, direct sowing on dry field	House building, weaving and embroidery, oil squeezing from camellia seeds, making bamboo crafts, pickling meat and fish
December	Slash-and-burn	Direct sowing and harvesting on dry field, catching fish, stocking of fish seed	Repairing irrigation works, making bamboo crafts

1 Fir saplings, camellia, tea
2 Sweet potato, leeks, indigo, maize, cotton, carrot, oilseed rape, soya beans
3 Most farmers buy fry from the market now
4 Bamboo shoots
5 White radish, Chinese cabbage, cabbage, eggplants, tomatoes, chili, garlic, coriander

Table 2.5. Agricultural calendar of Kuangli village (a village by the river)

Place Month	Forest area	Farming area	Resident area
January	Planting trees[1]	Preparing paddy fields, direct sowing[2] on the dry field, preparing paddy fields	Weaving cloth
February	Planting trees, harvesting satoyama products[3]	preparing paddy fields, direct sowing and harvesting in the dry fields, applying animal manure	Raising ducks, drying vegetables, weaving cloth
March	Planting trees, harvesting satoyama products	Seeding, preparing paddy fields, harvesting and direct sowing in the dry fields, rearing fry, harvesting green manure	Raising ducks, fishing, weaving cloth
April	Harvesting satoyama products	Transplanting rice seedlings, direct sowing on the dry field, rearing fry, stocking of fish seed	Raising ducks
May	Logging, harvesting satoyama products	Conducting weeding, fertilizing and pest control, growing vegetables	
June	Weeding, logging, harvesting satoyama products	Harvesting in the dry fields, conducting weeding, fertilizing and pest control, fish culturing in paddy fields, harvesting rice	
July	Weeding, logging, harvesting satoyama products	Harvesting in the dry fields, harvesting rice, threshing	Weaving and dyeing cloth, fishing
August	Weeding, logging, collecting camellia seeds, harvesting satoyama products	Harvesting rice, harvesting glutinous rice, threshing, direct sowing and harvesting in the dry fields, catching fish	Weaving and dyeing cloth, fishing
September	Collecting camellia seeds, harvesting satoyama products, planting trees	Direct sowing and harvesting in the dry fields, harvesting ratoon rice, catching	Repairing houses

		fish, harvesting glutinous rice	
October	Collecting camellia seeds	Harvesting glutinous rice, direct sowing and harvesting in the dry fields. catching fish, harvesting ratoon rice, growing vegetables	House building, oil squeezing from camellia seeds, weaving, pickling meat, duck and fish.
November	Collecting camellia seeds, cut charcoal trees, preparing winter buffalo grass	Direct sowing and harvesting in the dry fields, catching fish	House building, weaving and embroidery, oil squeezing from camellia seeds, making bamboo crafts, making charcoal, pickling meat, duck and fish.
December	Preparing winter buffalo grass	Catching fish	Making bamboo crafts, weaving cloth

1 Fir saplings, camellia, bamboo, fruit trees (plum, waxberry, pear, loquat, mandarin orange, persimmon, Chinese wampee, Yuzu, chestnut), Tung oil

2 Uncaria (Chinese herb medicine), oilseed rape, maize, peanuts, potato, sweet potato (feed pigs), cassava, beans, cotton, taro, green manure, indigo

3 Fern, edible insects, rats, chestnut, bamboo shoot, birds, wild boar, pheasant, river snail

Table 2.6. Agricultural calendar of Liangli village (a village on the mountain but relocated to the valley)

Place / Month	Forest area	Farming area	Resident area
January	Planting trees[1]	Direct sowing[2] into the dry fields, harvesting tea leaves	
February		Harvesting tea leaves	
March		Harvesting tea leaves	
April		Seeding, transplanting rice seedlings, direct sowing into the dry field, stocking of fish seed, harvesting tea leaves	Raising ducks,
May		Transplanting rice seedlings, weeding and pest control, growing vegetables, harvesting tea leaves	
June	Weeding, logging	Harvesting into the dry field, weeding and pest control, harvesting tea leaves	
July	Weeding, logging	Harvesting in the dry fields, weeding and pest control, harvesting tea leaves	
August	Weeding, logging, Collecting camellia seeds	Harvesting rice, threshing, catching fish, harvesting tea leaves	
September	Collecting camellia seeds	Direct sowing and harvesting in the dry fields, harvesting glutinous rice, harvesting tea leaves	Raising ducks
October	Collecting camellia seeds	Direct sowing into the dry field	
November	Collecting camellia seeds, cut charcoal trees		
December			

1 Fir saplings, fruit trees

2 Lotus, sweet potato, maize, taro

Figure 2.8. Agricultural calendar of the Dong people in Sanjiang County

Table 2.7. Festival calendar in Sanjiang County

Month	Festival
January	Chinese New Year, Sa rituals[1], Yue ye[2]
February	Spring Community Day
March	Folk Song's Day, Qingming Day
April	April Eighth Day
May	Worshipping Ox Festival/ May Fifth Day, Duanwu Festival
June	June Sixth Day
July	July Fourteenth Day
August	Autumn Community Day, Mid-autumn Festival
September	
October	Fish Day
November	
December	

1 Sa is the most important deity in Dong's culture. In January, the Dong people have special rituals to worship Sa.

2 Yue ye (in Dong's language) is a Dong traditional social activity that the whole village visits another Dong village and enjoys dinner and singing and dancing for three days or more.

a) The similarity of agricultural activities of the Dong people in Sanjiang County

Figure 2.8. shows that the Dong people conduct various agricultural activities in different areas throughout the year.

In the forest area, the primary activities include planting trees in winter, weeding and logging in summer, and collecting camellia seeds in autumn. Traditionally the Dong people used buffalo to help with farming activities. Although most farmers replace buffalo with small agricultural plow machines, some poverty-stricken families still raise buffalo for farming.

According to some interviewees, poverty-stricken families raise buffalo to get additional income because the government provides a subsidy for raising buffalo. As long as the farmers raise buffalo, they collect buffalo grass in the forest before winter. The Dong people also collect satoyama products from the forest. Like many other ethnic minority people in southwest China, the Dong people also have a long tradition of bird hunting. Before handing over guns to the government in 2000, the Dong people hunted birds in the forest. The major satoyama products they get from the forest are plants like fern and bamboo shoots, and wild animals like rabbits, chickens, or boars by trapping.

In the farming area, the most important agricultural activity is rice cultivation. After paddy field preparation work in winter, the Dong people start seeding in March and transplanting in April. The paddy field requires weeding, pest control, and fertilizing in summer. Rice is ripe for harvesting in late July. After the regular rice was harvested, the Dong people continued to harvest local Dong glutinous rice in August. Most farmers plant ratoon rice in Sanjiang so that they continue to harvest ratoon rice till September.

The Dong nationality are famous for their Rice-Fish-Duck Symbiotic System, and this kind of farming system is observed in most part of Sanjiang county. In February, the Dong people rear fry in small ponds and transfer the fish into the paddy field after the transplanting season. Then the Dong people can catch the fish in the latter half of the year and pickle the fish to make traditional Dong cuisine for preservation, entertaining guests, or festivals.

Sanjiang is a mountainous area. Apart from some paddy fields, the Dong people managed many dry fields to obtain enough food and get economic profits. Under the impetus of Sanjiang's "promotion of tea, camellia and bamboo" policy, many Dong people plant tea in their dry field, and the activity of harvesting tea leaves becomes an essential part of their agricultural activities from January to September. According to the different crops, the sowing time on the dry field is different throughout the year. However, there are two major sowing seasons on the dry field in winter and summer when the rice cultivation activity is not too busy. Therefore there are also two harvesting seasons on the dry field.

There are also agricultural activities in the residential area. Many Dong people raise ducks in the village. The ducks eat pests in the paddy field. Together with fish culturing in the paddy field, the Rice-Fish-Duck Symbiotic System is complete. Some Dong people that were interviewed say that they raise ducks regardless of the time. They raise ducks whenever they find eggs in the ducks' nest, while other Dong people say they raise ducks for big festivals. The Dong people's most significant festivals in this region are July Fourteenth Day and Chinese New Year. They raise ducks in February and August so that they can eat them during the festivals. After harvesting cotton and indigo in June, the Dong people started weaving and dyeing cloth in summer and making traditional Dong costumes and embroidery in winter. After collecting the camellia seeds in autumn, the Dong farmers conduct oil squeezing from camellia seeds in the manufactory in their village in late autumn. After the logging season in summer, the timber was dried and ready to be used for house building and repairing in October, November, and December. The Dong people like to prepare a new or clean house for the Chinese New Year.

Many Dong farmers become migrant workers in big cities when they are not busy with rice cultivation work. Some farmers become full-time migrant workers and only return to the village at festivals and to help villagers when there are people building houses or when there are significant issues or decisions to be made concerning the future planning of the village.

b) Differences in the agricultural calendars of three Dong villages

Differences of the agricultural calendars in the Dong villages in the Sanjiang region were also observed.

(1) Gaoyou

Gaoyou is a village located on the mountain top. In the field observation, scattered bamboo plantation in the forest area was spotted. However, no interviewees from the village say they grow bamboo. Therefore, the bamboo was assumed to be wild or wasn't used or managed for long. Gaoyou villagers buy fir saplings from the market instead of growing seedlings when planting fir trees. Gaoyou farmers don't make charcoal, so there is no charcoal forest.

Due to the mountain climate in the farming area, little ratoon rice was found in Gaoyou, and residents say the ratoon rice doesn't grow well in this village. Therefore climate is a critical factor in rice cultivation in Gaoyou village. In the interview and field observation, it was found that apart from the tea plantation, Gaoyou has many dry fields of sweet potato and leek. Sanjiang's poverty alleviation policy of "one village, one brand" promotes one economic product in each poverty-stricken village. For Gaoyou, sweet potato and leek are their branded products. They use local species of sweet potato and leek. Due to the mountain climate, their local sweet potato and leek are famous for their taste. Their products are transported and sold in big cities and restaurants. There are large tea plantations and seven tea manufactories in the village. Farmers harvest tea leaves every day from January to September and sell them to the local tea manufactories or outside business people who drive vans into the village to collect tea leaves. Since their economic product is famous for its "green" growing processes, farmers apply manure fertilizers to their dry fields. However, few farmers raise pigs in their houses now, so they don't have enough manure fertilizer in the village. They buy and transport manure fertilizer from a nearby chicken farm. For the fish stocking in the paddy field, few Gaoyou residents rear fry now. Most of the farmers buy fry from the market. Since Gaoyou is located in a mountainous area, they have a shortage of land. So the local farmers make full use of their land, and it is hard to see abandoned farmland in Gaoyou.

In the residential area, Gaoyou preserves the traditional village landscape well. Nearly all houses are in the traditional style, three-floored wooden houses, or the first floor is bricked for fire prevention, and the upper floors are wooden. The interviewees say that there were no fire disasters in their memories. Because of the preservation of the traditional landscape, Gaoyou village was on the tentative list of UNESCO's World Heritage Sites in 2012. Later the local government helped to create a Leek Festival to promote tourism in Gaoyou village in spring. Since it is on the mountain top and there is only a small stream running through the village, the village has a problem of water-scarce. Therefore, in winter, many farmers conduct irrigation and water pipe repairing. Few farmers raise ducks in Gaoyou.

(2) Kuangli

Kuangli is a village located on the riverbank. Although the residents rarely use bamboo material now, some interviewees say they still plant some bamboo in the forest. Kuangli residents also plant several kinds of fruit trees. They have a long history of planting plum trees. Recently the government gave them some other species, including waxberry and pear, so there are more various fruit species in Kuangli.

For the farming area, there is no tea plantation in Kuangli. Instead, they plant another species, a Chinese herbal medicine called Uncaria, promoted by the local government. Interviewees say they don't plant Uncaria in the old days, but they plant it now because they can receive subsidies by planting this species from the government. It is worth mentioning here that in another village called Qingqi, which is located around 4 km away from Kuangli that interviews were also taken, farmers don't grow any tea plantation or Uncaria, because the government doesn't promote these crops in Qingqi village so that they can't receive any subsidy from planting them. It was observed, and the interviewees agreed that there are many abandoned farmlands in the village.

There are two parts of the village in the residential area, the old village and the new village, located on opposite banks of the same river. Interviewees say they don't think there is any difference in their agricultural activities. Houses in the old village are wooden houses, and those in the new village located along a road are in brick style. Interviewees say that it is difficult to transport house building materials like bricks from the market to the old village. After the materials are transported to the new village by truck, the only transport to access the old village became a small boat. There are few brick houses in the old village. The interviewees also mentioned that the government helped them build brick houses for fire prevention. Kuangli residents have a long tradition of raising ducks. They raise local species they call "Dong duck." They say Dong ducks are smart in that they eat only the pests in the paddy field and therefore help with rice cultivation. Outside species of duck eats rice in the paddy field instead of pests.

Because Kuangli is located along the river, residents can go fishing in the river, and they have a unique fish festival in the village. The biggest festival for the Kuangli residents is July Fourteenth Day. They made unique cuisine from glutinous rice to worship spirits in the old days. But this activity was prohibited after the Broken Capitalism Campaign in the 1960s. Some temples in the village were torn down, and the giant stones used in the architecture were transported to the river and used as bridges. Some Miao villages, another national minority, are located near Kuangli village. There are always fights between these two ethnic minorities. The interviewees mentioned that sometimes there are flood hazards in the village. Since there is a new dam construction on the upper river, the river is predicted by the residents to be lost in floods in fifty years.

A new road was completed on the bank of the old village, and some residents in the new village moved back to the old village's bank. Since there is a "one residential base for one household" policy in rural China, and the new house is generally in western brick style, local governors predict that the old village with traditional wooden houses will be disappeared.

(3) Liangli

The relocated new village was built on their old paddy field. The interviewees said that there is little change in their agricultural activities. They have a similar agricultural calendar with Gaoyou, which is also a mountainous village. In the farming area, their paddy field is located on flat land. In the old days, they traveled far from the mountain top to the mountain foot to manage their farmland, but now it is easier to do farming. The new village is designed by the government to promote tourism. Therefore there are several changes in the village. They started planting lotus in the farmland. There was no Fengyu bridge in the village. However, since Fengyu bridge is considered as an essential character for Dong culture, the government built a Fengyu bridge on a stream in the new village to promote tourism. And there are some new species of landscape trees in the village. The houses in the new village are in the same

style, the first floor is built with bricks for fire prevention, and the upper floors are wooden, which are the traditional Dong style. Liangli residents tore down the old houses and used the woods to build new houses. The old village is now flattened and planted with tea or fir plantations.

2.4 Discussion

2.4.1. The integration of different national cultures: the fusion of tradition and modernity

From the annual agricultural calendars and the festival calendar, the integration of different national cultures was observed. Although there are several traditional Dong festivals, including Worshipping Ox Festival and Fish Day, traditional Han festivals like Qingming Day and Duanwu Festival are also celebrated in the Dong villages. Other national minority festivals are also celebrated in this region. For instance, Folk Song's Day is a traditional Zhuang national minority festival. Since the local government is promoting this festival for tourism and culture revival, and there is a three days' national holiday for this festival in Guangxi Province now, many residents celebrate Folk Song's Day, including the Dong people.

There is also the fusion of tradition and modernity in the Dong villages. Although some traditional agricultural practices are lost in some Dong villages, like making charcoal, rearing fry, raising buffalo, and growing fir saplings, some traditional activities remain, like fir plantations and camellia plantations, glutinous rice cultivation, and rice-fish farming (some Dong villages have complete rice-fish-duck farming, while some Dong villages don't have a tradition of raising ducks). Although more and more young laborers become migrant workers in the big cities, some farmers still come back to complete farming and planting activities and celebrate festivals in the village. Sanjiang is a poverty-stricken county, and the government has promoted various economic production in different villages, which brought about new crop species like tea plantations into the villages. Technique innovation also changed the way of the Dong farmers' agricultural activities. Many farmers now apply chemical fertilizers and pesticides to their forest and farmland and use plow machines instead of buffalo. However, in reaction to the market needs for green and organic products, some Dong people still apply manure fertilizer to the dry field. And the interviewees said they wouldn't apply chemical fertilizer to the crops they consume within the households. The Rural Revival Policy has brought about changes in the residential area. The villages became clean, and many wooden houses were changed into brick houses. There are many reasons the Dong people favor brick houses, whether it is the new fashion or fire prevention. The new style of housing is a mixture of tradition and modernism, in which the first floor is in brick style for fire prevention and the upper floors are in wooden style.

In summary, the integration of different national cultures and the fusion of tradition and modernity were found in the Dong villages in Sanjiang.

2.4.2. The promoting effects of policy and the change of market in agricultural activities

The differences in agricultural calendars in the three villages reveal the promoting effects of policy and market. The Dong farmers respond to the local government's promotion of economic crops positively. Farmers only plant new species like tea or Uncaria if there is a subsidy policy for planting them. The market is also an important factor when the Dong farmers plan their agricultural activities. When the farmers plant a new tea plantation, they first change the camellia plantation into a tea plantation. Although camelia is the traditional crop that they

used to squeeze oil, now they can easily purchase oil from the market, and they say that the yield of camellia is too low to get economic profits. Therefore they change the camellia plantation into the new tea plantation to get more economic profits. However, in 2018 the local government started to promote a new camellia species, which is said to have a higher yield, and they will give subsidies to farmers who are willing to plant new camellia species. As a result, there were many dry fields and forest areas changed into camellia plantations. Therefore, policy and market are two essential factors in changing agricultural activities.

There are examples of the failure of new agricultural practices resulting from problematic policy and market. In the early 21st century, the Sanjiang government promotes the "tea, camellia, and bamboo" policy. At that time, many farmers planted bamboo hoping to get economic profits. However, the raw bamboo timber got moldy very soon, and Sanjiang is a mountainous area where the road construction and transportation condition are not sufficient enough to transport the raw bamboo timber out to the manufactories on time. And the speed of development of bamboo manufactories is not corresponding to the production speed of bamboo, so tons of bamboo timber were left moldy in the forest before they were transported to the manufactories. Now most farmers abandoned the management of bamboo, and the plantation of bamboo consumes lots of forest land in Sanjiang. This failure in promoting economic crops show that the policymakers need more consideration according to the local climate, the topographic conditions, market needs, and matched development of manufactory and market.

In the interviews, the Dong farmers mentioned that before they can manage the farmland to fulfill their own needs, the farmland was managed by the community before the 1980s. At that time, they must plant double-cropping rice. Interviewees remembered that every farmer was busy with rice cultivation most of the year, leaving them no time to conduct traditional activities like making traditional Dong costumes and enjoying traditional Dong cuisines. After the 1980s, when farmers could manage their farmland personally, they gradually abandoned double-cropping rice. Now they have more time to conduct other agricultural activities and work in the cities. Therefore, it is suggested that the government consider the local farmers' needs when making agricultural policy.

2.4.3. The unchanged agricultural activities connected with the Dong cultural identity

Although many modern agricultural activities and activities adopted from other nationalities were observed, some unchanged agricultural activities related to the Dong cultural identity can still be found.

Although there are changes in tree species in the Dong villages, it is difficult to observe farmers change the fir plantation into another plantation. Fir trees are essential in the Dong culture. Past researchers studying the relationship between fir trees and the Dong people found that fir trees provide timber and material for their house building and life suppliers, and the Dong people also have a spiritual connection with fir trees. For example, in some Dong regions, Dong people plant fir trees when a daughter is born in their family. When their daughter grows up and gets married, the fir trees are big enough to be used as dowry to the new family. For Dong people living in wooden houses, fir trees provide timber for their house building and repairing. Dong people living in brick houses sell timber only when they want to repair their house or build a new house to exchange for money to buy bricks. So fir plantation is highly related to the housing of Dong people. And there is a public fir forest in every Dong village preserved for building public architecture like Fengyu bridge and Drum Tower. When the community's fir forest doesn't have enough timber, the residents in the village will also provide

timber from their private forest to build public architecture. Therefore, fir trees are also crucial in connecting the community relationship in the Dong culture.

As mentioned above, all Dong people interviewed say they plant their local glutinous rice species. Glutinous rice has been the primary food source for the Dong people for a long history. They use glutinous rice to make unique cuisines in festival celebrations. Although non-glutinous rice has become more prevalent in their table, they still cultivate glutinous rice for festivals and events like wedding presents. Although political changes like the Broken Capitalism Campaign destroyed some traditional cultural activities, some ethnic minority culture and the related agricultural activities remained.

It is also worth mentioning that, although market and policy are important factors in farmers' selection of agricultural practices and crop species, there are other factors like farmers' personal preferences. For instance, the duck species mentioned above, the Dong people in Kuangli raise their local duck species because they eat pests in the paddy field instead of the rice. Therefore the ducks help with their rice cultivation and complete the Rice-Fish-Duck Symbiotic System. Another example is that Gaoyou village planted local species of sweet potato and leek for a long time, and now due to the excellent taste of these products, they export these local products to the market and get economic profits. And all Dong people interviewed said they plant their local glutinous rice species. Therefore, it is concluded that residents' preference is also an essential factor in choosing which crops to plant, and it is suggested that when making agricultural product promotion policy, policymakers can cooperate with the local farmers and use local species for promotion.

2.5 Conclusion

In this chapter, the annual agricultural calendars of three Dong villages in Sanjiang were summarised, and there is the integration of different national cultures and the fusion of tradition and modernity in this region. There are promoting effects of policy and market in agricultural activities change of the Dong people, and unchanged agricultural activities are connected with the Dong cultural identity.

According to these findings from their various agricultural activities throughout the year, it was observed that the Dong people are hardworking and they are willing to exchange their labor for economic profits. Therefore, the government can have more innovation and cooperation with the Dong residents to plan more environmentally-friended agricultural development in this region. It is also suggested that the government consider the local farmers' needs when making agricultural policy. And residents' preference is also an important factor in choosing which crops to plant or which species to raise, and it is suggested that when making a product promotion policy, policymakers can cooperate with the local farmers and use local species for promotion. And there should be more infrastructure to connect the villages and the market. According to the local climate, the topographic conditions, market needs, and matched development of manufactory and market, the policymakers need more consideration in regional development plans. When making economic development goals, the cultural identity of the Dong people must be taken into consideration. It is suggested that the government support and preserve their cultural activities and landscapes. Since natural disasters like floods and fire hazards are often mentioned when discussing about housing styles, it is suggested that the government pay more attention to the hazard prevention work in the Dong villages.

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Chapter 3 Changes in natural resource utilization regimes in Gaoyou Village

3.1 Introduction

As Nassauer summarises in her research on culture and landscape structure, she describes that culture and landscape interact in a feedback loop. Landscapes are structured according to cultural perspectives, including the political system, economic use, aesthetic preferences, and social conventions, and the landscape affects culture in turn. This feedback loop of culture and landscape is connected by adopting natural resource management activities, such as planting, subdivision, harvesting, and building, in the fundamental ecological framework of the land (Nassauer 1995). Based on indigenous knowledge acquired from close and long-term involvement in local ecosystems, traditional natural resource management regimes that incorporate generations of local experience and practice can provide important information for sustainable resource management and the development of environmental conservation plans. (Menzies 2006).

While people around the world are making efforts to build a sustainable society, the Ministry of the Environment, Japan, and the United Nations University Institute for the Advanced Study of Sustainability jointly launched the Satoyama Initiative (SI) in 2010 at the 10th meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP 10) to realize "societies in harmony with nature" through landscape approaches to arouse interest in biodiversity and ecosystem conservation and to rebuild a healthy human-nature relationship both in Japan and internationally. In a narrow sense, the Japanese term satoyama refers to secondary woodlands and grasslands near human settlements that provide natural resources, including fuel, fertilizer, and fodder for settlers. The SI features the term satoyama landscape to refer to the traditional Japanese rural landscape as a heterogeneous landscape, a land-use mosaic of interrelating land-use elements including woodlands, paddy fields, grasslands, irrigation canals, and human settlements (Takeuchi 2010). Fukamachi and Oku used inventory data and interviews to model the resource utilization regimes of the village and the surrounding farmland and forest in three satoyama landscapes in western Japan in the early twentieth century. By comparing the changes of the resource utilization regimes and the satoyama landscapes, and the natural and social backgrounds behind these changes, Fukamachi and Oku found that while there are regional characteristics including land-use elements, the pattern of landscape, and management regimes in the three satoyama landscapes in the early twentieth century, they have all undergone significant changes (Fukamachi and Oku 2011). As we face a global environmental crisis, the satoyama landscape is often used as a model for a sustainable natural resource management system (Morimoto 2010).

As satoyama-like landscapes exist throughout the world, the term "socio-ecological production landscapes and seascapes" (SEPLS) is used by the SI to describe these satoyama-like landscapes that are "managed via interactions between ecosystems and human to create various ecosystem services for human well-being" and "characterized by a mosaic of different ecosystem types: secondary forest, timber plantations, farmlands, irrigation ponds, wetlands, grasslands, beaches, and coastal zones, as well as human settlements" (Saito et al. 2020). The SI recognizes that SEPLS can provide a wide range of ecosystem services and contribute to human well-being when managed effectively. The overall objective of SI is to collect and analyze cases of SEPLS to promote and support SEPLS to maintain their contribution to human-being (Paris Declaration of the Satoyama Initiative 2010). There are hundreds of case studies implementing the SI worldwide, including several ethnic minority villages, such as Dong ethnic minority villages, in Southwest China (IPSI Secretariat, 2019).

Due to historical factors, disadvantaged ethnic minorities tend to distribute in remote areas. The Dong nationality, one of the 55 ethnic minorities in China with a population of around 3 million according to the 2000 census (Population Reference Bureau, 2010), is distributed in the mountainous area in Southwestern China. The Dong people practice natural resource management for self-subsistence within their environment with limited natural resources and few connections with the outside world and create a unique socio-ecological production landscape by applying long-standing agricultural practices. These people reside along rivers in mountainous areas with relatively limited natural resources. Therefore, the Dong minority developed a traditional resource management regime to make full use of resources from forests, fields, and rivers to achieve self-sufficiency, resulting in the Dong landscape characterized by efficient use of natural resources in each land-use system and cyclical use natural resources in different land-use systems. The natural resource management regime changes to adapt to varying external environmental conditions. Due to remoteness, transport occlusion, and cultural segregation, which have severely constrained their economic development, the traditional landscape structure and natural resource management regimes are still preserved in some Dong villages. Nowadays, significant changes occur in the Dong villages, as urbanization has motivated young residents to migrate to larger cities to pursue better working opportunities. This migration has caused aging problems in rural areas and the loss of cultural identity and traditional lifestyles. Events with sudden impacts, such as the construction of a new road, will create fragmentation of land use, while tourism changes the lifestyle of residents and land uses. Under the SI, it is assumed that the characteristics and changes of the Dong landscape and the related resource management regimes can provide an excellent example for understanding the evolution of socio-ecological production landscapes over time, and the Dong landscape needs to be conserved so that it can maintain its contribution to human well-being.

Previous research has revealed several key elements of the Dong rural landscape and their methods of managing the forests, paddy fields, and rivers. However, few studies have been conducted to understand the driving factors of their land-use or natural resource management regime changes at the landscape level. The case studies of Dong villages implementing the SI focused only on the forestry or the agricultural systems (IPSI Secretariat, 2019). Little research was done applying the landscape approach, which means studying the natural resources management regimes considering the relationship between different land-use systems is needed. The management of natural resources includes utilizing natural resources and conserving them to satisfy the needs of present and future generations. This research focused on natural resource utilization (NRU) of Gaoyou, Sanjiang. The objectives of this study were (1) to reconstruct the traditional NRU regime within and between different land-use elements in a Dong village as a baseline study for future research on other similar Chinese socio-ecological production landscapes; (2) to show the changes of NRU regimes; (3) to understand the background of changes in the livelihoods and NRU regimes of the Dong minority people; and (4) to provide recommendations for future sustainable management plans.

3.2 Methodology

3.2.1 Research site

Gaoyou village was chosen as the research site because after the interviews across Sanjiang county (chapter 2), it was found that Gaoyou village preserves the traditional landscape well, and its land is in high use.

Fig. 3.1 shows the location of Gaoyou village. Figure 3.2 is an aerial image of the village showing the present landscape of Gaoyou village. It is in a mountainous area, and the village area is surrounded by farmlands and forests. One thing worth attention here is that there are many tea plantations all over the village. The selected Gaoyou village is located on the top of a mountain, with an altitude of 500 m. Gaoyou village preserves a traditional Dong landscape with delicate wooden houses and diverse land-uses, and is on the list of tentative World Heritage sites provided by UNESCO (Unesco.org, 2013). The basic information about this study site is listed in Table 3.1. Because the administrative boundary of the village was not available, when deciding the boundary of this study site, the villagers were asked about the boundary of the area where they acquired natural resources. Group discussions among residents were conducted to draw the village border. Since the land is highly used in Gaoyou villagers, it is not difficult to identify their land use and draw the village border with the help of some geographical boundaries such as mountain ridges and geographical landmarks such as large pine trees.

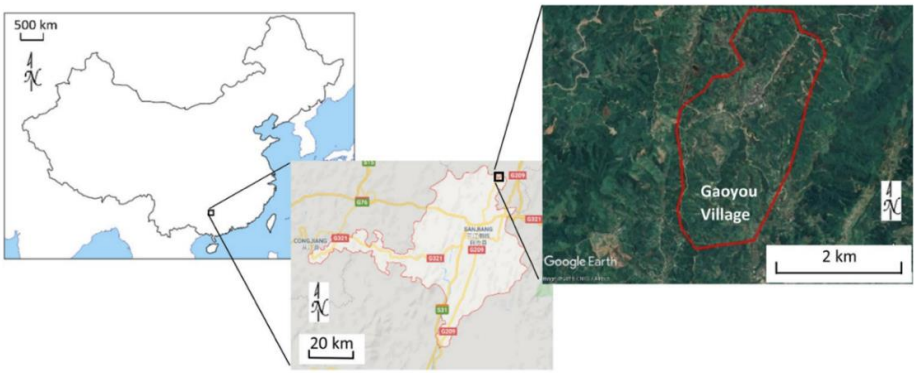

Figure 3.1. Maps of the study area Gaoyou village. (Data source: Google Maps.)

Figure 3.2. The present landscape of Gaoyou village (photographed in 2017)

Table 3.1. Baseline information about Gaoyou village

Population (permanent resident population[1])	Households	Area (ha)	Farmland area (paddy fields/ dry fields/ others) (ha)	Forest area (ha)	Residential area[2] (ha)	Other area[3] (ha)	Average elevation (m)
1820 (1003)	488	460	100 (67.2/ 22.3/ 10.5)	270.4	6.7	82.9	500

1. The permanent resident population stands for farmers staying in the village for more than six months a year.
2. According to the village government, the residential area is included in the dry field.
3. Others include water bodies, abandoned land, and others.

Data source: Gaoyou village government. Data recorded in 2017.

3.2.2 Methodology

The interview method is often applied in combination with GIS to analyze land-use change (Mottet et al., 2006). The interview is more important when there are no published maps or written records about the past landscape. Participant observations were collected through interviews with local farmers and field surveys to reconstruct the landscape structure and the corresponding NRU regimes identified by the respondents in several significant socioeconomic periods. The respondents were randomly selected for general discussion in the first step, and other respondents were subsequently selected and introduced by a village chief, cooperative chief, or a primary school teacher for in-depth interviews. All respondents had lived in the village for more than 20 years and had a good understanding of the landscape and agricultural activities. In the general discussion part, residents were mainly asked about baseline information about Gaoyou village and the most critical points in time that they observed significant land-use changes and NRU. In the personal interview, the interviewee was asked about household information and the major resource management regimes in their residential area, farming area, and forest area in each critical socioeconomic period defined in the general discussion before. Referring to Fukamachi and Oku's models of traditional land use schemes (Fukamachi and Oku, 2011), models of the landscape structure and NRU regimes for each socioeconomic period were drafted with information derived from interviews while referring to historical documents and governmental data. Then the drafted models were taken back to the village and asked the same respondents for rectification and improvement. Two groups of more than 10 residents of general discussion were taken in two different village centers. 19 male interviewees and 3 female interviewees were interviewed in the in-depth interviews. 3 hours were taken in each general discussion, and over 2 hours were taken in each in-depth interview. In each interview, the researcher was accompanied by a translator, a local governor, and an agriculture expert. Interviews were taken during several visits to Gaoyou village in September, October, November 2017, February, May, and July 2018.

3.3 Results

3.3.1 Traditional NRU regime in Gaoyou village

Information from interviews was used to draw Figure 3.3 to illustrate the traditional relations between the satoyama landscape patterns and the NRU regimes. When defining "traditional," residents were asked what the agricultural activities were like before the liberation of China when their villages were relatively untouched by the outside world, and the indigenous knowledge and lifestyle were retained.

Gaoyou is a village located on the top of a mountain. After settling down there, peasants created the satoyama landscape with traditional agricultural activities. High mountains restrict the arable land area, so the residents developed various uses for the limited land resources. The resident area lies on relatively low and flat land surrounded by farming area, and the farming area is surrounded by forest.

(1) Farmland

Peasants set aside small areas near their houses as vegetable gardens in the farming area. In the flat and low land where water could be accessed and maintained, peasants changed the land into paddy fields for glutinous rice cultivation. In the land with some slopes or where water accessibility was difficult, peasants changed the land into dry fields where they could grow food sources other than rice.

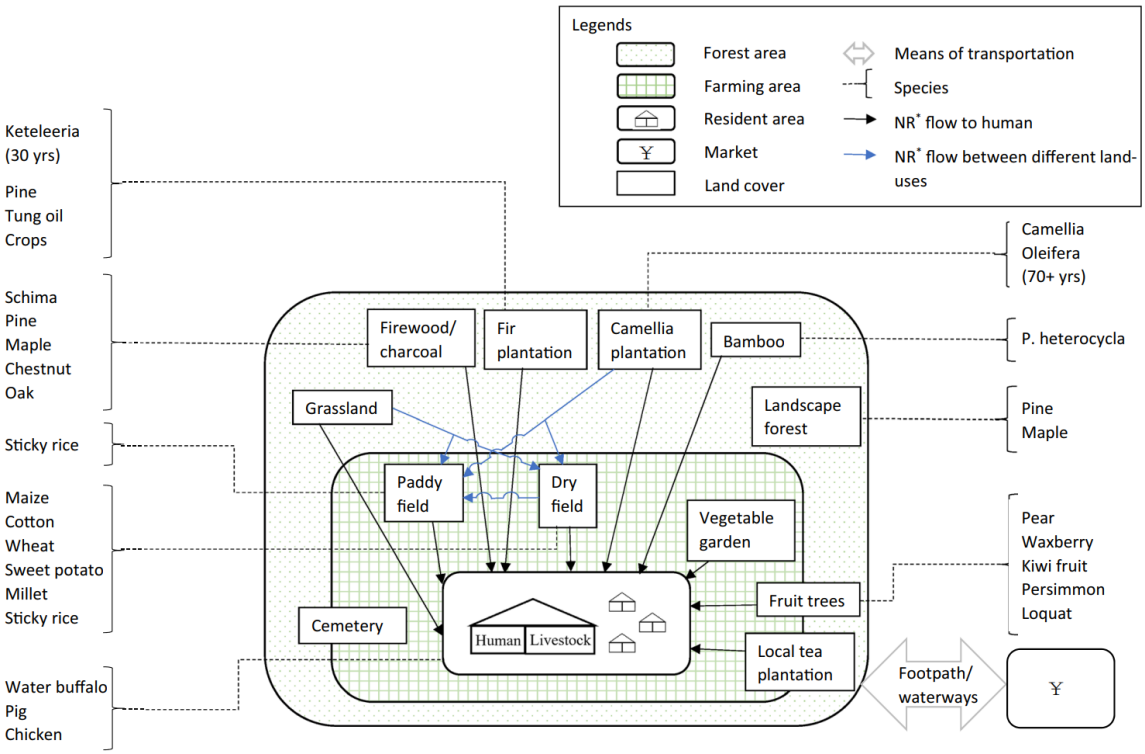

Figure 3.3. Relations between traditional satoyama landscape patterns and the NRU regime in Gaoyou.

Natural Resource (NR) flow means the flow of natural resources such as plants and animals

The peasants cultivated glutinous rice, their traditional primary food source, in paddy fields in the farming area. They kept the seeds of glutinous rice every year instead of buying seeds from the market.

The Dong peasants have a long tradition of cultivating fish in paddy fields, so paddy fields provided another food source. After harvesting glutinous rice in autumn, the remaining straw could be used to feed water buffalo or material for producing commodities such as sandals.

Due to the shortage of paddy fields for glutinous rice cultivation, dry fields also provided peasants with food, including maize, wheat, millet, and sweet potatoes. The peasants also cultivated some glutinous rice in dry fields, but due to the water shortage, the production of this glutinous rice depends on the weather conditions. The peasants grew cotton in dry fields to obtain fiber and material for producing commodities. The remains of the crops could also be used as feed for water buffalo. The peasants frequently managed their vegetable gardens to obtain the vegetables they needed every day.

(2) Forest

Behind the farming area is the forest in the high elevation of the mountains. In the transition zone between the forest and farming area, peasants set aside some land for cemeteries and local tea plantations. Some wild fruit trees were left for fruit collections. In the forest, peasants left some landscape forests considering their cultural beliefs. They planted fir, camellia, and bamboo in the forest; gathered firewood from it; and kept some grassland for cattle grazing and medicinal herb gathering.

In the forest, the Dong peasants planted fir trees as their primary source of timber with which they built their houses. The peasants in this village do not have the tradition of raising seedlings for fir plantations; instead, they tend to buy saplings from the local market. To make full use of the limited land resources, the Dong peasants interplanted other tree species, such as pine or Tung oil trees, among the fir trees as additional sources of timber or materials. They also grew some crops, such as potatoes, under the fir trees to produce more food. Apart from fir plantations, the Dong peasants grew camellia trees to obtain oil for their diets. After making oil, the remnants of the camellia seeds can be used as materials like shampoo or medicine for external use.

Bamboo was also planted in the forest to obtain house construction and commodity production materials. Grassland provided places and feed for water buffalo grazing and materials for commodity production. Local doctors collected herb medicine here. Firewood was obtained from the forest, and fruits were gathered from the wild fruit trees.

Because the Dong minority have a traditional cuisine called Youcha, in which tea leaves are the main ingredients, they have a long tradition of planting local tea. Therefore, the Dong peasants obtained food from local tea plantations as well. The peasants hunted for animal meat, such as wild boars, pheasants, goats, birds, and rabbits.

(3) Husbandry

Apart from cultivating fish in the paddy fields, the peasants kept water buffalo, considered essential for farming, in their houses. Rich peasants owned water buffalo, while

poor peasants shared water buffalo between 4 or 5 households. They also raised pigs and other livestock like chickens in their houses.

Regarding the NRU regimes, peasants obtained meat and eggs from the livestock they raised in their houses in the resident area.

(4) Natural resource flow among areas and annual agricultural calendar

There was natural resource flow across different areas as well. For example, crop remnants from the dry fields and plants from the grassland could be used as organic fertilizer in the paddy fields. After harvesting the glutinous rice, the peasants reserve water so that the remains will decompose and fertilize the soil for the next cultivation season. After oil squeezing, the remains from camellia seeds were applied to the farming area as a pesticide. The feces from the livestock in the residential area were applied to the farming area as organic fertilizer.

Before the liberation of China in 1949, there was no road leading to Gaoyou village. Dirt roads and waterways were the only connection between the market and the village, and the market was dozens of kilometers away from the village at the foot of the mountain. Therefore, there was little exchange between the market and the village in the old days. Some oil, timber, pork, vegetables, and sandals were sold for rice and salt. In the old days, the peasants used waterways to transport timber to the market, more than 10 km away from the mountain. The market where they sold pork and vegetables was more than 20 km away. Some residents went out to work as laborers in other villages due to the shortage of arable land in the village.

The traditional annual agricultural calendar of peasants in Gaoyou is summarized in chapter 2. Traditionally the villagers use the Chinese lunar calendar, and during the interviews, they preferred to use the Chinese lunar calendar when talking about time. The exact dates of the lunar calendar are different in each year when converting to the Gregorian calendar and are often one month later than the Gregorian calendar.

Traditional lifestyle contains various production activities using resources from the natural environment. Some traditional production activities require efforts throughout the year. To take traditional wooden house building materials as an instance, all timber used in this activity came from their fir forest. To manage the fir forest, after Chinese New Year in January in the Chinese lunar calendar, they plant new saplings in winter, conduct weeding and intermediate felling later, log the trees and dry the timber in summer. After the busy rice harvest season in autumn, peasants build and repair their houses in preparation for the next Chinese New Year. Architects in every Dong village orally inherit architecture knowledge from their teachers. Architects help design and process the timber, and house owners later ask people in the village to help build the house together and treat them with dinner and help them build their houses. Some Dong characteristic public buildings like drum towers, which are used as meeting houses. Each household donates some timber from their forest when building and repairing drum towers. All materials used in the house building came from the village, and timber processing was also conducted inside the village.

Another example is traditional Dong costume making. Peasants plant cotton in spring and harvest it in summer to get materials for cloth making, and plant indigo in winter and harvest it in spring to get materials for cloth coloring (as is shown in Table 2.4 in chapter 2). After the materials are ready, women weave cloth at home to prepare for costume making when

they are not busy with farming, usually in summer and winter. When the cloth is ready, they dye and dry it in the sun with dye made from indigo in summer. After the busy autumn harvest season, women hurry up to make traditional costumes at home and decorate them with traditional embroidery so that everyone in the family gets new clothes for the upcoming Chinese New Year. The traditional costume making also uses resources from the local natural environment. Since it consumes significant time and effort, peasants only get one or two new clothes in one year.

3.3.2 NRU regime changes in Gaoyou village

After the liberation of China, the government organized farmers to form working teams and villages to form agricultural cooperatives that managed the land, taking orders from the government. Products of the land, including rice and timber, were regarded as collective property. The NRU regime changed dramatically when this remote Dong village formed more connections with the mainstream culture and acquired modern agricultural technology. After the Reform and Opening Up Policy, market economics significantly changed the Dong people's lifestyle and the NRU regime. According to the 2010 census, 44.89% of the population in Gaoyou were migrant workers and left the village for work for more than six months per year. The present relationship between satoyama landscape patterns and the NRU regime in Gaoyou with information derived from interviews and historical documents is shown in Figure 3.4.

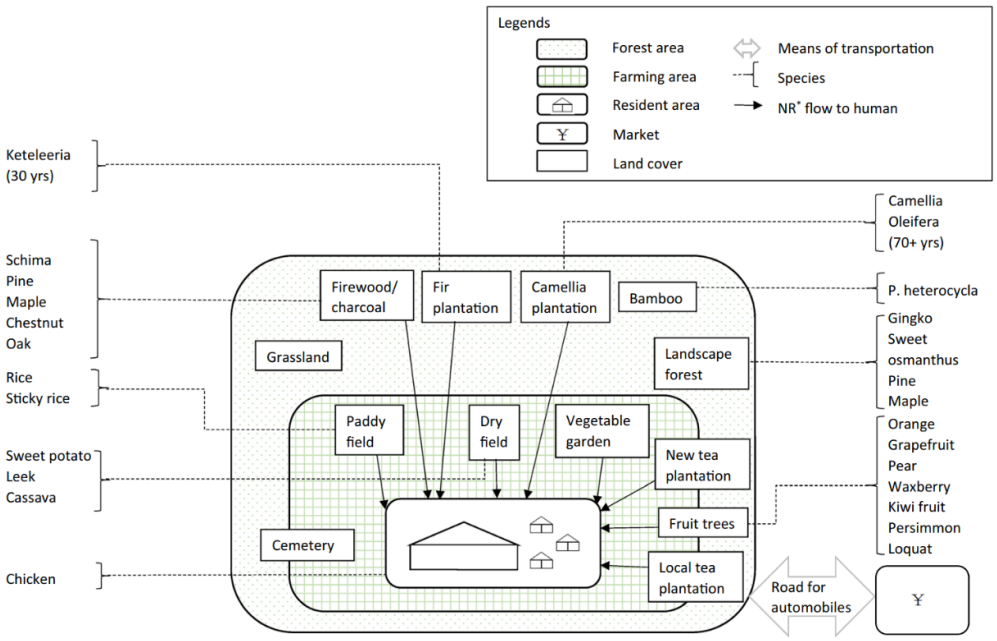

Figure 3.4. Present relations between satoyama landscape patterns and the NRU regime in Gaoyou.

Natural Resource (NR) flow means the flow of natural resources such as plants and animals

(1) Farmland

The government paid great attention and efforts to increase agricultural production in the 1950s. Farmers were organized to reclaim farmlands in the mountains to grow crops like sweet potatoes and maize. Cemeteries were also transformed into dry fields to grow crops, and the tombstones were used as farmland ridges. The Dong people grew only local glutinous rice in the paddy fields. The government introduced hybrid non-glutinous rice, multiple cropping, and the glutinous rice system into Gaoyou. The people kept seeds for their local glutinous rice but obtained the non-glutinous rice seeds from the supply and marketing cooperative. The functional teams had agricultural production targets to meet, so every peasant was busy farming, including cultivating double-cropping non-glutinous rice and glutinous rice, which left them little time to manage their vegetable gardens. Cassava was introduced into the dry fields as another source of food. Fish cultivated in the paddy fields were valued as collective property and were distributed evenly in the village square every day. Extensive irrigation work was completed during this period.

After the land was distributed to the farmers and established a market-oriented economy, they could manage the land according to their own needs and aspirations. After many rural laborers became migrant workers in big cities, only women, children, and the elderly were left in the village, and some farmland was left unmanaged or even abandoned if it was in a remote area that was difficult for weak laborers to access. The farmers wanted to move closer to the newly constructed road, so they moved their farmland or vegetable gardens closer to the road and built new houses. They gave up double-cropping non-glutinous rice and grew mainly single-season non-glutinous rice for daily food and a little local glutinous rice for festival dinners and events. The crop diversity decreased in the dry fields. It was convenient to buy food from the market, so there was no need to grow food crops. The lifestyle changes and the time-consuming processes involved in making the Dong costumes led the Dong people to buy clothes from the market, so the farmers gave up cotton production. They began to grow economic products like sweet potatoes and leeks in the dry fields, which were recognized as the brand products of Gaoyou and were popular at the market. Some dry fields were changed into tea plantations to pursue better economic profits.

Chemical fertilizer was introduced to Gaoyou in the 1960s and replaced the traditional organic fertilizer, such as manure and straw. However, due to the present market need for organic food, some farmers in Gaoyou have adopted manure fertilizer again for growing crops. Since few farmers raise pigs in their houses now, they currently buy manure from pig farms or chicken farms.

(2) Forest

During the Great Leap Forward campaign, farmers nearly clear-cut the forest to provide energy to support industrialization processes, such as steel-making and railway construction. Landscape forests, fruit trees, and firewood forests were degraded tremendously. Some old trees in the landscape forests were cut during the Cultural Revolution. The country realized this problem and later began aerial seeding afforestation. Peasants lived in houses that were confiscated from big landlords. Peasants needed to apply for timber when they wanted to repair their houses.

After the Reform and Opening Up Policy, energy changes caused people to use firewood less and less. There was no place for a fire in their new houses. Therefore, the

firewood forests recovered. Machinery replaced animal labor, so few households raised water buffalo. Grassland was left unmanaged and degraded since there was no need for grazing. A local doctor told us that it is difficult to find herbs nowadays in grassland.

Consequently, the Dong villagers protect their landscape forests now. They have also planted some new species, including Gingko and sweet Osmanthus trees, in the village as landscape trees. Since it is now easy to buy commodities and house-building materials, few people use bamboo. No one knows how to make commodities from bamboo in this village. No one grows crops under the trees in the forest now. The Dong people continued to hunt in the forest until 2000 when guns were forbidden. They still use some traditional tools to catch rabbits and mice nowadays.

Sanjiang county is a national-level poor county. The government has made efforts to improve the local economy in many ways. Considering the mountainous landscape and long tradition of forestry in this area, the government established several fir tree farms and encouraged the farmers to plant more camellia trees in the 1970s and more tea plantations in the 1990s. The new tea, which is not a local species but was introduced by the government, is now prevalent in Gaoyou. Because this type of tea does not require intensive management, and farmers can earn profits every day throughout the year except in winter, this crop is suitable for the weak laborers left in the village. Since it is very convenient to buy blended oil from the market, a large area of camellia plantations was changed into new tea plantations. Since new favorable policies encourage farmers to grow camellia at present, some farmers are now considering changing tea plantations back to camellia plantations. The farmers who still harvest oil from camellia now bring the seeds to factories in town for oil squeezing instead of using the traditional method of squeezing oil by themselves. The residents of Gaoyou still manage and gather timber from their fir forest today.

(3) Husbandry

During the agricultural cooperatives period, pigs and water buffalo belonged to the village collective. Peasants had to hand in meat to the government but could keep the pigs' heads to feed themselves. Poultry was forbidden at that time.

Since the energy shift enabled the replacement of animal labor, the number of water buffalo decreased. Now only impoverished farmers raise water buffalo in their houses to receive some subsidy from the government. One pig farm was established in the village, so farmers do not raise pigs now. They still raise some chickens.

(4) Resource flow among different areas

Chemical fertilizer, fodder from the market, and pesticides wiped out most of the interactions between areas of land used for different purposes. Now farmers obtain resources directly from these different types of land.

A rough road was built in the 1980s. Gaoyou village has had more commercial exchanges with the market outside since then. The road for automobile traffic was constructed in 2005. After the road construction had been completed, farmers started to sell some timber by road. However, some farmers still use horses or waterways to transport timber nowadays.

3.4 Discussion

3.4.1 Backgrounds and NRU regime changes

With the dynamics of NRU regimes in each land-use area and the complexity of interactions among different land-use areas, the NRU system across a satoyama landscape contains high levels of complexity and uncertainties. Their changes are driven by mutual interactions among the political, demographic, socioeconomic, and ecological domains. For ethnic minority villages, cultural background significantly influences NRU regimes changes. The market-oriented economy and political allowance have motivated farmers to change their land use and NRU regimes frequently in recent decades. Since it is now easy to buy products from the market, the farmers manage their land to pursue economic profits rather than satisfy subsistence needs. Sanjiang is a national-level poor county, and the local government has implemented several policies to lift the county out of poverty. Rural laborers turned into migrant workers in the cities, leaving the relatively weak laborers with fewer choices in land resource management. Due to its geographical limitations, some peasants in Gaoyou became migrant workers to do farming jobs for landlords in other villages before the 1950s because of the shortage of food from their limited land resources. The national census in 2010 shows that 44.89% of the people in Gaoyou were migrant workers, much higher than 24.46%, the total percentage of migrant workers in the Sanjiang Region. Some farmland has been abandoned because weak laborers cannot manage land in remote areas. Although no data shows how much of the farmland has been abandoned, the interviewees estimated that one-third of the farmland had been abandoned. Due to Gaoyou's topographical characteristics of mountainous landform and its above-average number of migrant workers, this number is more significant than the Sanjiang governor's estimation of 5% of abandoned farmlands located mainly on the slopes in the Sanjiang region.

Tea, camellia, and bamboo were the leading products in developing characteristic agriculture according to the local tradition and geographical conditions. After the tea industry was promoted in Sanjiang county in the 1980s, the area of tea plantations increased from 2129 ha in 2000 to 12701 ha in 2019, as is shown in Figure 3.5, and the area is still growing. According to the village government, in 2017, there was 39 ha of tea plantations in Gaoyou. Holling and Meffe (1996) argued that while economic activity creates monoculture in the landscape that increases short-term benefits, it also results in less resilient and more vulnerable ecosystems. Particular concerns regarding ecosystem services and resilience should be addressed in accordance with the rapid increase in tea plantations in Sanjiang. One point worth noting here is that although farmers in Gaoyou have a long history of planting tea and camellia, and they used local species for a long time, in the development of the tea and camellia industries, they do not grow with local species but instead use the seeds provided by the government, which are usually more productive than the seeds of the local species. Farmers continue to plant the new species when they find it surpasses the local species in productivity, costs, or efficiency or when the government promotes the new species with subsidy.

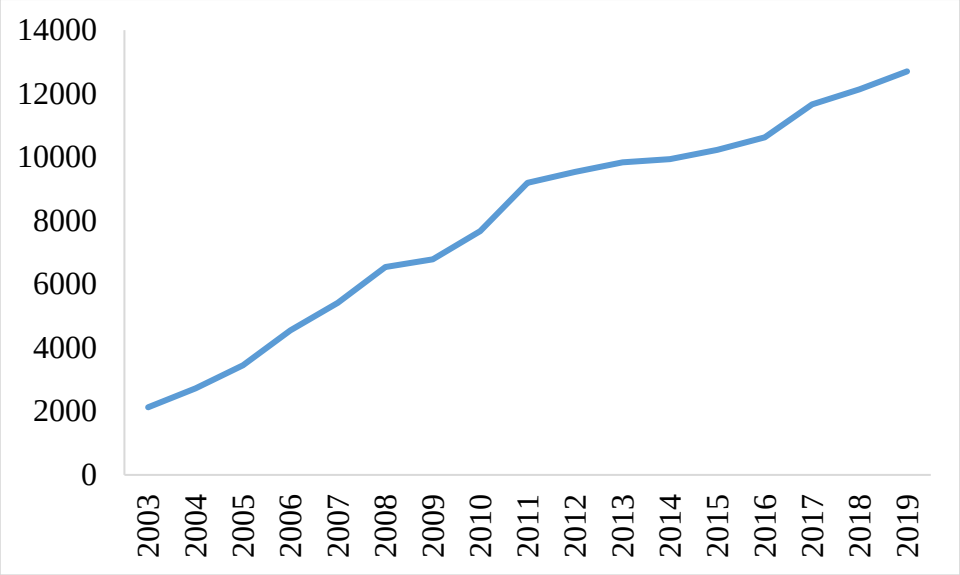

Figure 3.5. Change of tea area (ha) in Sanjiang county

Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2020

When farmers want to change the species in their land, they first consider changing old camellia production since the productivity is low and depends on the weather, which is not ideal for economic income. Then, they consider changing dry fields into tea plantations since tea is easier to manage than other crops and can provide income every day. Farmers seldom change their paddy fields or fir forests into tea plantations. Nowadays, most dry fields are planted with leek and sweet potatoes, which are recognized as the characteristic agricultural products of Gaoyou and can be sold for reasonable prices. However, the farmers said in the interviews that they are thinking about changing the tea plantations back into camellia again because the government is implementing an allowance for camellia plantations, and they are willing to respond.

In the past decade, tourism developed after Gaoyou became famous for its cultural landscape. New roads and facilities are under construction to attract more tourists.

In conclusion, the NRU regime in Gaoyou is much simpler now operated by relatively weak laborers, but the land is still used intensively.

3.4.2 Traditional NRU regime changes with lifestyle changes of the Dong people

As Altieri (2002) mentioned in his review on agroecology, for small farmers with limited resources and located in remote areas, the complex traditional farming system adopting polyculture and agroforestry patterns helps farmers minimize risks in harsh environments, satisfy their life needs, and help themselves without modern technologies such as chemical fertilizers and pesticides. The traditional NRU regime of Gaoyou exemplifies this practice. Their strategy of growing multiple crops in the dry fields, interplanting crops under fir plantations, and cultivating fish in the paddy fields have increased agricultural productivity and promoted diet diversity. The traditional soil and pest management method, such as manure fertilizer and the remains from camellia seeds as pesticides, demonstrates the indigenous knowledge and experience in farming in environments with limited resources. The Dong people developed their distinctive culture, such as cuisine, using local resources, costumes

suitable for working in this mountainous area, and festivals and play to celebrate the harvest. They also record the indigenous knowledge and experience in songs passed down through the generations. The traditional NRU regime kept its self-sufficiency by involving indigenous time- and space-specific knowledge that peasants gained from interacting with the natural environment.

Political changes have significantly disturbed and altered the NRU regime by changing the crop species, introducing modern technologies, and damaging the cultural landscape and activities. Tremendous changes occurred when the market-oriented economy and urbanization made the Dong people communicate more with and integrate into the mainstream culture and change their lifestyle by changing their demands and aspirations. The change in costumes can be taken as an example. The market provides commodities like clothes, which are much more time-consuming and require much more effort to produce using the traditional methods. Furthermore, some young Dong people now consider traditional costumes out of style when they leave the village for study or work. Therefore, the traditional Dong costume disappeared gradually with the disappearance of a series of agricultural activities related to costume-making, such as cotton and indigo plantation. Besides, Zhou (2010) recorded in their research on ethnic minority costumes that, nowadays, traditional costumes are faced with an outflow problem that the Dong people sell their costumes to tourists from home and abroad. They are losing their lifestyle and culture at the same time.

3.4.3 Gaoyou village preserves its landscape well

As mentioned above, the lifestyle change of the Dong people caused their NRU regime to change simultaneously. One change that is easy to observe is in their house style. It is traditional for the Dong people to build wooden houses using timber harvested from their fir forests designed by local architects with help from other residents. Nowadays, the Dong people favor brick houses and exchange their old wooden houses for them when they have enough income. Many Dong villages are filled with brick houses and are challenging to identify in the Sanjiang Region. However, the cultural landscape in Gaoyou village is preserved, with wooden houses and other traditional structures, such as wooden stages and drum towers. After performing a literature review and interviewing people from Gaoyou and other villages where there have been considerable changes in the cultural landscape, it was found that the excellent preservation of the cultural landscape in Gaoyou took place under the following backgrounds.

The first important issue is the natural geography and transportation infrastructure. The location of Gaoyou in a mountainous area limits its development and success in preserving the traditional landscape. The Dong people do not have the tradition or resources to produce bricks for house construction, so they have to import construction materials like bricks from the market. It is very inconvenient to obtain construction materials if there is no road for trucks. Considerable differences were observed in housing style on two banks where there is the road on one bank. Most houses were built from bricks on the bank with a road, while most houses are wooden on the other bank without a road. The road connecting Gaoyou village with the market outside was completed in 2005. Before that, it was challenging to transport construction materials into the village. Therefore, the village retained its housing style into the 21st century. A new road has been under construction to facilitate tourism development since 2018. The total length of the road in Sanjiang was 404 km in 2006, had doubled a year later, and is still increasing. With more and more roads under construction, the problem of roads and lifestyle changes should be given more consideration.

Another significant background is legal protection. The Chinese government pays great attention to conserving ethnic minority culture and traditional rural landscapes. Gaoyou village was selected as one of the "10 beautiful villages" in Liuzhou City in 2007, was included in the first list of traditional Chinese villages in 2012, and was on the list of tentative World Heritage sites compiled by UNESCO in 2013. In order to preserve its landscape, the government introduced a subsidy program for building wooden houses, which worked quite well. Villagers still build wooden houses designed by local architects using timber from their forests.

3.5 Conclusion

The case study at Gaoyou village indicates significant changes in NRU regimes in the Dong ethnic minority villages in Southwest China. The following recommendations for future management plans and policymaking are made. Since NRU regimes contain high levels of complexity and dynamics, more site-specific research needs to be done to understand the driving factors, disturbances, and existing conflicts not only in one land use system but also the interactions between different land-use systems to design future management plans that are sustainable and beneficial for both the indigenous people and the environment. Studying indigenous NRU regimes doesn't mean that we want to return to the traditional agricultural management but to understand the indigenous knowledge that is time- and space-specific, which local peasants gain from their persisting interaction with the natural environment. This knowledge can be essential in making future sustainable management plans in the local area. Farmers respond actively to the government's calling in changing their land use and species when there are proper incentives like subsidies. Innovated policies should give farmers more incentives to help them develop sustainable NRU regimes. Ethnic minority people like the Dong people are faced with problems of losing their indigenous lifestyles and related culture. More concerns and research should be put into conserving ethnic minority culture and landscapes in China.

This research demonstrates the potential of adopting the Satoyama Initiative in studying natural resource management regimes changes. This initiative mentions the importance of rebuilding a healthy relationship between humans and nature, which doesn't receive much attention in the current agricultural policy of the Rural Vitalization Strategy, whose general goal is the modernization of agriculture and rural areas (Wang and Xu, 2019). I hope this research can shed light on future research in Chinese ethnic minority villages on the traditional knowledge and sustainable NRU regimes, and this knowledge can be applied in designing future sustainable landscape plans. Many connections between different land-use systems were found by applying the satoyama concept. However, in China, the administrative management of other land-use systems is conducted by various governmental bureaus (Wang and Xu, 2019). Joint efforts should be made to conserve these connections.

There are several deficiencies in this research. Firstly, apart from utilizing natural resources, the Dong people's effort to conserve and improve environmental assets is also worth paying attention to if we want to understand their whole natural resource management regimes. More research on ethnic minority people's traditional knowledge on living in harmony with nature needs to be done to fully understand their natural resource management regime and provide recommendations for making sustainable management plans today. Secondly, all data were derived from interviews and historical documents. Therefore, we can understand the backgrounds of the NRU changes, but it is challenging to identify the drivers of the NRU changes and make the causal relationship between them. I hope this study can provide a baseline for future research on the drivers of changes and ethnic minority people in other areas.

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Chapter 4 Land-use/landscape pattern changes and related environmental driving forces in Gaoyou Village

4.1 Introduction

Land is a spatial base for anthropogenic activities that provide natural resources such as food, plant matter, water, and shelter to fulfill human needs (Foley et al., 2005). Against this background, the Land-Use and Land-Cover Change (LUCC) scientific research program put forward under the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) in 1993 prompted a rapid upward trend in research on land-use change (Lambin et al., 1995; Long, 2021). While local in-tensive land usage has brought about an increase in food and fiber production while causing global environmental degradation in some regions (Foley et al., 2005; Newbold et al., 2015; Bugalho et al., 2011), other areas have seen reduced land management or even abandonment, which jeopardize biodiversity and ecosystem services (Bugalho et al., 2011). Research on land-use change in China has attracted much interest, while accelerated urbanization has brought about urban growth and cropland loss in China (Weng, 2002; Liu et al., 2010; Liu et al., 2003). The processes, driving factors, and ecological effects of rural land-use change in the mountainous areas of western China require more research compared to the flourishing research in the metropolitan area in eastern and coastal China (Peng et al., 2008) since rural China is experiencing land-use problems, including the abandonment of farmland, non-agriculture, and non-grain preference (Long et al., 2016; Su et al., 2020).

Previous studies have concluded that land-use types and intensities are related to landscape structure, function, and processes (Vitousek et al., 1997) and that landscape changes are most likely to be observed from changes in land use (Dadashpoor et al., 2019; Liu et al., 2014). As such, it is important to integrate analysis of changes in land use and landscapes (Tang et al., 2020) in related research. While rapid development in such studies has been seen, Bürgi et al.'s identification of challenges in the field highlighted that most landscape-change analyses tended to focus on spatial patterns while neglecting landscape functions and processes. The authors concluded that further research on the driving forces behind landscape change may shed light on how to address related challenges (Bürgi et al., 2004). The complexity of land-use systems calls for multidisciplinary analyses of the dynamic human-environment interactions associated with land-use change, but the lack of spatially explicit data makes it difficult to incorporate biophysical, socio-economic, and political factors (Foley et al., 2005; Lambin et al., 2003). Systematic analysis of local-scale land-use change studies can shed light on finding the general principles that can explain current land-use change and predict future land use systems (Lambin et al., 2003).

Past research shows that traditional landscapes managed by indigenous people based on traditional ecological knowledge (TEK) gained from long-term interaction with the surrounding environment are resilient to disturbances and that ecosystem services are maintained in such areas (Gómez-Baggethun et al., 2013). However, industrialization, urbanization, and various significant changes in Chinese rural development policy have changed the lifestyles of indigenous people and rural landscapes (Yan et al., 2021). The Dong people (one of 55 minorities in China) have long used TEK to manage their land, thereby supporting traditional characteristic landscapes. The Dong rice-fish-duck initiative in Guizhou is also designated as a Globally Important Agricultural Heritage System (GIAHS). Past research on natural resource utilization regimes in the Dong village of Gaoyou in southwestern China has shown intensive land-use regimes and interaction between different land-use

elements in the traditional landscape, with results indicating that natural resource utilization has changed against a background of socio-economic development in modern China (Qin et al., 2021). The rural revitalization goal announced as part of the CCP's 19th Congress in late 2017 aims to support commercial activity in rural areas, ecologically sound living environments, local interaction, effective governance, and prosperity via promotion of development into rural China. However, the plan also raises certain challenges, including the need for market-based revitalization with focus on rural land resources. While this approach may increase local property values, it may also deprive locals of their land (Yan et al., 2021). Accordingly, there is an urgent need to clarify land-use changes in indigenous ethnic minority villages to determine the status of landscapes, thereby enabling plans for the preservation of traditional scenery and suggestions for the implementation of rural revitalization strategies.

With the prevalence of remote sensing technology and GIS, many researchers have used land satellite imagery and GIS to study changes in land-use/landscape patterns and related driving forces (Long et al., 2021). Recent years have also seen increased interest in higher-resolution data from unoccupied aircraft systems (UASs, or drones) for land-use/land-cover mapping (Gray et al., 2018) and change detection (Yao et al., 2019). Recent papers revealed the implications of drones in precision agriculture and vegetation (Rango et al., 2009), urban environment and management (Zhu et al., 2018), and disaster hazard and rescue (Gioia et al., 2021). Landscape metrics are often used to evaluate fragmentation. A variety of landscape metrics have also been developed and applied to quantify landscape composition and configuration (McGarigal, 2015; Li and Wu, 2004; Cushman et al., 2008; Southworth et al., 2002).

The authors' previous research on Gaoyou involved a reconstruction of the present local landscape. Due to a lack of appropriate GIS data at the time, villagers were inter-viewed to enable the conclusion of results. In the study reported here, information from the previous research was used to interpret satellite imagery from 2009/2020 and drone imagery from 2019, and land classification maps were made. The Fragstats computer program was used to determine changes in land use and landscape patterns, and redundancy analysis (RDA) was applied to clarify relationships with environmental factors. The analysis involved the variables of altitude, slope, and distance to rivers as topographical parameters representing natural environmental conditions and distance to settlements/main roads as anthropogenic parameters representing land accessibility.

The objectives of the research were to (1) determine spatio-temporal changes in land use; (2) clarify landscape pattern changes; and (3) identify major environmental factors contributing to changes in land use and landscape patterns.

4.2 Methodology

4.2.1 Research site

The study was conducted in Gaoyou village of Sanjiang Dong Autonomous County, Liuzhou City, Guangxi Zhuang Autonomous Region, in southwest China (N 25°59′02″, E 109°52′35″), which is on one of the headwaters of Lake Dongting and the Yangtze drainage basin. Gaoyou is located on a mountain, with an average elevation of 500 m, a subtropical climate, and hilly topographic conditions making the village suitable for forestry development, with major forestry species including fir trees (Cunninghamia lanceolata), pine trees (Pinus massoniana), bamboo and camellia (Camellia oleifera). Average temperatures are 26.2°C in

July and 10.7°C in January, and annual precipitation is 1,300 – 1,400 mm. As shown in Figure 4.1, Gaoyou maintains a traditional Dong landscape with delicate wooden houses and diverse land usage and is tentatively listed as a World Heritage site (Unesco.org, 2013). The study site is detailed in Table 4.1, and the location is shown in Figure 4.2.

Figure 4.1. Gaoyou (2017)

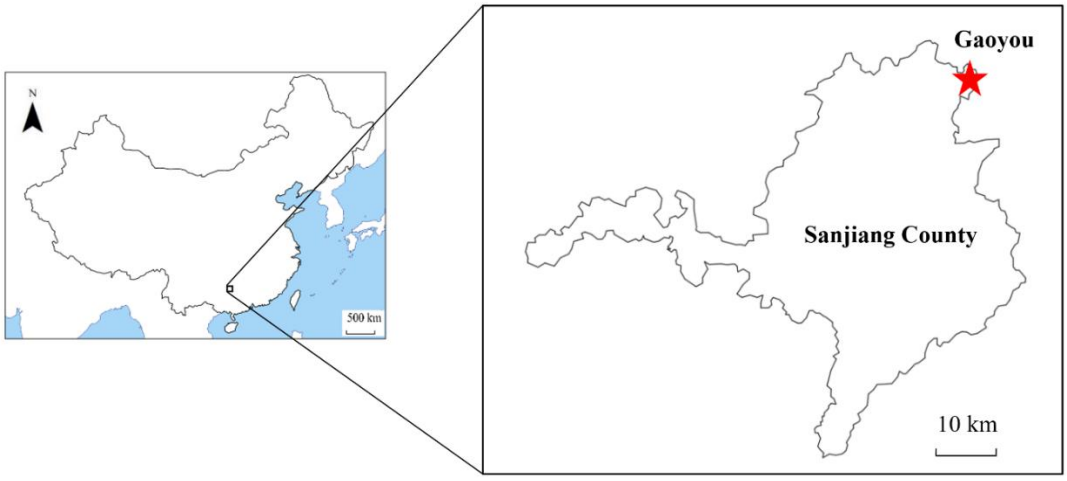

Figure 4.2. Location of Gaoyou village.

Table 4.1. Baseline information about Gaoyou village

Population (permanent resident population[1])	Households	Area (ha)	Farmland area (paddy fields) (ha)	Forest area (fir/ camellia) (ha)	Tea plantation (ha)	Garden plot (ha)	Built-up land (ha)	Other area (ha)	Average elevation (m)
1960 (1230)	496	530.5	89.5 (85.2)	330.9 (153.3/ 86.7)	39.5	43	15.2	12.4	500

1. Permanent resident population stands for farmers staying in the village for more than 6 months in a year.

Data source: Gaoyou village government. Data recorded from Gaoyou village's official planning for 2020-2035 was obtained from the local government in 2020. Please note that this data is different from that in chapters 2&3 because the data sources are different. Since Guangxi Zhuang Autonomous Region conducted a confirmation of the rural land right in the past decade and the work was finished in 2018, the newly published official data of the village is different from the data recorded in 2017 in chapters 2&3.

4.2.2 Methodology

(1) Data collection and processing

Land-use changes in Gaoyou were determined by comparing land classification maps for 2009, 2019, and 2020. Those for 2009 and 2020 were derived from GeoEye-1 satellite imagery (spatial resolution: 46 cm) acquired on 9 February 2009 and 14 November 2020. That for 2019 was derived from Phantom 4 Pro drone imagery from two flight missions captured at the flight height of 270m on 11 May 2019, and the time was selected during the rice transplanting season when paddy fields are filled with water easily be identified from the drone imagery. The drone imagery was processed in Agisoft Metashape Professional to produce an orthophoto mosaic of Gaoyou with a resolution of 11 cm (Figure 4.3). Satellite data were georeferenced to drone data via 150+ ground control points in ArcMap 10.7. All imagery was later processed in ArcGIS 10.7 to create thematic land-use categorization maps, which were visually interpreted by the same researcher to minimize potential inconsistencies. With reference to the authors' previous research on landscape mapping in Gaoyou (Qin et al., 2021), the land classifications were mixed forest, fir plantation, camellia plantation, tea plantation, paddy field, dry field, barren land, residential area, and road (Table 4.2). The land classifications also considered that since the resolutions of the imagery data were different, each land use type could be clearly identified from each imagery, and each polygon is relatively homogenous and differed from the surroundings. The only difficulty is distinguishing between paddy field and dry field in the satellite imageries of 46cm' resolution. Since paddy field can be identified from the drone imagery of 11cm' resolution, and due to China's "Red Line" policy for arable land under which farmers may not make changes to paddy fields. It is very unlikely that farmers reclaimed new paddy field in recent years. It was assumed that the paddy field remained unchanged and interpreted the farmland identified in the satellite imageries as paddy field where the same area is identified as paddy field in the drone imagery. As the official administrative boundary of the village was unclear on May 11, 2019, the study area in relation to drone imagery was determined from group discussions in which villagers were asked where they acquired natural resources. The village border was then determined considering geographical boundaries such as mountain ridges and landmarks such as large pine trees. ASTER DEM information (spatial

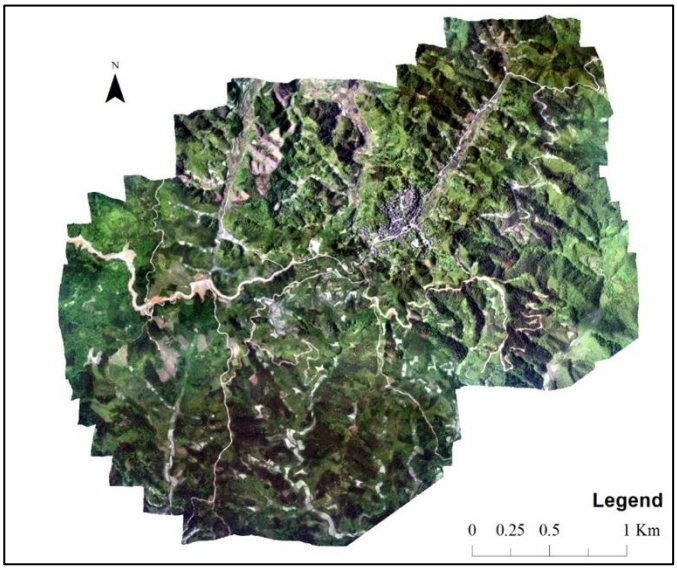

Figure 4.3. Orthophoto mosaic (11 cm pixel size) of Gaoyou village in 2019

Table 4.2. Land use types

Land use types	**Descriptions**
Mixed forest	Including landscape forest, firewood forest, bamboo forest, and other mixed plantation and natural forest.
Fir plantation	Single plantation of fir trees.
Camellia plantation	Single plantation of camellia trees.
Tea plantation	Single plantation of tea.
Paddy field	Irrigated paddy field for rice and glutinous rice cultivation
Dry field	Irrigated paddy field for crops other than rice, rainfed paddy field (including dry rice cultivation), irrigated cropland (for example, peanut field), rainfed cropland (for example, sweet potato field), and vegetable field (for example, leek field).
Barren land	Land that is cleared with no vegetation or construction on it.
Settlement	Houses and the nearby open area, pathways, and vegetable gardens.
Road	Road for automobiles.

resolution: 30 m) produced by Japan's Ministry of Economy, Trade, and Industry and NASA data were used to derive environmental variables including altitude, slope, and aspect in ArcGIS 10.7.

Interviews with villagers and local administrators were conducted during land-use mapping and analysis of land-use changes in Gaoyou.

(2) Analysis of land-use change and landscape pattern change

The land-use classification maps for 2009-2019-2020 were imported into the Fragstats program for extraction of more information on land-use/landscape pattern changes from various landscape metrics (McGarigal, 2015; Southworth et al., 2002). Patches, which are the fundamentals for calculating landscape metrics, are represented with polygons of identified land-use types in each year (McGarigal, 2015). Landscape metrics computations were

conducted at the class-level, in which all patches belonging to the same land-use type were aggregated, and at the landscape-level, where all patches in the landscape were aggregated.

The class-level landscape metrics describing changes in land-use type changes were: total (class) area (CA) and percentage of landscape (PLAND) to highlight land-use changes; number of patches (NP) and splitting index (SPLIT) to describe fragmentation levels; largest patch index (LPI) and perimeter area fractal dimension (PAFRAC) to de-scribe changes in patch shapes for each land-use type; and the aggregation index (AI) to determine increased aggregation of land use.

The metrics for the landscape level were the number of patches (NP), and the splitting index (SPLIT) used to determine the extent of landscape subdivision or fragmentation, the landscape shape index (LSI) describing changes in patch shape, the contagion index (CONTAG) and aggregation index (AI) used to determine landscape aggregation extent, and Shannon's diversity index (SHDI)/Shannon's evenness index (SHEI) to describe changes in landscape diversity (Tables 4.3 and 4.4).

As mentioned before, minimal changes in paddy field characteristics were assumed due to the difficulty of distinguishing between paddy and dry fields from satellite images and China's "Red Line" policy for arable land under which farmers may not make changes to paddy fields. As the minimal change was identified in satellite imagery, only CA and PLAND values were calculated for paddy fields. CA and PLAND road areas were calculated because roads comprise a significant part of the village's land. The total road length was determined to represent road change in each year instead of other landscape metrics at class level.

Table 4.3. Landscape metrics at class level for land-use change analysis

	Abbreviation	Range
Total (class) area	CA	$CA > 0$, without limit.
Percentage of Landscape	PLAND	$0 < PLAND \leq 100$
Number of patches	NP	$NP > 0$, without limit.
Largest patch index	LPI	$0 < LPI \leq 100$
Perimeter area fractal dimension	PAFRAC	$1 \leq PAFRAC \leq 2$
Splitting index	SPLIT	$1 \leq SPLIT \leq$ number of cells in the landscape area squared
Aggregation index	AI	$0 \leq AI \leq 100$

Table 4.4. Landscape metrics at landscape level utilized for changes of landscape pattern analysis

	Abbreviation	Range
Number of patches	NP	$NP > 0$, without limit.
Landscape shape index	LSI	$LSI \geq 1$, without limit
Contagion index	CONTAG	$0 \leq CONTAG \leq 100$
Aggregation index	AI	$0 \leq AI \leq 100$
Splitting index	SPLIT	$1 \leq SPLIT \leq$ number of cells in the landscape squared
Shannon's diversity index	SHDI	$SHDI \geq 0$, without limit
Shannon's evenness index	SHEI	$0 \leq SHEI \leq 1$

a) Landscape metrics at class level

Total (class) area (CA) is calculated by:

$$CA = \sum_{j=1}^{n} a_{ij} \left(\frac{1}{10{,}000}\right) \quad (1)$$

a_{ij} = area (m^2) of patch ij.

Percentage of Landscape (PLAND) is calculated by:

$$PLAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100) \quad (2)$$

P_i = proportion of the landscape occupied by patch type (class) i.

a_{ij} = area (m^2) of patch ij.

A = total landscape area (m^2).

Number of patches (NP) is calculated by:

$$NP = N \quad (3)$$

N = total number of patches in the class.

Largest patch index (LPI) is calculated by:

$$LPI = \frac{\max_{j=1}^{n}(a_{ij})}{A}(100) \quad (4)$$

a_{ij} = area (m^2) of patch ij.

A = total landscape area (m^2).

Perimeter-area fractal dimension (PAFRAC) is calculated by:

$$PAFRAC = \frac{2}{\frac{\left[n_i \sum_{j=1}^{n}(lnp_{ij} \cdot lna_{ij})\right] - \left[\left(\sum_{j=1}^{n} lnp_{ij}\right)\left(\sum_{j=1}^{n} lna_{ij}\right)\right]}{\left(n_i \sum_{j=1}^{n} lnp_{ij}^2\right) - \left(\sum_{j=1}^{n} lnp_{ij}\right)^2}} \quad (5)$$

a_{ij} = area (m^2) of patch ij.

p_{ij} = perimeter (m) of patch ij.

n_i = number of patches in the landscape of patch type (class) i.

Splitting index (SPLIT) is calculated by:

$$SPLIT = \frac{A^2}{\sum_{j=1}^{n} a_{ij}^2} \quad (6)$$

a_{ij} = area (m^2) of patch ij.

A = total landscape area (m^2).

Aggregation index (AI) is calculated by:

$$AI = \left[\frac{g_{ii}}{max \rightarrow g_{ii}}\right](100) \quad (7)$$

g_{ii} = number of like adjacencies (joins) between pixels of patch type (class) i based on the singlecount method.

Max→g_{ii} = maximum number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method.

b) Landscape metrics at landscape level

Number of patches (NP) is calculated by:

$$NP = N \quad (8)$$

N = total number of patches in the landscape.

Landscape shape index (LSI) is calculated by:

$$LSI = \frac{.25\ E^*}{\sqrt{A}} \quad (9)$$

E = total length (m) of edge in landscape; includes the entire * landscape boundary and some or all background edge segments.

A = total landscape area (m^2).

Contagion index (CONTAG) is calculated by:

$$CONTAG = \left[1 + \frac{\sum_{i=1}^{m}\sum_{k=1}^{m}\left[P_i \circ \frac{g_{ik}}{\sum_{k=1}^{m} g_{ik}}\right] \circ \left[ln\left(P_i \circ \frac{g_{ik}}{\sum_{k=1}^{m} g_{ik}}\right)\right]}{2ln(m)}\right](100) \quad (10)$$

P_i = proportion of the landscape occupied by patch type (class) i.

g_{ik} = number of adjacencies (joins) between pixels of patch types (classes) i and k based on the double-count method.

m = number of patch types (classes) present in the landscape, including the landscape border if present.

Aggregation index (AI) is calculated by:

$$AI = \left[\sum_{i=1}^{m}\left(\frac{g_{ii}}{max \rightarrow g_{ii}}\right)P_i\right](100) \quad (11)$$

g_{ii} = number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method.

max→g_{ii} = maximum number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method.

P_i = proportion of landscape comprised of patch type (class) i.

Splitting index (SPLIT) is calculated by:

$$SPLIT = \frac{A^2}{\sum_{i=1}^{m}\sum_{j=1}^{n} {a_{ij}}^2} \quad (12)$$

a_{ij} = area (m^2) of patch ij.

A = total landscape area (m^2).

Shannon's diversity index (SHDI) is calculated by:

$$SHDI = -\sum_{i=1}^{m}(P_i \circ lnP_i) \quad (13)$$

P_i = proportion of the landscape occupied by patch type (class) i.

Shannon's evenness index (SHEI) is calculated by:

$$SHEI = \frac{-\sum_{i=1}^{m}(P_i \circ lnP_i)}{\ln m} \quad (14)$$

P_i = proportion of the landscape occupied by patch type (class) i.

m = number of patch types (classes) present in the landscape, excluding the landscape border if present.

(3) Analysis of land-use change trajectories and environmental drivers of change

Multivariate analysis was applied to demonstrate the relationship between land-use change trajectories and environmental drivers. The land-use classification maps were processed in ArcMap 10.7 to develop a spatial-temporal database with layers showing land-use types in 2009, 2019, and 2020 and of environmental variables. A 10m by 10m grid was created for the three land-use maps, and land-use change trajectories (Mertens and Lambin, 2000) and environmental variables were recorded in each sample. This produced 65,210 samples evenly distributed across the landscape. A letter was assigned to each of the nine land-use types (tea plantation (T), camellia plantation (C), dry field (D), barren land (B), fir plantation (F), road (R), mixed forest (M), paddy field (P) and settlement (S)) and the land-use type that occupies the maximum area of the grid was recorded in each sample in 2009, 2019 and 2020. Land-use change trajectories, defined as the land-use change in each temporal sequence (2009 - 2019 and 2019 - 2020), were built by comparing the recorded land-use type in each sample in the corresponding year (e.g., a land-use change trajectory may be DT in 2009 – 2019 (D = dry field, T = tea plantation) and DT in 2009 – 2019 represents the sample land-use type changed from dry field to tea plantation; and DD in 2009 – 2019 represents stable dry fields in this period) (Mertens and Lambin, 2000; Hietel et al., 2005; Kong et al., 2010).

To introduce the trajectories into multivariate analysis, the qualitative land-use type data were binary-coded and converted into presence-absence data (Kong et al., 2010). These were then divided into two sets of 81 variables, each representing one of the nine land-use types at two-time points in individual time intervals (2009 and 2019, and 2019 and 2020). A total of 65 land-use change trajectories were observed between 2009 and 2019 and 53 between 2019 and 2020, with variables comprising more than 0.1 percent of land-use change chosen for multivariate analysis. These included 38 types for 2009 and 2019 and 22 for 2019 and 2020.

Table 4.5 summarizes the environmental variables, with altitude directly derived from ASTER DEM and aspect/slope derived from DEM using the spatial analysis function in ArcGIS 10.7. Aspect data were classified as 1 (flat terrain), 2 (north, 0 – 22.5° and 337.5 – 360°), 3 (northeast, 22.5 – 67.5°), 4 (east, 67.5 – 112.5°), 5 (southeast, 112.5 – 157.5°), 6 (south, 157.5 – 202.5°), 7 (southwest, 202.5 – 247.5°), 8 (west, 247.5 – 292.5°) and 9 (northwest, 292.5 – 337.5°) [28,33]. The environmental variables of distance to rivers, distance to settlements, and distance to roads were derived from land-use map data for 2009 because more roads were constructed in the following years, and those in 2009 were the main ones. The lo-cation of Gulou Drum Tower used in calculating distance to settlements and the location of rivers did not change during 2009 – 2020. Distance to settlements was based on the Euclidean distance from the central point of the sample grid to Gulou Drum Tower, which is considered the central point of the village. Distance to rivers was based on the Euclidean distance from the central point of the sample grid to the river.

All data processing for multivariate analysis was conducted in Rstudio, with direct gradient analysis used to clarify relationships between land-use change and environmental variables. Initial testing of environmental gradient lengths using detrended correspondence analysis (DCA) indicated axis lengths of <3 SD in all cases, indicating the appropriateness of redundancy analysis (RDA) for this dataset (Hietel et al., 2004).

RStudio was used for RDA analysis of the relationship between land-use change, trajectory type, and environment variables for 2009 – 2019 and 2019 – 2020.

Table 4.5. Statistical analysis of environmental diversity in Gaoyou

Environmental Variables		**Value range**	**Median**	**Standard deviation**
Natural attributes	**Altitude (m)**	325 - 620	504	64.88
	Slope	0.3 - 44.5	15.1	7.50
	Aspect	1-9	5	1.96
	Distance to river (m)	0 - 1500	300	264.30
Anthropogenic attributes	**Distance to settlement (m)**	0 - 2800	1050	612.24
	Distance to road (m)	0 - 1103	160	217.95

4.3 Results

4.3.1 Land-use maps for 2009, 2019 and 2020

Changes in different land-use types for 2009 – 2019 and 2019 - 2020 are shown in Figure 4.4. During 2009 – 2019, 70.3% of types in the samples remained unchanged, although mixed forest areas were changed to other types. As small fir plantations are difficult to identify from satellite imagery and are often mixed with other vegetation types, fir saplings are sometimes categorized as mixed plantation areas. Between 2009 and 2019, there was a significant change of mixed forest to fir forest, indicating the planting of fir saplings or their growth. There is also a change from fir plantation to mixed plantation, indicating that firs were not replanted after timber harvesting or that fir saplings were too small to be identified. Fir plantation land use mostly changed to the barren land, dry field, or road categories, with changes to barren land suggesting use for other purposes. Reduced camellia plantation use is seen during 2009 – 2019, with many areas changing to fir plantations, while 2019 – 2020 exhibits an increase in camellia plantation use from dry fields and barren land. A change in dry fields (mainly used for growing sweet potatoes and leeks) is observed throughout the study period, with a particular change to camellia plantations during 2019 – 2020. Changes of barren land (indicating land-use change) into tea plantations during 2009 – 2019 are associated with land clearance before 2009. Between 2019 and 2020, more barren land was changed into camellia plantations than into tea plantations. Villagers report that land was cleared for tea plantations before 2019, but a decision was made to create camellia plantations instead during that year. Barren land was also created in association with road construction in 2009 and was thereafter left unmanaged to create mixed forest naturally. A continuous increase in use for tea plantations is observed. The new road areas were mostly fir plantation, creating a landscape of roads cutting through local forests.

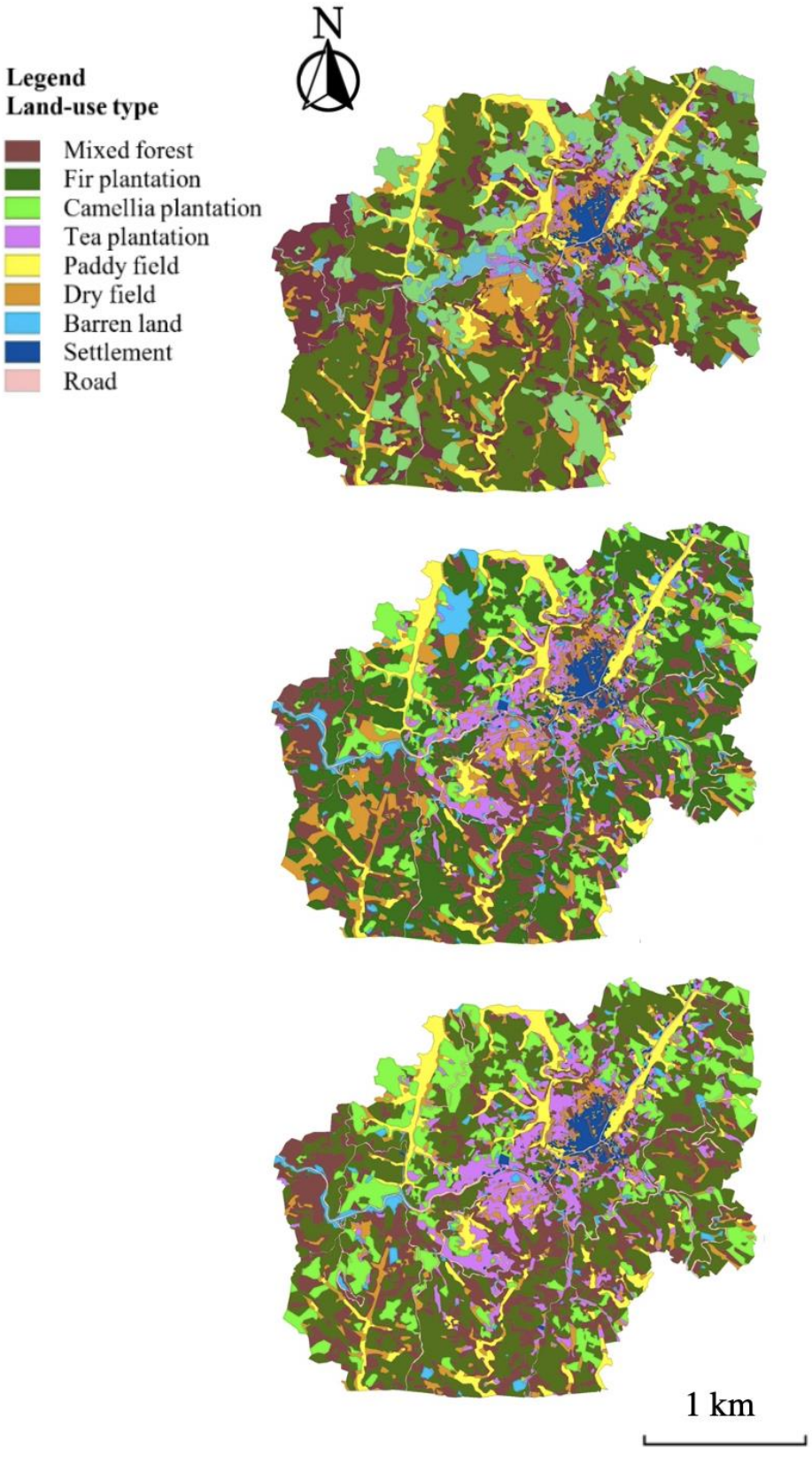

Figure 4.4. Land use maps for 2009, 2019, and 2020 in Gaoyou village.

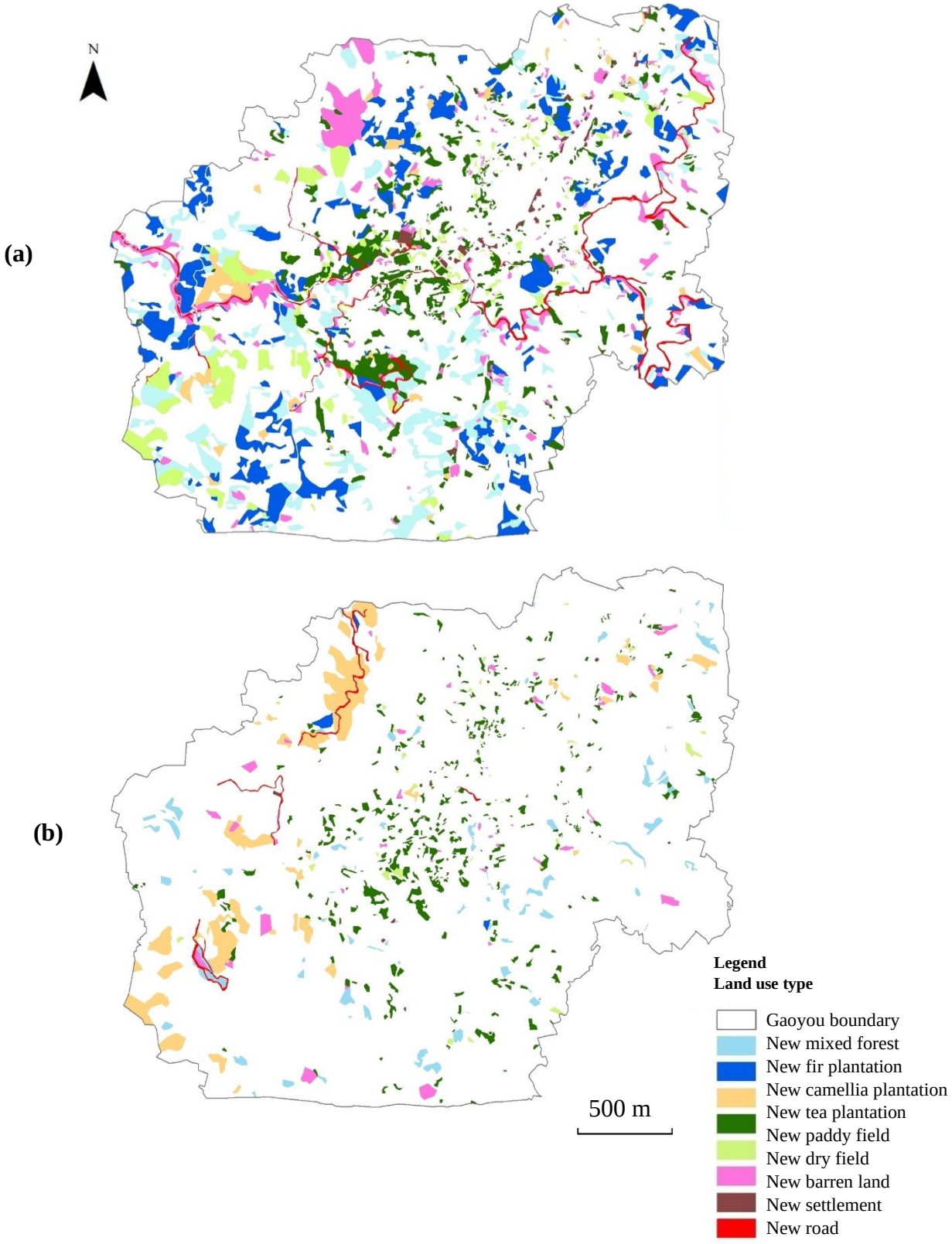

Figure 4.5. Maps of new land-use locations for (a) 2019 and (b) 2020 Gaoyou village.

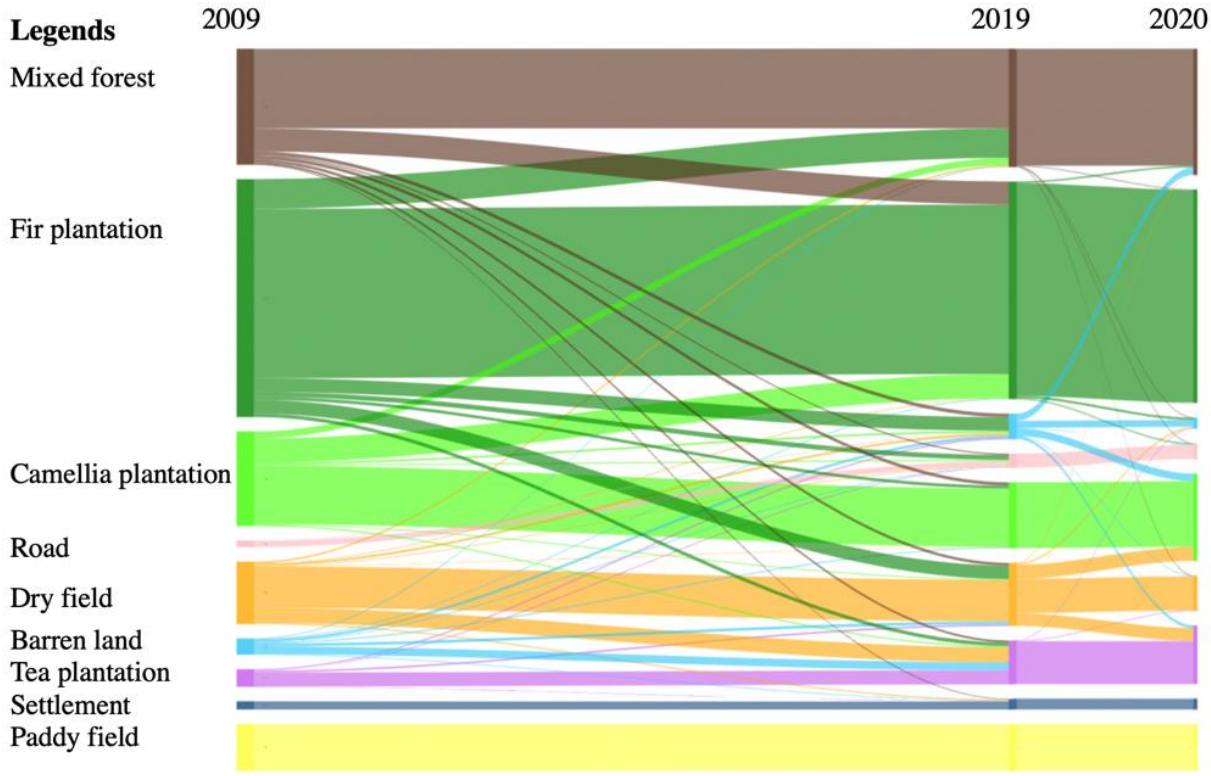

Figure 4.6. Land-use compositions for 2009, 2019 and 2020, and related inter-year changes indicated by flows between land-use types in each year.

4.3.2 Changes in land use and landscape patterns

Due to a lack of data showing the change of physical landscape in the research area in the study period, only the change of landscape quality in terms of the structure of land cover was studied. The land-use maps for 2009, 2019, and 2020 were imported into Fragstats to calculate selected landscape metrics.

(1) Changes in landscape metrics at class level

The CA and PLAND landscape metrics at class level (representing the area of each land-use type) are shown in Table 4.6, while changes in NP, LPI, PAFRAC, SPLIT, AI, and road length are shown in Figure 4.7. Table 4.7 shows the annual change rate in areas of each land-use type calculated from Table 4.6, indicating acceleration both for increases and decreases.

Table 4.6. Total area coverage between 2009, 2019 and 2020 for the classified land-use types. CA: total (class) area; PLAND: percentage of landscape

Land-use type	2009		2019		2020	
	CA (ha)	PLAND (%)	CA (ha)	PLAND (%)	CA (ha)	PLAND (%)
Mixed forest	125	19.13	127	19.53	136	20.81
Fir plantation	256	39.22	234	35.89	228	35.05
Camellia plantation	102	15.59	71	10.90	94	14.41
Tea plantation	19	2.91	47	7.25	63	9.68
Paddy field	51	7.76	50	7.71	50	7.69
Dry field	67	10.29	68	10.41	38	5.87
Barren land	17	2.68	27	4.22	13	2.04
Settlement	9	1.34	11	1.76	12	1.80
Road	7	1.09	15	2.32	17	2.64
Total	652	100	652	100	652	100

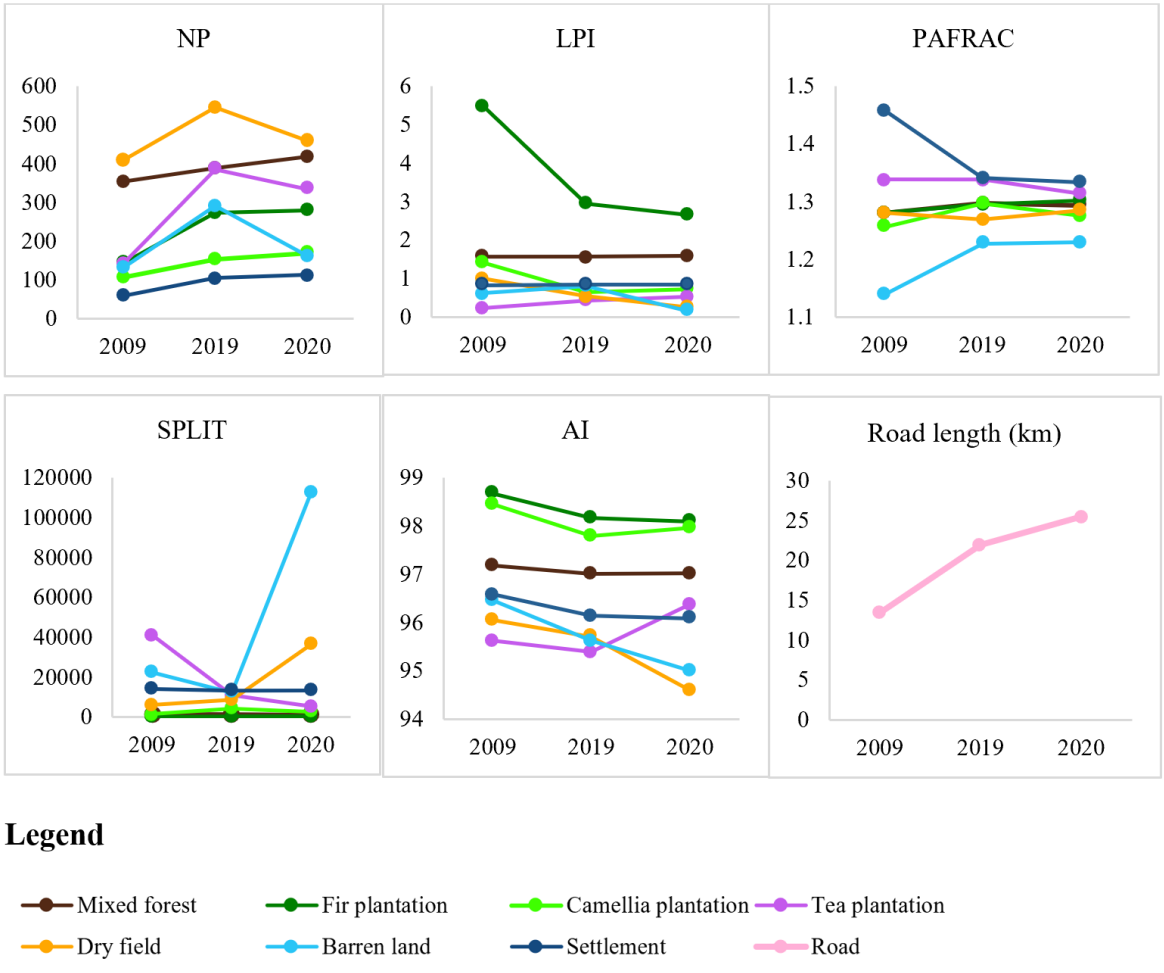

Figure 4.7. Changes in landscape metrics at class level.

NP: number of patches; LPI: largest patch index; PAFRAC: perimeter area fractal dimension; SPLIT: splitting index; AI: aggregation index.

Table 4.7. Percentage change, net change and rate of change between 2009, 2019 and 2020 for the classified land-use categories

Land Use Type	Change (%)			Net Change (ha)			Rate of change (ha/Year)		
	2009-2019	2019-2020	2009-2020	2009-2019	2019-2020	2009-2020	2009-2019	2019-2020	2009-2020
Mixed forest	0.40	1.28	1.68	2	9	11	0.2	9	1
Fir plantation	-3.33	-0.84	-4.17	-22	-6	-28	-2.2	-6	-2.5
Camellia plantation	-4.69	3.51	-1.18	-31	23	-8	-3.1	23	-0.7
Tea plantation	4.34	2.43	6.77	28	16	44	2.8	16	4
Paddy field	-0.05	-0.02	-0.07	-1	0	-1	-0.1	0	-0.1
Dry field	0.12	-4.54	-4.42	1	-30	-29	0.1	-30	-2.6
Barren land	1.54	-2.18	-0.64	10	-14	-4	1	-14	-0.4
Settlement	0.42	0.04	0.46	2	1	3	0.2	1	0.3
Road	1.23	0.32	1.55	8	2	10	0.8	2	0.9

The increasing NP and the decreasing AI indicate mixed forest fragmentation. For fir plantations, the increased NP and PAFRAC and the decreased LPI and AI indicate lower aggregation, with large areas divided into smaller patches. Dry fields are also less aggregated, as indicated by the increased SPLIT and decreased AI. Camellia plantations exhibit different trends of landscape metric change for the time sequence 2009 – 2019 – 2020, with a large portion of camellia plantations in 2019, an increased SPLIT and a decreased AI in 2009 – 2019, and a decreased SPLIT and an increased AI in 2019 – 2020 showing fragmentation of old camellia plantations and aggregation of new camellia plantations. Tea plantations exhibit increased size, with simpler and more aggregated areas. Residential zones show increased and less aggregated areas. Roads (Table 4.8) show increased area, length, and width calculated by road length divided by road area in each year.

(2) Changes in landscape metrics at landscape level

Figure 4.8 shows changes in landscape patterns from metrics at landscape level.

Table 4.8. Road changes

	Length (km)	Area (ha)	Width (m)
2009	13.4	7	5.2
2019	22.0	15	6.8
2020	25.5	17	6.7

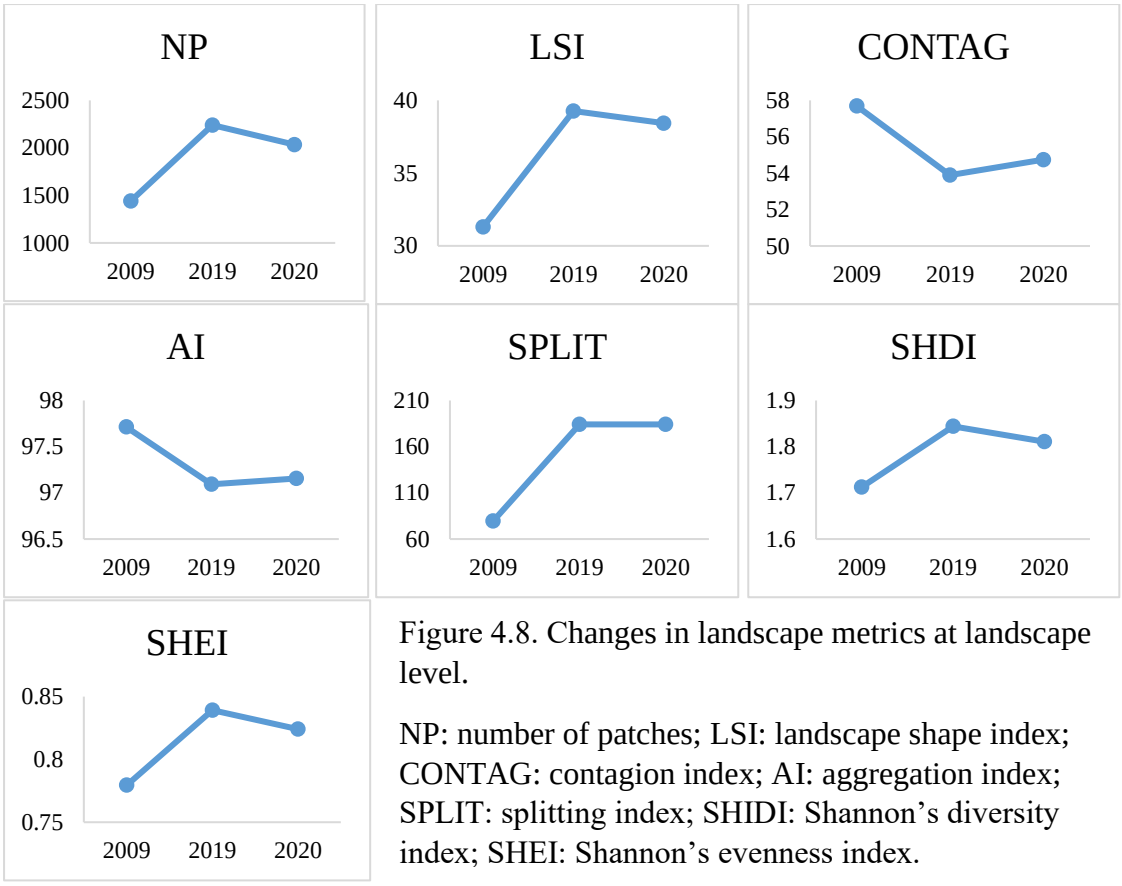

Figure 4.8. Changes in landscape metrics at landscape level.

NP: number of patches; LSI: landscape shape index; CONTAG: contagion index; AI: aggregation index; SPLIT: splitting index; SHIDI: Shannon's diversity index; SHEI: Shannon's evenness index.

In summary, before 1990, when tea plantations were first introduced in Gaoyou, local land use was mainly comprised of traditional land uses of the Dong people, and the land uses introduced during the People's Commune Period (Qin et al., 2021). Increased plantation of tea during 2009 – 2019 resulted in greater landscape diversity and caused fragmentation and disaggregation, leading to landscape irregularity. However, new tea/camellia plantation from 2019 onward combined these aggregated and detached patches to create larger areas, thereby simplifying the landscape and reducing diversity.

4.3.3 Relationship between land-use change and environmental variables

A total of 65 land-use change trajectories for 2009 – 2019 and 53 for 2019 – 2020 were identified. Less significant trajectories comprising less than 0.1 percent of the landscape were omitted in the RDA analysis conducted to establish the relationship between land-use change and environmental variables. These included 38 land-use change trajectories for 2009 – 2019 (MM, MF, MC, MT, MD, MB, MR, FM, FF, FC, FT, FD, FB, FR, CM, CF, CC, CT, CD, CB, CR, TT, TD,TB, PP, DM, DT, DD, DB, DS, BF, BC, BT, BD, BB, SS, RB and RR) and 22 for 2019 and 2020 (MM, MF, FM, FF, FC, FB, FR, CC, TT, PP, DM, DC, DT, DD, DB, BM, BC, BT, BD, BB, SS and RR).

In the RDA analysis results shown in Figure 4.9 and Figure 4.10, the first 2 RDA axes for 2009 – 2019 account for 72.64% of the total variation, and those for the second period account for 85.4%. These figures highlight the relationship between land-use change and environmental variables in Gaoyou.

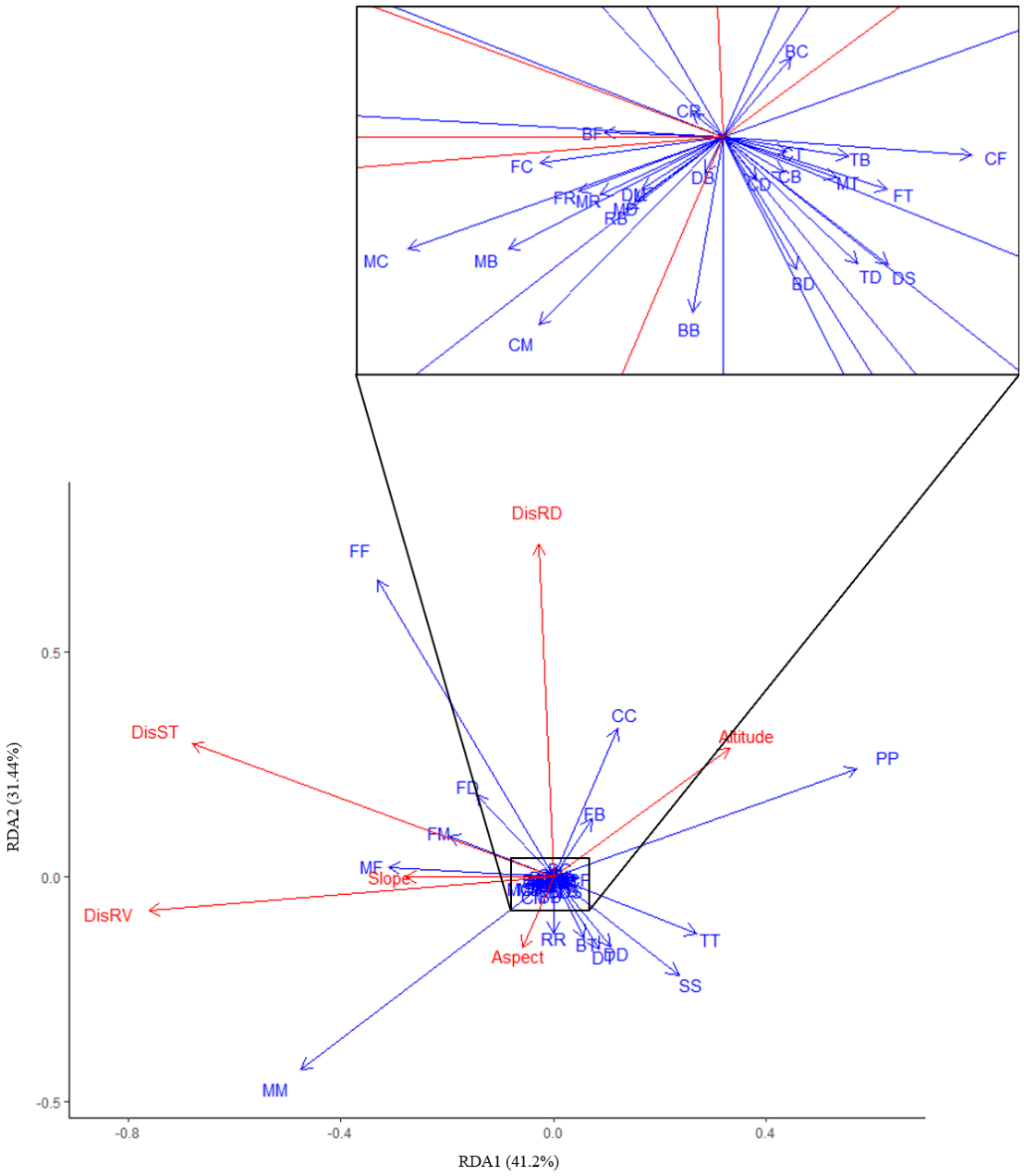

Figure 4.9. RDA ordination of land-use change trajectories (blue arrows) in relation to environmental variables (red arrows) for 2009 – 2019

DisRV: distance to rivers; DisRD: distance to roads; DisST: distance to settlements. Arrows represent relative values of environmental variables and land-use change trajectories. Correlations between environmental variables and land-use change trajectories are indicated by the cosine of angles between the corresponding arrows, with <90^{o} indicating a positive correlation and >90^{o} a negative correlation. With projection of arrows for land-use change trajectories into arrows for corresponding environmental variables, the distance from the origin to the projection point indicates the relative value of the environmental variable where land-use change is most likely to occur.

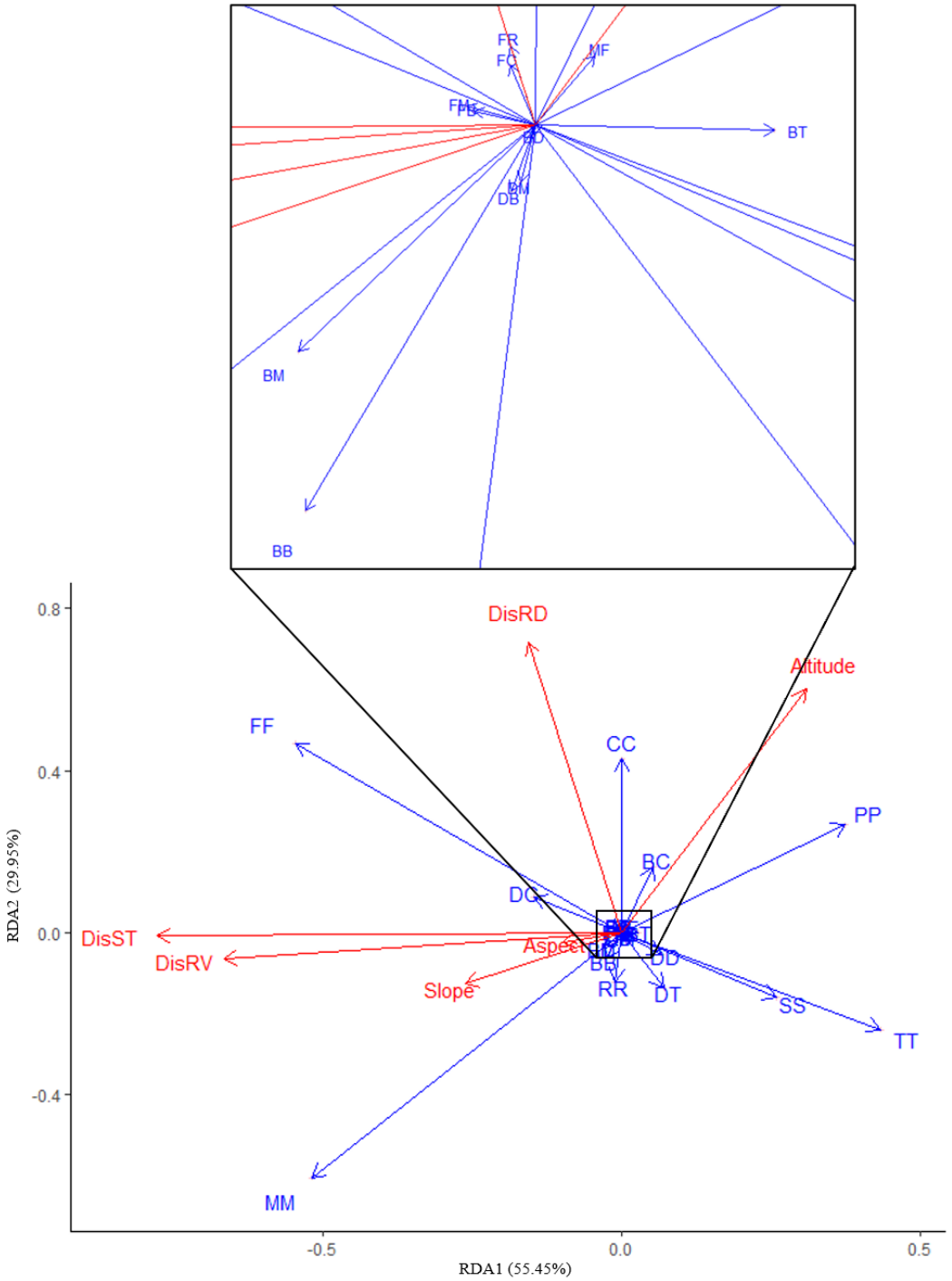

Figure 4.10. RDA ordination of land-use change trajectories (blue arrows) in relation to environmental variables (red arrows) for 2019 – 2020

DisRV: distance to rivers; DisRD: distance to roads. DisST: Distance to settlement. Arrows represent relative values of environmental variables and land-use change trajectories. Correlations between environmental variables and land-use change trajectories are indicated by the cosine of angles between the corresponding arrows; with <90° indicating a positive correlation and >90° a negative correlation. With projection of arrows for land-use change trajectories into arrows for corresponding environmental variables, the distance from the origin to the projection point indicates the relative value of the environmental variable where land-use change is most likely to occur.

In both periods, it is more likely that unchanged areas of mixed forests, fir plantations, and camellia plantations are distant from village and road zones and on steep slopes, stable tea plantation and dry field areas are close to village and road zones, paddy field and settlement areas are on flat land close to river zones, and barren land is at low altitudes close to road zones.

In both periods, it is more likely that land distant from village zones and on steep slopes was changed to mixed forest, forests distant from village or road zones and at high altitude or on steep slopes are were changed to fir plantations, forest, and farmland distant from village and road zones and on steep slopes or at high altitude were changed to camellia plantations, land very close to village and road zones and with some sloping were changed to tea plantations, land close to village and road zones was changed to dry fields, land near road zones was changed to barren land. The new road is built on relatively steep slopes.

4.4 Discussion

4.4.1 Direction of land-use change in Gaoyou

The research results show that nearly 30% of local land underwent change between 2009 and 2019 (annual rate of change: 3%) and 9% between 2019 and 2020, and the pace of change is accelerating. Although some changes (such as those between fir plantations and mixed forests) may be attributable to natural succession and research deficiencies, most were related to human activity.

The results, including maps showing the location of land-use types from Figure 4.4, location of new land-use from Figure 4.5, mean values of environmental variables for each land-use type, and location of land-use change trajectory in relation to environmental variables from Figure 4.9& 4.10, were summarized and combined with those of chapter 3 and interviews with villagers and local administrators to create the transect model in Figure 4.11 showing the direction of land-use changes. As tea plantations were first established in Gaoyou in 1990, land use before this time was considered important. Due to a lack of clear satellite imagery from before 2009, three groups of villagers were organized to discuss and highlight major land-use changes occurring between 1990 and 2009. Barren land is not included in the model, indicating land-use transition.

Before the establishment of tea plantations in the 1990s, there was no traffic access. The land-use types in Gaoyou were mainly traditional land-use of the Dong people and the land-use types that were brought into the village by the government during the People's Commune Period (Qin et al., 2021). Paddy fields running along the riverside were flanked by residential areas, and dry fields behind the village were situated with fir and camellia plantations. There is also forest and farmland at low altitudes distant from the village. In 2009, a road was constructed on the old path in the area. Camellia is a traditional Dong plantation that was previously used for plant oil production, but today is used for other purposes because today, oil is purchased from the market. Tea plantation is prevalently promoted, and some camellia plantations and dry fields have been converted for this purpose. Developments in the energy sector have also reduced demand for firewood, meaning that mixed forest areas have recovered. Depopulation has left dry fields un-managed, creating barren land. In 2019 a significant increase in tea plantation areas was observed, with some farmers switching from camellia plantations and dry field areas. More roads have also been constructed in forest areas. In 2020 when the plantation of a new species of camellia was promoted by the government in Sanjiang County via farmer subsidies, operation in dry fields distant from the village and on

certain slopes was changed accordingly. The area of tea plantations continues to increase, particularly on dry field terrain.

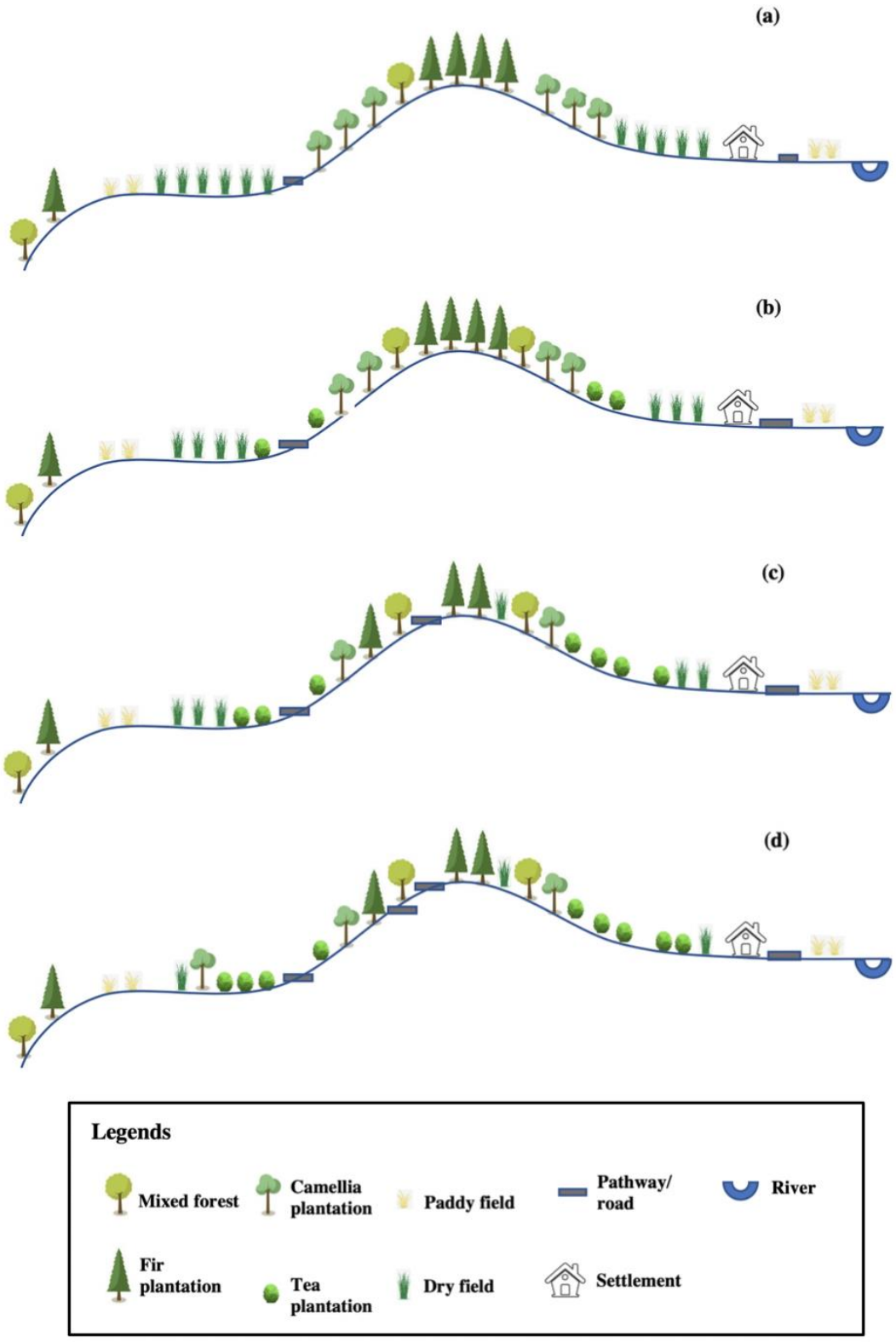

Figure 4.11. Transect models of land-use change: (a) around 1990; (b) 2009; (c) 2019; (d) 2020

4.4.2. Backgrounds of rapid land-use change

a) Clarification of land-use change in relation to natural and anthropogenic variables

Results from this research indicate that environmental variables play an important role in land-use change. Land accessibility affected where changes occurred, and natural variables constrained the type of change. The relationship between land-use change and environmental variables has an association with local workforce aging, but residents remain hard-working and willing to adopt land-use changes along with related management. Environmental variables were limited to natural attributes and proxy attributes in this research due to the lack of official socioeconomic data at village level in the research area. Further research on the driving forces of land-use change in this area needs to include more environmental variables.

The official data of Table 4.9 provided the backgrounds of depopulation and the related land-use change. Since Sanjiang is near the Pearl River Delta area, in which metropolitan cities that receive a large population of migrant workers like Guangzhou and Shen are located, many farmers from Sanjiang became migrant workers in the Pearl River Delta area. Although there is no official data showing the designation of these migrant workers in Sanjiang, local administrators provided the information that in response to the national policy of poverty alleviation, Liuzhou city is cooperating with Zhanjiang city in the Pearl River Delta to provide working opportunities in Zhanjiang city for residents, and the official data shows that 42,300 Liuzhou residents became migrant workers in Guangdong Province in the Pearl River Delta area in 2021. Past research in ethnic minority villages in southwest China shows that with limited economic opportunities in the villages, many ethnic minority people chose to become short-distance and long-distance migrant workers (Gustafsson and Sai, 2006). This phenomenon has driven the cropland decline in the villages (Yu et al., 2020) and the loss of cultural identity in the young generation of ethnic minority children born in the cities (Geary and Pan, 2003). However, due to the “hukou” system (the household registration system) that prevents migrant workers from settling down in the urban areas, most of them who had entered the cities in search of work opportunities have no choice but to return to their villages when they are old (Cheng and Selden, 1994). The degraded cropland may not provide enough subsistence for the returned old laborers in the villages, which requires future research.

Local-government’s land-use maps for village planning from 2020 to 2035 indicate applications different from my observations. Some dry fields reportedly used for rice cultivation in 2020 appeared as tea plantations in the 2019 land-use map, which was derived from drone imagery. Accordingly, land-use monitoring based on remote sensing techniques is required in the area to support adequate food supplies.

Table 4.9. Percentage of migrant workers in the whole population in Sanjiang County

Year	Male (%)	Female (%)	Total (%)
1990	0	0	0
2000	11.17	10.66	10.93
2010	26.53	22.14	24.46

Data source: the official statistics provided by the Agricultural Bureau of Liuzhou in 2017

b) Role of policy intervention in land-use change

Policy intervention brought land-use change into Gaoyou village by introducing new land-uses by means of reform in the rural land system (Qin et al., 2021) and by providing subsidies for those crops favored by the government. Past research highlighted the importance of subsidy intervention on land-use change (Lambin et al., 2001; Lubowski et al., 2006; Jiang et al., 2013; Keys and McConnell, 2005). Local government's promotion has prompted the development of tea and camellia plantations in recent years. Figure 4.12 shows images of the area, which was covered with fir plantations in 2009. Although the land was cleared in 2019 for potential tea plantations, the 2020 data show plantations with camellia seedlings. This demonstrates farmers' quick response in relation to government subsidies and indicates the high importance of such in local land management regimes. Accordingly, long-term governmental plans in landscape planning and policy-making are expected to be beneficial.

Figure 4.13 shows how increased road area and length are causing forest fragmentation. Local administrators have increased road presence via tourism-related construction in Sanjiang and local government funding to relieve poverty in the area. Interviews with local administrators from Liuzhou Agricultural and Rural Office and Sanjiang Agricultural Bureau explained that there is a lack of overall planning for the use of poverty alleviation funds because the settlement and local farmland/forests are managed by different administrations (Wang and Xu, 2019), but road construction is seen as the most efficient route to poverty alleviation regardless of the administrative body (Park and Wang, 2010; Li et al., 2016). It is evident that road support agricultural profit by providing routes to markets, and the large area of the bamboo plantation from field observation in this research is a failure example of problematic promotion of agricultural products and the poor transportation linked to the only bamboo manufactory in Sanjiang that the raw material bamboo went moldy in the producing area, as is pointed out by the local administrators. There is also a lack of planning for road construction; administrations simply launch a tender process to secure contractors, who themselves decide where to build new roads, resulting in the rapid road growth within the village and the non-sufficient road that connects the producing area, manufactories, and market (Shukla and Jharkharia, 2013). In order to promote tourism in Gaoyou village, the Sanjiang government has decided to expand the width of roads so that more automobiles can come into the village. Results from Table 4.8 demonstrated that the road construction work in Gaoyou not only fragmented the forest where the new road was built but also caused land-use changes along the old road. The results show that the road was built on relatively steep slopes in Gaoyou. During the study's field survey, landslides onto roads were observed due to a lack of maintenance funding. Accordingly, different administrations should collaborate with ecological experts on village development plans.

(a) (b) (c)

Figure 4.12. Rapid land-use changes in the same area. (a) Fir plantation (2009) (b) Barren land (2019) (c) Camellia plantation (2020).

Figure 4.13. Road changes in (a) 2009, (b) 2019 and (c) 2020.

c) Role of local Dong people's traditional ecological knowledge

Previous research emphasized the potential contribution of traditional ecological knowledge in conserving biodiversity (Berkes et al., 1995) and making sustainable resource management plans (Kumar et al., 2021). Japan launched the Satoyama Initiative in 2010 to realize "societies in harmony with nature" through landscape approaches to arouse interest in biodiversity and ecosystem conservation and rebuild a healthy human-nature relationship (Takeuchi, 2010). It highlighted the importance of traditional ecological knowledge in case studies both in Japan and internationally (Wang and Xu, 2019; Takeuchi, 2010; Fukamachi et al., 2001; Berglund et al., 2014; Dublin and Tanaka, 2014; Saito et al., 2020; Mohri et al., 2013). Research on rural landscapes adopting traditional ecological knowledge across the globe can provide models for making sustainable management plans. The research result demonstrates the potential of using Gaoyou village as a model for sustainable resource management plans if the landscape and related natural resources management regimes, including land resource management, are well preserved. The three aspects of traditional ecological knowledge, knowledge system, system of practice, and moral and spiritual values were identified (Berkes et al., 1995).

As for system of practice, results from chapter 3 indicated favorable land-scape preservation in Gaoyou (Qin et al., 2021). This chapter suggested efficient use of local land resources despite extensive farmland abandonment in mountainous areas of southwestern China (Shi et al., 2016). Gaoyou farmers reported almost no land abandonment in the village; in the absence of young laborers to manage farmland distant from the village, farmers tend to grow tea or firs rather than abandoning cultivation areas. Fir trees are highly valued in Dong culture, providing lumber and materials for construction and everyday living as well as having particular spiritual significance (Gu, 2007). The results showed that most fir plantations were not changed to allow other forms of land use. Residents also reported logging only for local construction rather than for commercial purposes, as well as immediate replanting of fir saplings for replenishment. Firs are also planted in dry fields distant from the village and roads. When the village's collective fir plantation (used for public structures such as Fengyu Bridge and Drum Tower) is depleted, residents contribute wood from their forest areas. Fir trees thus play an essential communal role in Dong culture.

It is worth pointing out that during the field observations and interviews with local farmers, many migrant workers of short-distance are observed in Gaoyou. Due to the Dong people's traditional ecological knowledge in moral and spiritual values, landscape forest is preserved in every Dong village where bio-resources are conserved. And many Dong farmers return to the village to participate in a discussion concerning the future development plans of the village, to help with villagers' house construction work, and to conduct major agricultural activities like rice cultivation and logging in the fir plantations. The research indicates a need for further research on the relationship between ethnic culture and constant land use without change.

Local tourism is developing due to Gaoyou's preservation status on UNESCO's Tentative List for Cultural Heritage, and the favorable development of tea plantations and local crops such as sweet potatoes and leeks supports local livelihoods. Tourism in other Dong villages tends to be managed by external commercial operators, while in Gaoyou, it is more promoted by residents. The area's relatively developed agricultural cooperatives and infrastructure may contribute to the efficient use of local land resources, and policymakers may view Gaoyou as a good example for rural revival and focus on the wellbeing of local farmers to ensure a fair income from tourism and sufficient livelihoods.

4.4.3. Possible loss in ecosystem services due to rapid land-use change

Due to the lack of data in evaluating the ecosystem services change in this research, some possible losses in ecosystem services observed in this research are pointed out in this subsection, hoping to shed light on future research in this area. Past research revealed that agricultural land abandonment might induce loss in ecosystem services, especially in bio-diversity loss (Benayas, 2007). Field observation found that some unmanaged dry fields turned into barren land with scattered vegetation, and a possible explanation for this is that Gaoyou is located in a mountainous area, where farmland reclamation may cause land degradation (Wang et al., 2004; Eckholm, 1975). Although roads support agricultural profit by providing routes to markets, their construction causes landscape fragmentation and represents land-use change, potentially causing significant ecological downsides (Jaarsma and Willems, 2002; Li et al., 2010; Fu et al., 2010). Results of changes in landscape patterns show a monoculture trend toward tea plantations in Gaoyou. Further environmental assessment for the area is required.

Roads are causing fragmentation. In Figure 4.14, the road in 2009 caused fragmentation in the fir forest and the camellia plantations. And in 2020, the path of the old road was changed into a new wider road built nearby. The abandoned old road was cleared as barren lands.

Figure 4.14. Road construction that caused fragmentation in Gaoyou village. (upper: 2009, lower: 2020)

4.5 Conclusion

This research identified rapid land-use change in a Dong ethnic minority village in southwest China. During 2009 and 2019, when tea plantations started to be widely promoted in Sanjiang, the landscape in Gaoyou became fragmented and more diverse, while between 2009 and 2019, the continuously increasing tea plantations and camellia plantation combined the detached patches and created a larger monoculture area, thereby reducing landscape diversity. Environmental variables of land accessibility affected where changes occurred, and natural variables constrained the type of change. Policy interventions like subsidies influence farmers' decisions on land use. Issues in land use like extensive road construction were observed. Although the results revealed an aging workforce in Gaoyou, the land resources were still efficiently used by the local Dong farmers.

This research demonstrates the potential of integrated analysis of land-use change, landscape pattern analysis, and multivariate analysis in studying rural land-use change. For instance, analysis of land-use change along gives the simple results that there is a rapid land-use change in Gaoyou, while the change in landscape metrics of landscape diversity and fragmentation shows that the introduction of new land uses may benefit the landscape pattern at the first stage but will jeopardize it if there is a monocultural trend in the new landscape.

There are deficiencies in this research. There is a limitation in the study period due to available satellite imageries in this region. The resolutions of imagery data were different; therefore, the assumption that paddy field remain unchanged was made, and the changes of mixed forest's composition are also neglected. And only natural and proxy variables were selected as environmental drivers due to the lack of some socioeconomic data at the village level.

It is suggested that more site-specific future research with a longer period in this region, more evaluation of the impacts of environmental driving factors and assessment of ecosystem services, and research on the relationship between ethnic people's traditional ecological knowledge and land-use change are needed. It is also suggested that different administrations should cooperate to make long-term regional development plans, and land use monitoring with remote sensing techniques is needed.

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Chapter 5 General discussions

In this research, I analyzed the agricultural activities, natural resource utilization regimes, landscape structure, and the related land-use systems in Sanjiang Dong Autonomous County, a Dong ethnic minority region in a mountainous area of southwest China. Multiple research methods were used in this research, including interviews, field observation, drone imagery acquirement, and satellite imagery analysis. In chapter 2, results from interviews and field observations in three Dong villages in Sanjiang county show that, although there are differences due to different spatial factors, both natural and socioeconomic factors, the Dong people conduct similar various agricultural activities in different areas throughout the year. And their agricultural calendar shows an integration of different national cultures and the fusion of tradition and modernity. In chapter 3, data derived from interviews and field observations in a specific Dong village called Gaoyou, which is on the UNESCO's tentative list of World Heritage Sites, shows the changes of indigenous natural resource utilization (NRU) regimes in a period from before 1949 to the present time (2018). The traditional NRU regimes indicate complex interactions between different land-use elements, while the present NRU regime is much simpler, with relatively weak laborers operating it. Results from chapter 2 and chapter 3 both emphasize the promoting effects of policy and market in changes of agricultural activities and NRU regimes, and the unchanged agricultural activities and NRU regimes are connected with the Dong cultural identity. Results from chapter 4 are derived from GIS analysis of drone imagery and satellite imageries in Gaoyou village, showing that there is an efficient use of land resources in Gaoyou village, and environmental factors, political and socioeconomic factors all contributed to the rapid change of land use and landscape pattern in Gaoyou village. Results from chapter 3 and chapter 4 show that Gaoyou preserves its landscape well, and the efficient use of land in Gaoyou can be used as a model for sustainable rural development plans.

5.1 Changes in traditional ecological knowledge of the Dong people

Traditional ecological knowledge (TEK) stands for all types of knowledge concerning the environment that a particular people derived from experience and traditions (Houde, 2007). Previous research indicates three aspects of TEK: knowledge system, system of practice, and moral and spiritual values (Berkes, 1995 & Reo and Whyte, 2011). For ethnic minority groups, since TEK comprises all types of knowledge, it is expressed indirectly in the ethnic minority people's knowledge, practice, respect, value, et. (Yuan et al., 2014). Houde identified six TEK manifestations: factual observations, management systems, past and current uses, ethics and values, culture and identity, and cosmology (Houde, 2007). I will use the three aspects of TEK to discuss the changes in TEK of the Dong people in Sanjiang in this subsection.

Results from chapter 2 show that the current agricultural activities in Sanjiang county are an integration of different national cultures and the fusion of tradition and modernity. For the knowledge system aspect, the traditional ecological knowledge of using local species by hunting and collecting wild vegetation like fern and Chinese herbs is maintained. For the practical system aspect, there is diverse land uses in the Dong villages, and the Dong people make full use of local resources. For example, they grow their local species in the farmland, including local glutinous rice, sweet potato, and leek. They also raise ducks for pest management and conserve craftsmanship that uses local fir timber to build traditional architecture. And for the moral and spiritual values, traditional festivals and ritual events are preserved in which traditional agricultural products like glutinous rice are used. And the traditional ecological knowledge is also preserved in their language and grand songs. Therefore,

some TEK of the Dong people is preserved in Sanjiang County. However, political and socioeconomic backgrounds brought new knowledge to the Dong people. The market plays an important role in the loss of traditional agricultural practices. For example, chemical fertilizer has replaced using tree leaves as fertilizer, and pesticide has replaced ducks for pest control. The Dong farmers respond to the local government's promotion of economic crops positively, and the increasing area of tea plantations in Sanjiang and the growth of Uncaria in Kuangli village are the examples.

In chapters 3 and 4, the results show that the natural resource utilization (NRU) regime in Gaoyou is much simpler now operated by relatively weak laborers. For the knowledge system aspect of TEK, after the ban of guns for bird hunting, their TEK in hunting birds and wild animals decreased. Grassland was left unmanaged and degraded since there was no need for grazing. A local doctor told us that it is difficult to find herbs nowadays in grassland; therefore, their TEK in harvesting satoyama products decreased. As for system of practice, there was still diverse land usage in the village; therefore, this part of TEK is maintained. On the one hand, farmers used less of their local species. For example, they plant new camellia species that are higher in productivity and came with a subsidy from the government, resulting in a loss of local species. Chemical fertilizer and pesticides replaced using their local soil and watershed management resources. Since few villagers wear traditional costumes, the craftsmanship and the related land use in Gaoyou were lost. On the other hand, some local species like sweet potato and leek were preserved, for they are promoted as the branded agricultural products in Gaoyou, giving the farmers economic profits. And some farmers still apply manure fertilizer to their dry fields to cultivate organic products. Some bioresources were conserved in their landscape forest for moral and spiritual values. In summary, there is a decrease in human-nature interactions. Tremendous changes occurred when the market-oriented economy and urbanization made the Dong people communicate more with and integrate into the mainstream culture and change their lifestyle by changing their demands and aspirations. The market-oriented economy and political allowance have motivated farmers to change their land use and NRU regimes frequently in recent decades. Political changes have significantly disturbed and altered the NRU regime by changing the crop species, introducing modern technologies, and damaging the cultural landscape and activities. In summary, the traditional ecological knowledge on making full use of local resources is disappearing. The Dong cultural identity keeps some TEK alive. Although market and policy are important factors in farmers' selection of agricultural practices and crop species, some local species are favored by the Dong people. For instance, fir plantation is still the main land use in Gaoyou's forest. Fir trees are highly valued in Dong culture for providing lumber and materials for construction and everyday living and have particular spiritual significance. The preservation of traditional architecture keeps the usage of fir plantation and related craftsmanship alive. Cultural conservation policy and tourism kept TEK alive. The location of Gaoyou in a mountainous area limits its development and success in preserving the traditional landscape. The government introduced a subsidy program for building wooden houses and banned building brick houses in the village, which helped preserve the architecture and related craftsmanship.

In summary, for the knowledge system aspect of TEK, the Dong people are still harvesting satoyama products, but the TEK is decreasing. For system of practice, there is still diverse land usage, but modern technology replaced their knowledge in full usage of local resources. However, some knowledge was maintained in some of the Dong villages. Their

moral and spiritual values help preserve bioresources in their landscape forest. Their TEK is recorded in their grand songs, and some TEK was maintained in traditional festivals and ritual events. TEK related to their cultural identity is more likely to be maintained, for example, the NRU for their architecture, food, and festivals. In total, the human-nature interaction is decreasing.

5.2 Backgrounds of changes in natural resource utilization regimes and land uses in the Dong villages

While industrialization, urbanization, and several significant changes in the Chinese state's rural development strategy have changed the lifestyles of farmers and the rural landscapes (Yan et al., 2020), the Dong people are also experiencing changes in their NRU regimes and land uses. Chapter 3 finds that the NRU regime changes with lifestyle changes of the Dong people and is now much simpler with relatively weak laborers operating it. Chapter 4 finds that the land use in Gaoyou is undergone rapid change by the driving force of environmental variables, and the landscape is more fragmented now. Results from chapter 2 show that the present agricultural calendar of Sanjiang county integrates different national cultures and a fusion of tradition and modernity, and results from Chapters 3 and 4 demonstrate that Gaoyou village preserves its landscape well. The land resources are still in efficient use.

Political factors contributed significantly to the changes in NRU regimes and land-use systems in China. Results in chapter 3 show that the Dong people's traditional NRU regime was interrupted in some important political events when the government organized farmers into producer cooperatives and communes and forced them to manage the land resources taking orders from the central government during Land Reform in the early 1950s to the end of the Cultural Revolution in late 1970s. One critical change is the increase of non-glutinous rice cultivation. The Dong people have a long history of cultivating a special group of glutinous rice, known as the Kam sweet rice (Lei et al., 2017; Lei et al., 2021). Since hybrid non-glutinous rice has a better yield than glutinous rice, the Dong people changed the rice species in their paddy field to fulfill the production quota in the time of producer cooperatives and communes. Lei et al. (2017) reviewed the ratio change of non-glutinous rice to glutinous rice in another Dong region in southeast Guizhou in southwest China. The ratio increased from around 1:4 in 1949 to around 8:2 in 1980 and continues to increase to more than 9:1 in 2015.

The Dong people were ordered to grow double-cropping non-glutinous rice in the collective time, which the interviewee described as exhausting in chapter 3. The double-cropping non-glutinous rice soon decreased after the Land Reform in the 1980s when farmers could manage their land according to their own willing and is rarely found in Sanjiang county today. Another significant change during this period was in the forest area when natural forest and secondary forest were all clear-cut to provide energy in the Great Leap Forward campaign in the late 1950s. The Cultural Revolution in the 1960s banned some cultural events of the Dong people. Chapter 2 mentions that the Dong people in Kuangli had religious events worshipping ghosts and gods until the Socialist Education Movement banned it. Temples where they conducted these events were torn down, and the stones used in the temples were changed into other uses like jumping stones in the rivers. Chapter 3 also demonstrates some land-use changes after 1949, when China is recovering from the war and seeking developments. The official data released by the Ministry of Land Resources shows that the cultivated land has increased by 14 percent between 1949 and 1958 (Zhang and Li, 1997). The Dong people in Gaoyou reclaimed more farmland and even changed their cemeteries into farmland. The tombstones were used as fields banks.

Another way that politics brings changes in the Dong village is by providing subsidies for those crops favored by the government (Lubowsk, 2006). An example of this is the increase in tea plantations after Sanjiang county promoted it in the 1990s. Chapter 3 provides the official data showing that the area of tea plantations increased from 2129 ha in 2000 to 12701 ha in 2019, as is shown in Figure 3.5. Another example of the influences of subsidies is that, after a long period of decrease, an increase in camellia plantation was observed after implementing a subsidy in planting new camellia species in chapters 3 and 4. Chapter 2 also provides examples of growing cash crops in the Dong villages that the Sanjiang government promotes by subsidies. Therefore, it can be concluded that the Dong people responded positively to the government's subsidies in changing their NRU regimes and land uses.

Chapter 4 pointed out another land-use change affected by political factors: rapid growth in road length and width. Poverty alleviation has been the top priority of the Chinese government in the past few years. As a poverty-stricken national county, Sanjiang receives national funding and has a poverty alleviation task. In China, the administrative management of land-use systems is conducted by various governmental bureaus (Wang and Xu, 2019). Since road construction is an easy indicator for poverty alleviation, local administrations, including Poverty Alleviation Office, Agricultural Bureau, and Forestry Bureau, build roads in different areas in the same village. The lack of cooperation between different administrations contributes to the increase in road construction in the Dong villages. The Chinese government has realized this problem and established the Ministry of Agriculture and Rural Affairs in 2018. Whether the problem of road construction without overall planning is solved calls for future research.

Since urbanization and industrialization have changed the Dong people's lifestyles, socioeconomic factors contributing to NRM changes and land-use changes have received more research interest in recent years. The market economy and improved infrastructure enabled the Dong people to easily purchase food, clothes, and materials from the market, suppressing their demand for acquiring food, fiber, and material from their land and promoting cash crops. The outflow of the rural population becoming migrant workers in the urban area leaves the village's relatively weak laborers. Yang et al.'s (2005) research on migration and rural poverty in China demonstrated that more than 20 percent of rural households in poor counties have at least one migrant worker in southwest China. Results from Chapter 2 also mentioned migrant workers observed in most households. Some of them conduct rice cultivation work in the village and become migrant workers in the urban area when it is not the season for farming. Other full-time migrant workers only come back to the village during festivals or when a significant decision concerning the development of the village is to be made. In this contest, the agricultural activities and land-use regimes are constrained in the villages. The land-use change from the dry field, which requires more time and effort to manage, to tea plantation or camellia plantation that requires less time, indicates that the laborers managing the land resources now are relatively weak. The relationship between proxy variables and land-use changes in chapter 4 shows that accessibility to the land decides where the land-use change is taking place. Dry fields near the road are more likely to stay unchanged than that far from the road, more likely to be changed into a tea plantation if it is located closed to the road, and more likely to be changed into camellia plantations if it is far from the road. It was assumed that managing the dry field takes bigger efforts than managing a tea plantation, and managing a tea plantation requires more effort than managing camellia plantations. The results also reveal that the laborers are getting weak now.

Concerns over grain security in China are growing as non-grain production (NGP) expands rapidly on farmland (Su et al., 2020; Guo and Wang, 2021). The same phenomenon is

observed in Gaoyou village when the dry field that was used to grow grain crops, according to chapter 3, is now changing into non-grain production like tea and camellia. As Guo and Wang discussed about the scientific understanding of China's NGF, we must admit that NGF is an unavoidable consequence of social and economic progress when farmers' needs are shifting from meeting survival needs to pursuing a better life (Long et al., 2016). NGF has improved the diversification of farming. We should also be aware of the potential risks of excessive NGF threatening national food security (Su et al., 2020). Chapter 4 shows that the landscape diversity in Gaoyou village increased during 2009 and 2019 with the increase of tea plantation within the village, but dropped during 2019 and 2020 when excessive land uses were changed into an aggregated monoculture of tea plantation and camellia plantation. Located in the mountainous area, Gaoyou village is faced with a shortage of farmland. In the interviews, residents mentioned that each household must send at least one man to work in the cities, or their paddy field will not provide them with enough rice to eat. In this context, the expansion of NGF has a huge risk of jeopardizing their grain security. Since there is a tendency of monoculture of tea in the Sanjiang region, and little research was conducted to understand the effects of continuous tea monoculture on the environment in this region (Arafat et al., 2019), my research calls for future research in the evaluation of ecosystem services in this area.

Although mediated by political factors, economic opportunities drive land use to change (Lambin et al., 2001). The Dong farmers are sensitive and respond fast to economic opportunities regarding subsidies and market prices. Results in chapters 3 and 4 show that the Dong people changed their old camellia plantation to tea plantations because the productivity of camellia was too low. The economic profit from old camellia is lower than tea leaves. Farmers can collect tea leaves every day for nine months in a year and sell them in exchange for money directly to the local tea manufactories or outside dealers who drive vans into the village to collect tea leaves every day. The Dong farmers are planting more camellia now because there is a subsidy for planting it and because the new camellia species is higher in productivity. The market price for camellia is very impressive in the research time in 2020. And farmers are readopting manure fertilizer in their farmland in Gaoyou village since the agricultural products produced in this way can be sold at a better price. However, agriculture has an economic lag (Whetham, 1925). According to the Sanjiang agricultural bureau, it takes around eight years for the newly planted camellia plantation to grow and produce seeds that they can sell for economic return. There may be a rise and drop in camellia seed's price. Failure to change land use may jeopardize farmers' confidence in the government and market and lead to rapid land-use changes.

The failure of the Sanjiang government's promotion of bamboo analyzed in chapter 2 indicates that a complete supply chain is important to fulfill agricultural production's expected outcome (Shukla and Jharkharia, 2013). Considerable land use of bamboo plantation was observed in the field observation, but few interviewees said they manage or use the bamboo material. Interviews with local administrative staff reveal the Dong people's long tradition of managing tea plantations, camellia plantations, and bamboo plantations. The Sanjiang government decided to promote these three agricultural products in 2009, in which time many Dong farmers changed their old land use into bamboo plantations. However, there was only one bamboo manufactory in the region. Due to the topographic conditions of the mountainous area, the transport infrastructure was not enough to connect the bamboo plantation and the manufactory. Farmers receive little economic profits from bamboo because most bamboo raw material decays quickly after cut in the forest. Now farmers don't manage the bamboo forest, and the existing bamboo plantation occupies many land resources. Therefore, it is suggested that a complete supply chain is needed in making sustainable land-use plans.

The various cultural resources of the Dong people are suitable to develop ethnic tourism. Appropriate ethnic tourism can encourage economic and cultural growth and facilitate heritage preservation (Yang and Wall, 2009). Chapter 2 mentions how ethnic tourism has brought extra income into the household's livelihood. However, tourism development is not suitable for all Dong villages since the market is limited (Sharpley, 2002). Chapter 2 mentioned that Gaoyou village created a Leek Festival to attract tourists. The festival attracted tourists in the first several years but lost its attractiveness due to lack of innovation in the following years according to the local administor. In chapter 4, the excessive road construction to promote tourism in Gaoyou village was mentioned, and in chapter 2, some farmland planted with lotus to attract tourists was mentioned. A similar phenomenon of land exploitation is also observed in other ethnic minority villages when developing tourism in China (Wang and Yotsumoto, 2019).

5.3 Suggestions for sustainable development in ethnic minority villages

The collaboration between national minority people, the government, the industry, ecological and natural disaster experts, and other stakeholders is needed for sustainable development in ethnic minority villages.

5.3.1 For public policy

It is suggested that conservation plans of traditional villages should consider not only conserving the houses but also the landscape, including the surrounding environment and related agricultural activities conducted by the local farmers that supported the landscape. During a visit to Sanjiang's most famous Dong village, Chengyang Village, where their Chengyang Fengyuqiao Bridge is listed as a UNESCO's World Heritage, it was observed that outsider business people took many economic opportunities from tourism development in this village instead of the local Dong farmers. Businessmen who do not belong to the Dong nationality were operating hostels and shops in traditional Dong houses rented from the local farmers or newly built houses in traditional styles that sell souvenirs which can be seen in other well-developed "old towns" in China. This phenomenon shows that the village is losing some of its cultural identity, and the local Dong people may not earn a fair income from their own village's development. The landscape of Gaoyou village has been carefully preserved. It is suggested that policymakers take Gaoyou village as a model for rural revitalization and pay more attention to the wellbeing of local farmers so that they can earn a fair income from tourism development and have a decent subsistence in the community.

The government's promotion of agricultural products is very important in rural residents' land resources management regimes, as evidenced by farmers changing their land use quickly in reaction to government subsidies. Since there is an economic lag in agriculture, the government should make long-term plans to promote agricultural products. Agricultural insurance should be accomplished to diminish fragile farmers' risk of changing NRM regimes and land-use systems. Instead of promoting common economic crops, it is suggested that the government promote agricultural products with more distinguished characteristics of the Dong people. Local governors revealed that most of the tea leaves harvested in Sanjiang are used as raw materials for some big branded tea companies in eastern China, resulting in the local farmers earning a small percent of the income in this industry chain. If the Dong people can develop their own big brand for tea, there will be more economic opportunities and incentives for the outflow population of Dong people to come back. One suggestion to develop a characteristic agricultural brand is to revitalize traditional resource management applying TEK.

The Sanjiang government selected tea, camellia, and bamboo for promotion because they are traditional Dong plantations. However, when promoting the plantations, how Dong farmers used to manage these plantations traditionally was neglected. Chemical fertilizer and pesticide were applied in the production processes. If the Dong farmers can use traditional natural resource management regimes to manage the new plantations, it will not only conserve the TEK of the Dong people, revitalize the land resources that are connected to it, is more environmentally friendly, but also add more economic values to the products. A good example is that organic sweet potatoes in Gaoyou that used manure fertilizer are more expensive than those used chemical fertilizer. For example, results from chapter 3 show that the Dong people used tree branches and leaves as fertilizer in the farmland in the old days. If this fertilizer is revitalized and replaces the chemical fertilizer in the new tea plantations and camellia plantations, it will help preserve the TEK of making full use of local resources and bringing more human intervention in the forest so that the biodiversity related to the satoyama landscape is preserved, and the method itself is sustainable. The agricultural products produced in this way may have a higher economic value. Faced with the depopulation situation of Dong villages today, technological innovations are needed so that the relatively weak laborers in the villages can adopt traditional management regimes. For example, the local government is promoting human feces fertilizer in Liuzhou City nowadays. Since there are not enough laborers in the villages to carry the feces fertilizer into the farmland as they did in the old days, the local government is developing a technique that can centralize processing the feces fertilizer and transport it directly to the farmland through pipes. It is also worth mentioning that when developing rural revitalization plans, it is very normal that the village invites outsider companies into the villages to develop the agricultural products. For example, the village leader of Gaoyou mentioned that they have a public forest of nearly 20 hectares, and they were planning to rent it to an outside company for planting tea. This may detach local farmers from their land. Therefore, it is suggested that the local government help establish agricultural cooperatives in the Dong villages and guide them to manage their land so that farmers can earn a fair income from the development of their villages. When implementing the rural revival policy and marketing land resources in a rural area, policy and law should protect farmers' profits and wellbeing and preserve the long-term relationship between farmers and their land. The failure of the bamboo industry advocates that the development of agricultural products should be accompanied with a complete supply chain, an accessible market, and good transportation conditions.

Results from chapter 2 reveal that before managing the farmland to fulfill their own needs, the community managed the farmland taking orders from the government before the 1980s. At that time, they must plant double-cropping non-glutinous rice, resulting in them being busy with rice cultivation most of the year, and leaving them no time to conduct traditional activities like making traditional Dong costumes and enjoying traditional Dong cuisines. After the 1980s, when farmers could manage their farmland personally, they gradually abandoned double-cropping non-glutinous rice. Now they have more time to conduct other agricultural activities and work in the cities. Therefore, it is suggested that the government consider the local farmers' needs when making agricultural policy.

Roads are becoming longer, wider, and changing path, resulting in fragmentation in Gaoyou, as is mentioned in chapter 4. The new roads are not well-maintained because there is a lack of integrated road planning and funds for road maintenance. Natural disasters may be increased as a result of the new road construction. It is suggested that when making developing plans for the communities, various administrations need to work together with ecological and natural disaster experts.

Chapter 4 also points out that rapid land use change needs monitoring. The results show that the data derived from satellite and drone imageries differed from official data. Under the context of non-agriculture and non-grain farming in rural China, more accurate land monitoring with remote sensing techniques is urgent for feasible rural development plans.

5.3.2 For future research

This research reveals that cultural identity plays an important role in maintaining TEK. Therefore, more site-specific research on the TEK manifested by indigenous NRM regimes and land-use systems and their changes are needed to fully understand the current status of the Dong people's TEK, what has been changed, why it was changed, and to find solutions on preventing it from diminishing and implications of the TEK so it can continue to benefit the future generations. There are 22 Dong villages that are on the Tentative list of World Heritage Sites, but few of them ever received research interests, and political and socioeconomic factors are also bringing changes into these villages. Therefore, case studies in these Dong villages are highly recommended. Results from chapter 3 indicate that the topographic conditions of Sanjiang constrained its development; therefore, many traditional Dong villages are preserved in the remote mountainous areas. Nowadays, due to a series of poverty alleviation policies, some Dong farmers were relocated to the road, like Liangli village in chapter 2, and some farmers built new villages where it is easier to be accessed, like Kuangli in chapter 3. These Dong farmers usually have two or more houses, where one is a traditional Dong house in the old village, and others are in western brick-style in the new village. In chapter 2, the "one residential base for one household" policy in rural China was mentioned, and local governors predict that the old village with traditional wooden houses in Kuangli will be disappeared. In this case, other old villages where many traditional Dong houses are preserved may soon be disappeared. Therefore, site-specific analysis in these traditional villages is urgent for conserving the TEK.

There are two ways of relocation for poverty alleviation purpose. One is to build a new village and move the farmers from the old village into the new village, as Liangli in chapter 2, and the other is to move the poor farmers from their villages to the towns. Although interviewees from chapter 2 reported few changes in their agricultural activities, it is very likely that the farmers relocated to the towns will experience a huge change in their agricultural activities, since their old village is usually distant from the town, which makes it difficult for them to conduct everyday farming jobs in their farmland which is usually located near to their old villages. Research on the current relationship between the relocated farmers and their farmland and forest, how it has changed, and how to secure the farmers' agricultural activities in their old village so that there won't be farmland abandonment is also needed.

The environmental assessment was not conducted in this research. Tea plantations in this area tend to become a monoculture, which needs further assessment. Future research in this area should be conducted for assessing the environment in terms of biodiversity change and other ecosystem services.

5.3.3 For changes in educational practices

Since this research identified that cultural identity is very important in conserving TEK, and previous research shows that there is a loss in cultural identity in the young generation of ethnic minority children born in the cities (Geary and Pan, 2003), protection of their cultural identity plays is critical and urgent. Workshops and education programs between researchers

and local minority people should be taken so that their needs can be heard, and the importance of conserving their traditional natural resource management regimes and landscape can be shared with them.

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Chapter 6 Conclusions

This research analyzed the changes of indigenous NRU regimes and land-use changes in a Dong ethnic minority region, identified some driving factors of the changes, and identified their TEK manifested by their NRU regimes and land uses.

In chapter 2, three Dong villages in Sanjiang Dong Autonomous County were selected to analyze the agricultural calendars of the Dong people in different place. The results show that the present agricultural calendar of the Dong people is the fusion of tradition with modernity and the merge of various national cultures. Policy and market have promoting effects in agricultural activities change, and the unchanged agricultural activities are connected with the Dong cultural identity. In chapter 3, the changes of indigenous natural resource utilization regimes in Gaoyou village during before 1949 and present days are identified. The results show that traditional NRU changes with lifestyle changes of the Dong people, Gaoyou preserves its landscape well, the NRU regime is much simpler now with relatively weak laborers operating it, but the land is still used intensively. GIS analysis of drone and satellite imageries in Gaoyou village in chapter 4 demonstrates that the village is experiencing fast land-use changes. The Dong cultural identity is linked to unaltered land usage. Gaoyou's land resource is effectively utilized. Land-use change can be explained by environmental and anthropogenic variables. Political factors and market change also affect land-use change.

There are some deficiencies in this research. The period of chapter 3 is different from that of chapter 4 due to limitation in available satellite imageries in this region. The resolution of satellite imageries is not good enough to distinguish paddy fields from dry fields. Therefore, in the research of land-use change in chapter 4, it was assumed that the paddy field stays unchanged, referring to the cultivated land "Red Line" policy in China. However, the results in chapter 4 show that the land use in the official data is different from what was observed from field observation and GIS analysis. Farmland that was already changed from paddy field to dry field is still counted as paddy field in the official data. This phenomenon indicates that some paddy fields in this research area may have been changed into dry fields and is not reported in this research. And this research may neglect some increase in fir plantation since small fir saplings were identified as mixed forest in chapter 4. Another limitation is that there are various environmental factors related to land-use changes. Chapter 4 only selected the natural and proxy variables due to the lack of socioeconomic data at the village level. This research only studied the natural resource utilization regime of the Dong people, but their natural resources conservation regime is also important.

As for the implications, this research can be used as a guideline for studying, conserving, and using the traditional ecological knowledge of the ethnic minority people for future research. For practitioners, the research results can be used as a model for making regional and global sustainable resource management plans in tackling environmental problems.

I hope this research can shed light on future research on ethnic minority people's natural resource management regimes and land-use changes at the village level from a landscape perspective.

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