Land Use Policy 103 (2021) 105329

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Agricultural production under rural tourism on the Qinghai-Tibet Plateau: From the perspective of smallholder farmers

Yang Lun [a], Sun Jing [b], Liu Moucheng [a], Min Qingwen [a,c,*]

[a] Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China
[b] Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China
[c] University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Keywords:
Sustainable development
Land use
Livelihoods
Agricultural productivity
Trade-off

ABSTRACT

Rural tourism has been the leading alternative livelihood of farmers on the Qinghai-Tibet Plateau in recent years. However, the trade-off between agricultural production and rural tourism has been gradually serious. Therefore, we selected the Zhagana Village, an example of rural tourism on the Qinghai-Tibet Plateau, to discuss the agricultural production under rural tourism from smallholder farmers' perspective, and analyze its existence severity of the trade-off. Based on the comparative analysis of smallholder farmers' agricultural production behavior (including the production scale, agricultural input, agricultural output, and production efficiency), we reviewed the agricultural production in the whole study region in 2005–2019. The results show a certain degree of trade-off between agricultural production and rural tourism on the Qinghai-Tibet Plateau. At the level of smallholder farmers, under the background of rural tourism development, agricultural production efficiency (mainly the production efficiency of grassland) has significantly increased due to the further expansion of the scale of livestock husbandry by smallholder farmers. At the regional level, with the development of rural tourism, the regional production structure has gradually changed from the integrated management of farming, forestry, and animal husbandry into the mode of taking animal husbandry as a dominant industry, farming and forestry as supplementary industries, but the regional agricultural productivity has not been stagnated or weakened.

1. Introduction

In the past 70 years, the population on the Qinghai-Tibet Plateau has increased by nearly four times, with the overall permanent population reaching 12.40 million, 52.02% of which is mainly engaged in agricultural production (Qi et al., 2020). Human livelihoods, especially smallholder farmers, have gradually become an essential factor affecting regional sustainable development (Kemp et al., 2013; Chen et al., 2015). However, smallholder farmers' livelihoods evolve dynamically with alterations in the external environment, resulting in their high subjection to dynamic changes. Such dynamic changes in smallholder farmers' livelihoods become even more apparent in ecologically fragile alpine regions that witness significant changes in their natural and social environments (Du et al., 2004; Harris, 2010; Yu et al., 2017; Georg et al., 2020). Since 1980, traditional agricultural production experiences an adverse impact in response to the annually increased temperature of 0.04 °C and precipitation of 0.67 mm on average (Duan and Xiao, 2015; Kelly et al., 2018; Liu et al., 2018; Yang et al., 2019a). By contrast, the tertiary industry boasts a rapid development and the implementation of policies regarding urbanization and targeted poverty alleviation (Yang et al., 2018; Zhang et al., 2019; Rongna and Sun, 2020). Consequently, rural tourism has gradually developed into the main alternative livelihood for smallholder farmers on the Qinghai-Tibet Plateau in addition to agricultural production (Duan et al., 2019).

However, in the wake of shifting from the agricultural production-based livelihoods to the alternative livelihoods represented by rural tourism, trade-off between agricultural production and rural tourism gradually becomes the concern of smallholder farmers, thus attracting more attention to the development of the former in the context of the latter (Fleischer and Tchetchik, 2005; Shen et al., 2019; Randelli and Martellozzo, 2019; Su et al., 2019; Mousa and Karwan, 2020). On the one hand, when smallholder farmers shift from the agricultural production-based livelihood strategy to a combined livelihood strategy with rural tourism, it includes the contention for the quantity and quality of labor force, capital investment, and other resources between agricultural and non-agricultural production activities. Therefore, as the

* Corresponding author at: Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China.
E-mail addresses: yanglun@igsnrr.ac.cn (Y. Lun), sunjing@caas.cn (S. Jing), liumc@igsnrr.ac.cn (L. Moucheng), minqw@igsnrr.ac.cn (M. Qingwen).

https://doi.org/10.1016/j.landusepol.2021.105329
Received 29 June 2020; Received in revised form 13 January 2021; Accepted 30 January 2021
Available online 15 February 2021
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more profitable and less time-consuming planting methods popularize among farmers concerning how cultivated land is used (Taboada et al., 2017; Jendoubi et al., 2020; Ichinose et al., 2020; Hoang et al., 2020), the usage of pesticides and other agricultural chemicals doubles (Adhikari et al., 2004; Shackleton et al., 2007; Xi et al., 2014). Simultaneously, in front of the public emerge such issues as stagnant grain production, land circulation, property rights adjustment, and soil nutrient enrichment (Xi et al., 2015; Hua et al., 2017; Wayessa, 2020). On the other hand, when smallholder farmers thoroughly shift from the agricultural production-based livelihood strategy to the alternative livelihood strategies represented by rural tourism, the competition between agricultural and non-agricultural production activities is aggravated and leads to further farmland abandonment (Zhang and Zhao, 2015). Meanwhile, because of the occurring non-agriculturalization of farmers' livelihoods, poverty can be alleviated and land utilization behaviors—including deforestation for farmland—reduced, thus mitigating the damage to the ground coverage and promoting the restoration of mountain vegetation (Wang and Yang, 2012; Hoefle, 2016; Shao et al., 2018).

Generally, current research on agricultural production under rural tourism has not been analyzed holistically from smallholder farmers' perspective. First, most studies describing the rural tourism development process are based on historical data or field surveys to comparatively analyze the development status between two or more periods. Few studies have investigated this problem on a long-term basis in designated areas. Second, focusing on quantitative analysis from certain aspects such as input and output to estimate agricultural production, such aspects as its yield, structure, and efficiency have not been comprehensively discussed. Finally, the essence of the trade-off between agricultural production and rural tourism concerns the opportunity costs caused by the transformation of farmers' livelihoods. In this regard, few studies have explored from the perspective of smallholder farmers' livelihoods, ignoring how the production behaviors of smallholder farmers influence regional agricultural production. Therefore, it is necessary to investigate the changes in agricultural production under the rural tourism on the Qinghai-Tibet Plateau, explore whether there is a trade-off between agricultural production and rural tourism and its severity, and put forward sustainable development suggestions from smallholder farmers' perspective.

2. Methodology

2.1. Analytical framework

For the framework of our study, rural tourism development was first taken as an external impact factor affecting the livelihoods of smallholder farmers. In contrast, the changing process of farmer types was used as evidence to describe rural tourism development. Second, a comparative analysis was conducted regarding yield, structure, and efficiency of agricultural production between different farmer types throughout our research cycle to reflect the changes in agricultural production behaviors of smallholder farmers in the rural tourism development process. Finally, the rural development process was linked with the changes in agricultural production behaviors of smallholder farmers, thus fully revealing how agricultural production evolved in the context of rural tourism development.

2.2. Study area

The example area in our study was set in Zhagana Village, Yiwa Town, Diebu County, Gansu Province, China (Fig. 1). Geographically located at 34°09'40" ~34°10'80" N, 103°08'49" ~103°10'15" E and including four subordinate natural villages (Dongwa, Yeri, Dari, and Daiba).

Firstly, this region is one boasting a long history of agricultural production and a high level of development on the Qinghai-Tibet Plateau. The coordinated development of farming, forestry, and animal husbandry covers all basic types of agricultural production on the

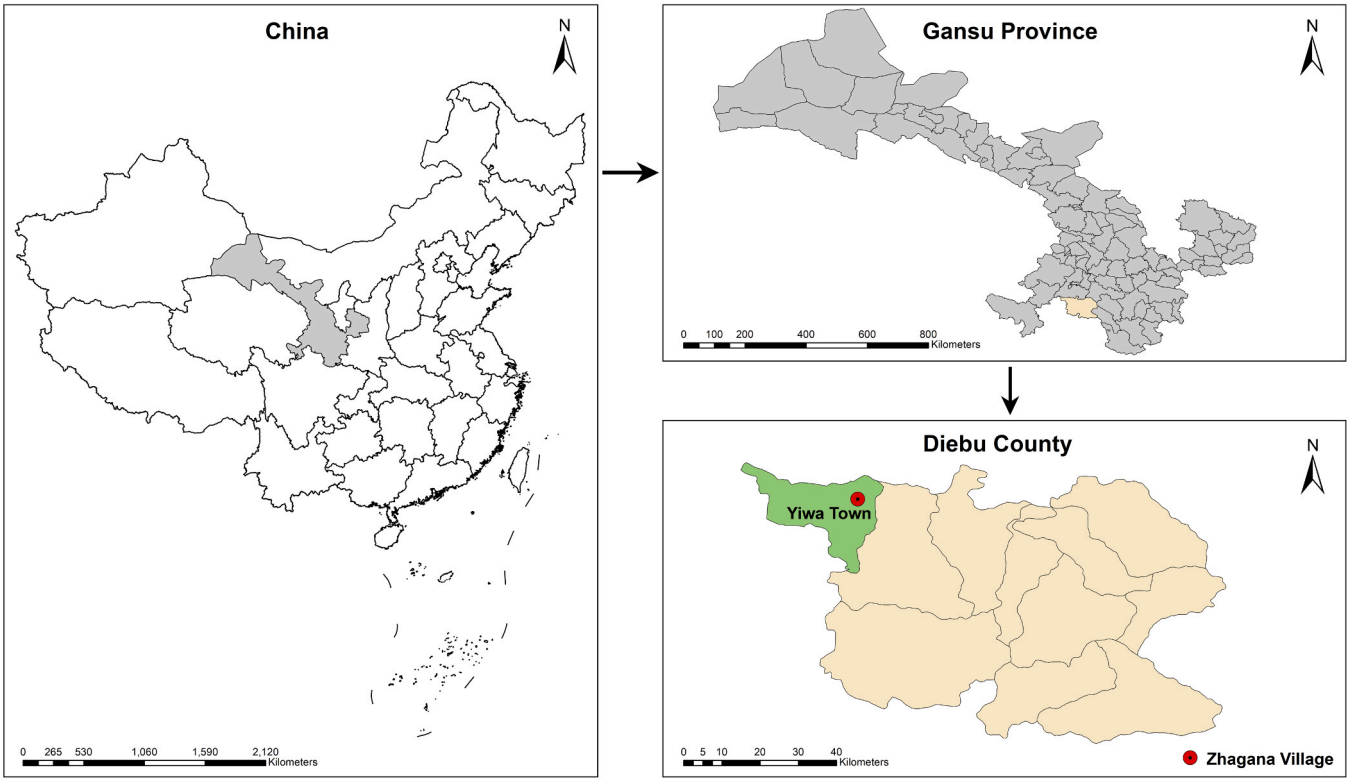

Fig. 1. The location of the study area.

Table 1
The number of samples.

Village name	Total number of households	First stage survey		Second stage survey	
		Sample number	Sample proportion	Sample number	Sample proportion
Dongwa	100	73	73.00%	32	32.00%
Yeri	48	28	58.33%	11	22.92%
Dari	26	20	76.92%	12	46.15%
Daiba	38	33	86.84%	22	57.89%
SUM	212	154	72.64%	77	36.32%

Qinghai-Tibet Plateau (Yang et al., 2019b). Secondly, Zhagana Village has become a hot spot and key area for rural tourism development on the Qinghai-Tibet Plateau. Thirdly, a large number of agriculture-oriented farmers, namely, those that take agricultural production as their main livelihood, live in the region, as well as a large group of part-time and tourism-oriented farmers who are involved in rural tourism development in different ways. They all contribute to the sound conditions required for studying rural tourism and agricultural production from the perspective of farmers' livelihoods.

2.3. Data sources

We visited Zhagana Village four times for field investigations from 2017 to 2019, accumulatively for about 4 months. The investigations involved all Zhagana Village farmers and were divided into two stages. The first stage spanned the period from April to May 2017 and was designated for the full sample survey, involving all headed farmers of 212 rural households in Zhagana Village. After excluding the samples with obvious errors and incomplete information, 154 effective headed farmers were surveyed and accounted for 72.64% of the total samples. The second stage was the follow-up survey, where the samples were screened using a stratified random sampling method. According to the first stage survey, farmers are divided into three categories (see Section 2.4.1 for details). We randomly selected 50% samples of three types of farmers for a follow-up survey (Table 1). The second stage survey comprised three rounds conducted from August to September 2017, October to November 2018, and October to November 2019, respectively.

2.4. Methods

2.4.1. Classification of farmer types

We used the decision-making tree analysis method to classify smallholder farmers' types (Darnhofer et al., 2005) and obtain the point in time when the type of farmers is changing. Whether to participate in rural tourism development and whether to invest in a family hotel are decisive indicators for dividing the type of farmers (Fig. 2). We define the agricultural-oriented farmer (F1) as the farmer who is not involved in rural tourism and investment in the family hotel. The farmer who participates in rural tourism development has not yet invested in a family hotel as a part-time farmer (F2). Tourism-oriented farmer (F3) is defined as the farmer who participates in the development of rural tourism and invests in a family hotel. Besides, we clarify three essential conditions for a family hotel: (i) there are at least five independent rooms for visitors to stay in; (ii) the rooms can provide essential services; (iii) farmers have exact pricing for those rooms.

2.4.2. Description of farmers' livelihoods transformation

Decision-making tree analysis was employed to mark farmers' time nodes to choose F1, F2, and F3, thus describing the general process of farmers' livelihood transformation before 2016. On this basis, the livelihood diversification index and non-agriculturalization index were used to reflect the subtle change trends of different farmer types from 2016 to 2019. Of them, the livelihood diversification index was adopted to reflect the part-time livelihood engagement degree of farmers (Solomon et al., 2019). This index was calculated via the Simpson Diversity Index (Simpson, 1949). Please see the details below:

$$D = 1 - \sum_{i=1}^{N} P_i^2$$

D represented livelihood diversification index, N represented the type of income source, and P_i represented the ratio of the i^{th} income source to the total family income, with its value ranging between 0 and 1. When D equaled 0, it suggested no diversification of livelihoods; otherwise, it implied a gradually increasing diversification of farmers' livelihoods as D value increased.

The livelihood non-agriculturalization index was used to reflect the involvement extent of farmers in non-agricultural employment (Zhao, 2013). This index was expressed as the ratio of non-agricultural income to the total family income. Please see the details below:

$$NA = Y_{NA}/Y$$

Y_{NA} represented the income of farmers engaged in non-agricultural activities and referred to the total income of farmers engaged in tourism reception and non-agricultural work in our study; Y represented the total family income of farmers. When NA equaled 0, it suggested no livelihood non-agriculturalization; otherwise, it implied a gradually increasing non-agriculturalization degree of farmers' livelihoods as NA value increased.

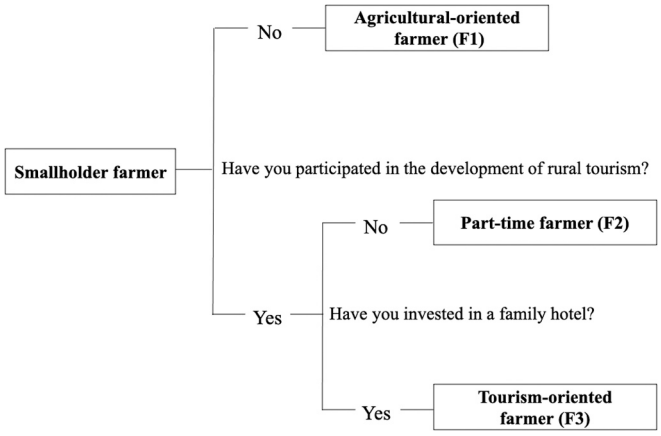

Fig. 2. Decision-making tree diagram of farmers.

2.4.3. Behavioral analysis of smallholder farmers' production

The behavioral analysis of farmers' production addressed a series of land-associated production activities, which was the core production factor (Dale and Polasky, 2007), including production scale, agricultural input, agricultural output, and production efficiency. This analysis method was carried out mainly based on the input and output. Of them, production scale reflected the 'yield' of agricultural production of these farmers (Huang et al., 2006); agricultural input and output reflected the 'structure' of their agricultural production (Van Ittersum and Rabbinge, 1997; Suh, 2004; Salvo et al., 2015) and production efficiency reflected the 'outcomes' of agricultural production based on the consideration of its 'yield' and 'structure' (Barrios, 2007; Looga et al., 2018).

Table 2
The analysis indexes of agricultural production behavior of farmers.

Index type	Index number	Index name	Index definitions
Production scale	L1	Area of farmland	The area of farmland is operated or utilized by farmers.
	L2	Number of livestock on woodland	The number of livestock farmed by farmers on woodland.
	L3	Number of livestock on grassland	The number of livestock farmed by farmers on grassland.
Agricultural input	L4	Material input on farmland	The amount of seeds, fertilizers, and pesticides put into farmland.
	L5	Labor input on farmland	The human force and animal force input by farmers to farmland.
	L6	Material input on woodland	The actual amount of feeds that farmers put into woodland.
	L7	Labor input on woodland	The human force and animal force input by farmers to woodland.
	L8	Material input on grassland	The actual amount of feeds that farmers put into grassland.
	L9	Labor input on grassland	The human force and animal force input by farmers to grassland.
Agricultural output	L10	Food products from farmland	The number of products that farmers can obtain as food from farmland.
	L11	Energy products from farmland	The number of products that farmers can obtain as energy from farmland.
	L12	Food products from woodland	The number of products that farmers can obtain as food from woodland.
	L13	Energy products from woodland	The number of products that farmers can obtain as energy from woodland.
	L14	Food products from grassland	The number of products that farmers can obtain as food from grassland.
	L15	Energy products from grassland	The number of products that farmers can obtain as energy from grassland.
Production efficiency	L16	Material input efficiency of farmland	The ratio of farmer's total output of farmland to total material input.
	L17	Labor productivity of farmland	The ratio of farmer's total output of farmland to total labor input.
	L18	Material input efficiency of woodland	The ratio of farmer's total output of woodland to total material input.
	L19	Labor productivity of woodland	The ratio of farmer's total output of woodland to total labor input.
	L20	Material input efficiency of grassland	The ratio of farmer's total output of grassland to total material input.
	L21	Labor productivity of grassland	The ratio of farmer's total output of grassland to total labor input.

(1) Production scale. Because the woodland and grassland are collectively owned, smallholder farmers are not allowed privatized management but their public use. Therefore, the production scale was characterized by such indicators as the area of farmland operated by farmers and the number of their livestock cultivated on the woodland and grassland (Table 2).
(2) Agricultural input. Agricultural input was characterized by such indicators as the actual amount of material input (including seeds, fertilizers, and pesticides) and labor input (including human force and animal force) by farmers on the farmland, woodland, and grassland that were currently operated or used to reflect their material and labor inputs to agricultural production (Table 2).
(3) Agricultural output. Agricultural output was characterized by the output of food products, and energy products yielded on the farmland, woodland, and grassland farmers currently operated or utilized to reflect their material output gained via agricultural production (Table 2).
(4) Production efficiency. Based on the production scale, agricultural input, and agricultural output, production efficiency was characterized by material input efficiency and labor productivity calculated from farmers' agricultural production activities on the farmland, woodland, and grassland to reflect their efficiency of agriculture production involvement (Table 2).

2.4.4. Regional agricultural production estimation method

In terms of the smallholder farmers' agricultural production behavior data before 2016, we used the retrospective interviews conducted in field investigations to obtain the production scale and agricultural output data. However, historical data on agricultural input is difficult to obtain. We carried out data estimation through a Univariate Time Series Model based on the data from 2016 to 2019 (Chen, 2014). Please see the details below:

The data for one of the agricultural input indicators in the research cycle $\{y_1, y_2, \ldots, y_T\}$ were submitted for the first-order autoregressive process:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \varepsilon_t \ (t = 2, \ldots, T)$$

Error term ε_t represented white noise, meeting the conditions of zero expectation, homoscedasticity, and no autocorrelation.

Based on the agricultural production behavior data of three farmer types, these data were considered by reference to changes in the quantitative structure of three farmer types to calculate and determine how the agricultural production evolved in Zhagana Village during the general process of farmers' livelihood transformation.

3. Results

3.1. Development process of rural tourism

From 2005 to 2019, rural tourism in Zhagana Village was no longer non-agricultural production involving few farmers and serving as income supplement; instead, it grew to become a vital pillar industry for the local economy and covered 3/4 of farmers who followed this trend in different ways (Fig. 3). According to the classification of farmer types, rural tourism development in this region can be divided into the three following main stages:

(1) The beginning stage of rural tourism. Zhagana Village initiated its rural tourism development in 2005 when some local farmers actively participated in rural tourism development in addition to

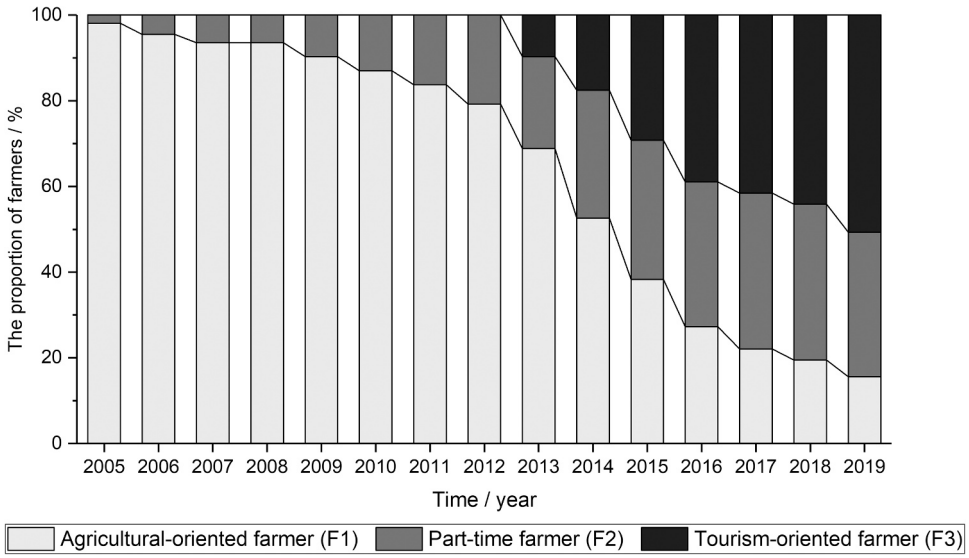

Fig. 3. Changes in the proportion of the three types of farmers in the study area from 2005 to 2019.

agricultural production (F2). Previously, the farmers provided services in a passive and freeway when tourists visited their village. On average, the number of farmers involved in rural tourism development from 2005 to 2012 increased by 44.65% annually. However, the farmer type was dominated by the traditional F1, accounting for 79.22% of farmers.

(2) The developing stage of rural tourism. In 2013, local farmers' large-scale investments in family hotels (F3) marked that rural tourism had gradually become a normalized and industrialized channel for economic growth in this area. On average, the number of farmers involved in rural tourism development from 2013 to 2015 increased by 41.11% annually, with the main contribution from F2 and F3, each accounting for 32.47% and 29.22% of the total farmers, respectively.

(3) The stable stage of rural tourism. From 2016 to 2019, the number of farmers involved in rural tourism development was relatively stable, with an increasing rate of merely 5.10% annually, on average, indicating that the local rural tourism development was gradually stabilized. F2 and F3 each accounted for 33.77% and 50.65% of the total number, respectively. Meanwhile, a decreasing trend, albeit slight, was observed in the number of F2.

However, significant changes were reported between 2016 and 2019 concerning the part-time livelihood engagement and non-agriculturalization degree of different farmer types. The average value of farmers' livelihood diversification index was 0.31–0.36 and followed a decreasing trend chronologically, while the livelihood non-agriculturalization index was 0.61–0.75 and followed an increasing trend chronologically. This suggested a weakened part-time livelihood engagement and enhanced non-agriculturalization among Zhagana Village farmers. Of these three farmer types, the livelihood diversification index of F1 was increased yearly. The livelihood non-agriculturalization index remained stable at 0, demonstrating that F1—although the agricultural-oriented livelihood strategy—showed a preference for part-time livelihood engagement; F2 type was characterized by a gradually decreased livelihood diversification index and an increased livelihood non-agriculturalization index. F3 type followed a decreasing trend with inevitable fluctuations while its livelihood non-agriculturalization index was enhanced yearly, indicating that F2 and F3 adopted the part-time livelihood and tourism-oriented livelihood strategies, respectively, exhibiting a development trend of weakened part-time livelihood engagement and enhanced non-agriculturalization. Of them, F3 had the lowest part-time livelihood engagement and highest non-agriculturalization degree.

3.2. *Agricultural production behavior of farmers*

The results gained by analyzing agricultural production based on land use showed that integrated management of farming, forestry, and animal husbandry was the basic feature of agricultural production in Zhagana Village. Of them, the grassland mainly contributed to agricultural input and output, while the farmland and woodland were used to supply food and energy products, respectively. Nevertheless, the production efficiency of them all appeared generally low. In the context of regional rural tourism development, Zhagana Village farmers further expanded the scale of animal husbandry while reducing the scale of farming and forestry; more material and labor resources were invested in the grassland to serve the overall goal of producing more energy products rather than food products. Meanwhile, the agricultural production efficiency (especially the grassland production efficiency) increased significantly (Appendix A).

In terms of an agricultural-oriented farmer, the agricultural production of F1 mainly depended on farming and forestry, supplemented by animal husbandry. Specifically, agricultural input and output were concentrated on the farmland and woodland, but the labor productivity was generally low. Nevertheless, the management scale, agricultural input, and output of the grassland increased from 2016 to 2019. This suggested that in the context of developing regional rural tourism, F1 stopped using farmland and woodland as the only livelihood options but began utilizing the development path of the integrated management of farming, forestry, and animal husbandry to enhance the output of food and energy products as well as improve agricultural production efficiency (Appendix A).

In terms of a part-time farmer, the agricultural production of F2 was characterized by relatively balanced development between farming, forestry, and animal husbandry; it reported the highest output of food products and the largest material input with the lowest efficiency. The material input gradually decreased from 2016 to 2019; apart from the grassland's labor input, that of the other two land types and the yield of energy products continuously increased. This indicated that, in the context of developing regional rural tourism, F2 no longer over-relied on material input for production but increased the labor input, which was further assigned to farming and forestry. Based on maintaining the integrated management of farming, forestry, and animal husbandry, the output of energy products and agricultural production efficiency were elevated (Appendix A).

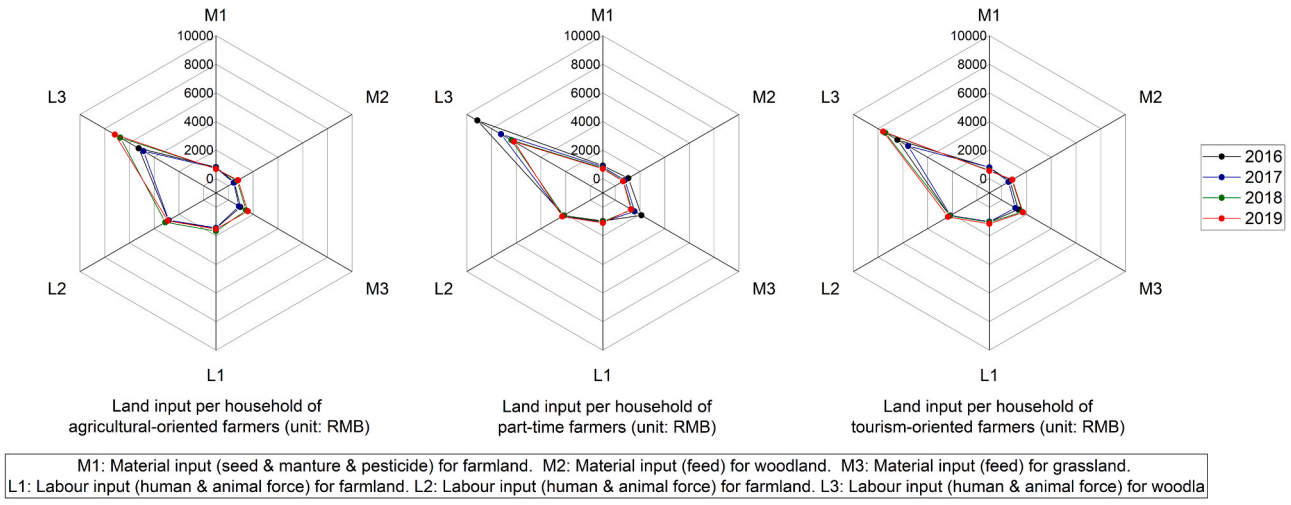

Fig. 4. Agricultural input per household of three types of farmers from 2016 to 2019.

In terms of a tourism-oriented farmer, the agricultural production of F3 mainly depended on animal husbandry and was supplemented by farming and forestry. Both the agricultural input and output were relatively low, but its agricultural production efficiency was high. From 2016 to 2019, a continuous increase was observed in the labor input, material input (except that to the farmland), and the yield of energy products. This suggested that, in the context of developing regional rural tourism, F3 type gradually paid more attention increasingly to agricultural production to obtain more energy products (Appendix A).

3.2.1. Production scale

Regarding production scale, the average farmland area managed by smallholder farmers was 0.42 ha, the average number of *Juema* pigs raised on the woodland was 3 heads, and the number of yak, dzo, and sheep increased on the grassland was 6, 17, and 2 heads, respectively. From 2016 to 2019, apart from the area of farmland and the number of sheep reared on the grassland, all indicators followed an increasing trend.

Among the three types of farmers, F1 was featured with the largest management area of farmland and the highest number of woodland livestock. The number of grassland livestock appeared to be the lowest. From 2016 to 2019, all other indicators aside from the management area of farmland of F1 showed an increasing trend. The number of grassland livestock of F2 appeared the highest and showed an increasing trend. The farmland management scale and the number of woodland livestock of F3 were the lowest and following a decreasing trend (Appendix A).

3.2.2. Agricultural input

Regarding agricultural input, the annual material input by smallholder farmers was 2848.73 RMB and followed a decreasing trend; the total yearly labor input was 10,320.51 RMB and exhibited an increasing trend. Of them, the material input (seeds, fertilizers, and pesticides) and labor force level assigned to farmland were generally the lowest, but the human force input increased; the material input (feed) and labor input level set to the cultivated grassland were the highest and showed an increasing trend (Fig. 4).

Among the three types of farmers, the total material input of F1 was the lowest but followed an increasing trend from 2016 to 2019. Both the material and labor inputs of F2 were the highest. Both indicators followed a decreasing trend. The labor input of F3 appeared the lowest but followed an increasing trend (Fig. 4 and Appendix A).

3.2.3. Agricultural output

Regarding agricultural output, the average annual output of food products yielded by farmers was 3077.89 kg and showed a decreasing trend; the average annual output of energy products was 57.08 kgce and demonstrated an increasing trend. Of them, the food products yield from the farmland immediately followed that of the grassland, with the product types including highland barley, oilseeds, potatoes, broad beans, oats, leafy vegetables, and medicinal materials; the yield of energy products ranked last, with crop straws as the main product type. The food products yield from the woodland was the lowest, with product types including fungi (mainly *Morchella*) and medicinal herbs (mainly *Potentilla anserina* and *Angelica sinensis*) naturally growing under the forest, as well as the *Juema* pigs farmed there; the energy products yield ranked first with the fuelwood-aimed dry branches and fallen leaves as the primary product type. The highest food product yield was reported on the grassland, with the product types including yak, dzo, and sheep raised by farmers; the energy product yield was second only to that on the woodland, with livestock manure as the main product type. From 2016 to 2019, the food product yields from farmland, woodland, and grassland significantly decreased, significantly increased, and fluctuated, respectively; the energy product yields on the farmland and grassland were elevated significantly, while the yield on the woodland experienced fluctuations (Fig. 5).

Among the three types of farmers, F1 was characterized by the lowest yield of food products and the highest yield of energy products, and both followed an increasing trend from 2016 to 2019. F2 was marked by the highest yield of food products and followed a rising trend. F3 was represented by the lowest energy product yield but followed a growing trend (Fig. 5 and Appendix A).

3.2.4. Production efficiency

Regarding production efficiency, both the average values of material input efficiency and labor productivity showed an increasing trend, reaching 12.25 and 3.38, respectively. Namely, based on the current labor or material level, every 1 unit of material or labor input by farmers would yield 12.25 or 3.38 units of agricultural products. Of them, the highest material input efficiency and labor productivity were observed on the grassland, and both demonstrated an increasing trend, while those on the woodland were the lowest, showing a decreasing trend (Appendix A).

Among the three types of farmers, the labor productivity of F1 appeared the lowest but showed an increasing trend from 2016 to 2019. The material input efficiency of F2 was the lowest and showed a decreasing trend. The material input efficiency and labor productivity of F3 appeared the highest, and both showed an increasing trend (Appendix A).

3.3. Regional agricultural production under rural tourism

The results of regional agricultural production estimates show that, in a long historical period, local farmers have gradually formed a relatively

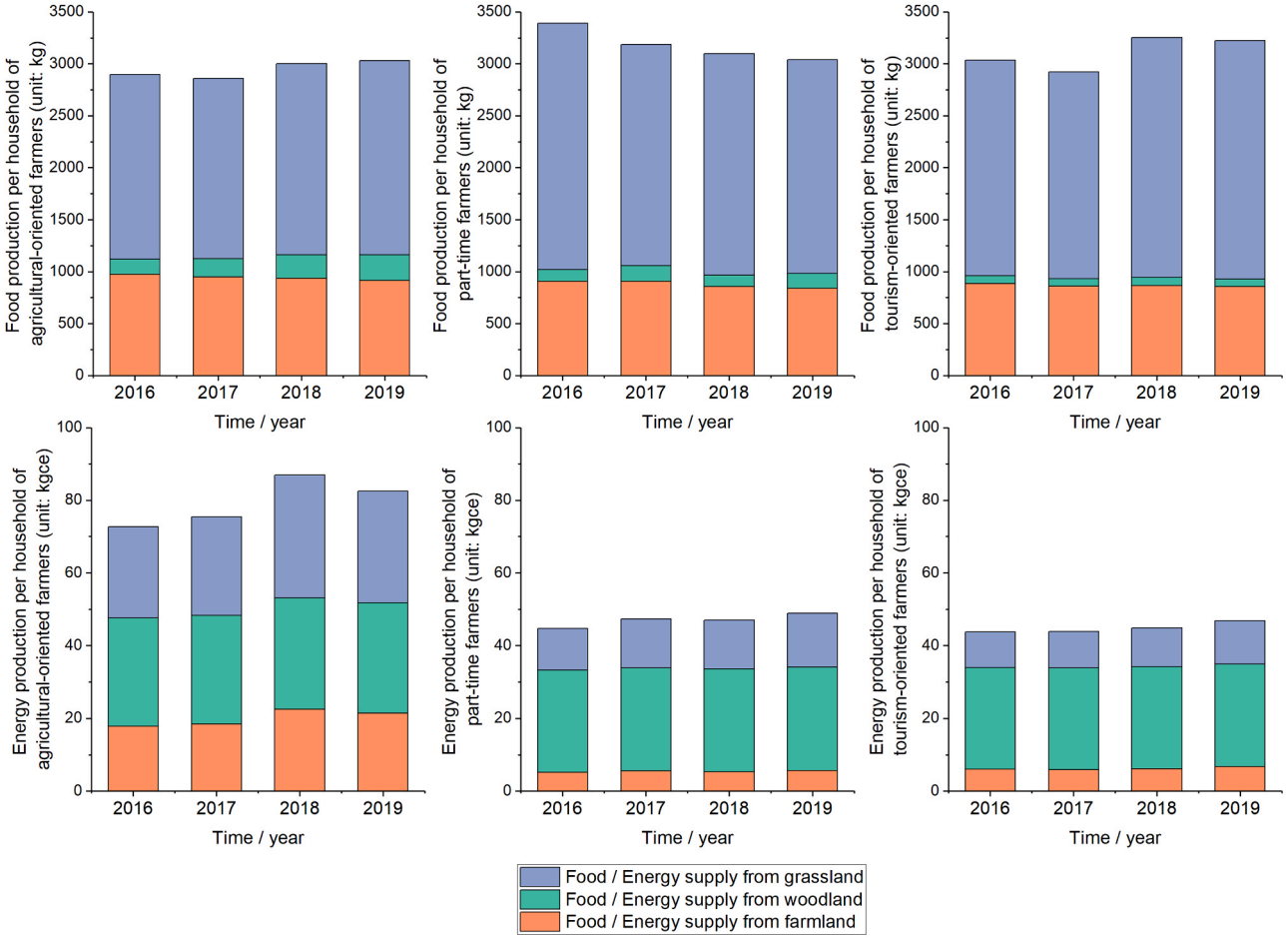

Fig. 5. Agricultural output per household of three types of farmers from 2016 to 2019.

stable agricultural production structure integrating farming, forestry, and animal husbandry by fully utilizing the limited farmland, woodland, and grassland resources in that relatively closed geographical environment to obtain necessary food and energies. Of them, animal husbandry and farming served as the primary food sources for farmers by supplying meat, milk, flour, and vegetables to farmers. At the same time, forestry functioned as their primary energy source by providing fuelwood.

However, in the context of regional rural tourism development, the agricultural production structure experienced significant changes. Namely, there was a certain degree of trade-off between agricultural production and rural tourism on the Qinghai-Tibet Plateau. In particular, the agricultural production structure was gradually transferred from the integrated management of farming, forestry, and animal husbandry to the animal husbandry-based structure, supplemented by farming and forestry. Specifically, the proportion of animal husbandry in agricultural production increased significantly, while the importance of farming and forestry declined. Nevertheless, the level of agricultural productivity in the entire region was not stalled or weakened, but, on the contrary, witnessed an increasing trend. Namely, the average annual output of food and energy products was enhanced in fluctuations (Fig. 6).

(1) The beginning stage of rural tourism. From 2005 to 2012, when rural tourism began to emerge and was accompanied by climbing regional agricultural productivity, the agricultural production structure did not change significantly. Of them, the output of regional food products increased by an average of 1.75% annually; on average, farming, forestry, and animal husbandry contributed 235,470.67 kg, 10,655.43 kg, and 337,511.33 kg, respectively, of food products annually. The output of regional energy products increased by an average of 1.84% annually; on average, farming, forestry, and animal husbandry contributed 1913.78 kgce, 5868.25 kgce and 2485.27 kgce, respectively, of energy products per year.

(2) The developing stage of rural tourism. With the rapid development of rural tourism from 2013 to 2015, the overall regional agricultural productivity followed a gentle upward trend. The integrated management of farming, forestry, and animal husbandry gradually shifted to the animal husbandry-based agricultural production structure. Of them, the output of regional food products decreased in 2013 but showed an increasing trend overall from 2013 to 2015, with an average growth rate of 1.45% annually; on average, farming, forestry, and animal husbandry contributed 207,024.03 kg, 17,881.60 kg, and 408,954.75 kg, respectively, of food products per year. The output of regional energy products increased in 2013 but followed an overall decreasing trend from 2013 to 2015, with an average reducing rate of 0.17% annually; on average, farming, forestry, and animal husbandry contributed 2166.22 kgce , 6052.81 kgce, respectively and 3233.79 kgce of energy products per year.

(3) The stable stage of rural tourism. With the continuously stabilized rural tourism development from 2016 to 2019, the regional agricultural productivity demonstrated a steady increasing trend, and the agricultural production structure continued its progress to the animal husbandry-based structure, supplemented by farming and forestry. Of them, the output of regional food products overall maintained an average growth rate of 0.75% annually, although it suffered a reduction in 2017 and 2019; on average, farming, forestry, and animal husbandry contributed

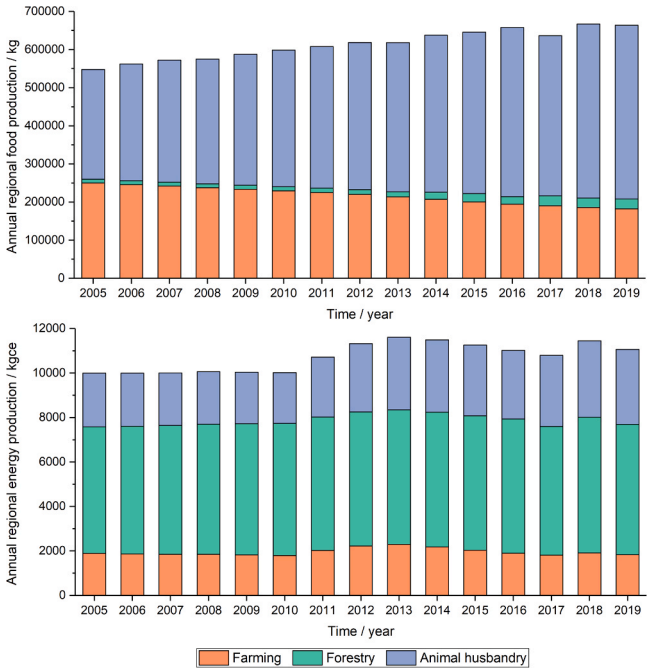

Fig. 6. Annual regional food and energy productions from 2005 to 2019.

188,065.72 kg, 24,065.73 kg, and 444,235.93 kg, respectively, of food products per year. The output of regional energy products decreased with an average reduction rate of 0.37% annually, although it increased in 2018; on average, farming, forestry, and animal husbandry contributed 1862.01 kgce, 5949.10 kgce, and 3267.71 kgce, respectively, of energy products per year.

4. Discussions

Our study's empirical results suggested that an increasing number of farmers are gradually involved in the development and construction of local rural tourism in different forms with the continuous prosperity of this industry in Zhagana Village. Under this background, the level of agricultural productivity in the entire region was not stalled or weakened, and the average annual outputs of food and energy products were enhanced in fluctuations. This is in line with the actual increase in agricultural production on the entire Qinghai-Tibet Plateau, especially the increase in animal husbandry (Li et al., 2020). As a credible explanation of this situation, both the development of regional rural tourism and the increase in part-time livelihood engagement and non-agriculturalization level allowed a continuous improvement in this region's tourist reception capacity. These mounting tourists stimulated the consumption volume of livestock products with local characteristics and, in turn, promoted the improvement in the agricultural production efficiency of animal husbandry and farmers engaged in tourist reception. Consequently, the level of agricultural productivity in the entire region was not stalled or weakened because of the rural tourism development but, on the contrary, maintained a relatively increasing trend.

However, further discussion is warranted to identify the sustainability of such a shift in regional agricultural production. On the one hand, rural tourism will surely expect further development with the increase in F2 and F3, and the trade-off between agricultural and non-agricultural production will continue. On the other hand, with the increased weight of animal husbandry, the problem of 'grassland-animal imbalance', the incoordination between the area-limited and fragile natural alpine meadow, and the increasing number of livestock has become increasingly prominent (Zhang et al., 2018). Moreover, highland barley, which serves as the essential feed source in autumns and winters, and the woodland, called 'winter pasture', will together pose a challenge upon the development of animal husbandry as the proportion of farming and forestry declines, thereby threatening the sustainability of agricultural production in the entire region.

Therefore, to avoid the unsustainable regional agricultural production situation, a policy intervention mechanism should be established by enhancing F1 and improving the labor productivity of the farmland and woodland. (1) A land circulation mechanism should be established to push the specialization of agricultural production and the diversified development of farmer types, thus achieving the 'balance' between agricultural and non-agricultural production at the farmer household level and promoting farmers' stable development agricultural production. (2) Regional agricultural brands should be built to fully explore the value and cultural connotation of agricultural products on the plateau, which will further benefit the prices of farming and forestry products, elevate the incomes of farmers engaged in agricultural production, and enhance their enthusiasm for agricultural production. (3) The rural tourism development path should be optimized by summarizing and planning the culture of farming, forestry and animal husbandry, exploring a rural tourism development model that combines natural landscape sightseeing with agricultural culture, and, thus, realizing a win-win development between the regional agricultural and tourism industries.

5. Conclusions

Since 2005, Zhagana Village has successively experienced the beginning stage (2005–2012) and developing stage (2013–2016) of rural tourism, entering the stable stage (2016–2019). The number and types of farmers involved in the development of rural tourism became gradually stable. In a long historical period, animal husbandry and farming functioned as the primary food sources for farmers, while forestry represented their energy's primary source. However, in the context of a certain degree of trade-off between agricultural production and rural tourism on the Qinghai-Tibet Plateau. Smallholder farmers further expanded the scale of animal husbandry while decreasing the scale of farming and forestry; the agricultural production efficiency (especially that of the grassland) significantly increased. On a regional scale, this region's agricultural production structure gradually transferred from the integrated management of farming, forestry, and animal husbandry to the animal husbandry-based structure, supplemented by farming and forestry. Nevertheless, the level of agricultural productivity in the entire region was not stalled or weakened but, on the contrary, witnessed that the average annual output of food and energy products were enhanced in fluctuations. However, this shift in agricultural production is now facing the challenge of 'grassland-animal imbalance' between the alpine meadow and livestock. Therefore, to avoid the potential unsustainability of regional agricultural production, it is recommended to enhance farmers' labor productivity engaged in agricultural production (especially for farming and forestry) by establishing a land circulation mechanism and accumulating regional agricultural brands, and optimizing a rural tourism development path.

CRediT authorship contribution statement

The authors declared that they have no conflicts of interest to this work. We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

Acknowledgments

This research was supported by the National Natural Science Foundation of China (Grant No. 42001249).

Conflicts of Interest

The authors declare no conflict of interest.

Appendix A. The average value of farmer's agricultural production behavioral analysis index.

Index number	Unit	Agricultural-oriented farmer				Part-time farmer				Tourism-oriented farmer				Average farmer			
		2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
L1	ha	0.43	0.43	0.42	0.42	0.44	0.43	0.42	0.41	0.42	0.41	0.40	0.39	0.43	0.42	0.41	0.41
L2	head	3.66	4.36	5.63	6.06	2.82	3.68	2.66	3.53	1.86	1.73	1.90	1.80	2.78	3.25	3.40	3.80
L3	head	15.43	12.50	22.37	24.60	38.71	27.03	23.48	21.63	24.43	19.93	30.60	31.87	26.19	19.82	25.48	26.03
L4	RMB	807.01	754.26	696.63	678.09	905.68	814.23	729.00	689.75	784.40	789.43	575.08	542.85	832.36	785.97	666.90	636.89
L5	RMB	1463.81	1447.78	1666.65	1525.02	966.15	1040.64	1012.64	1098.33	1012.67	1007.96	1046.10	1160.98	1147.54	1165.46	1241.80	1261.44
L6	RMB	486.72	429.84	714.00	782.01	1059.25	783.00	666.64	641.40	670.41	552.20	828.75	858.59	738.79	588.35	736.46	760.66
L7	RMB	2845.24	2820.69	3105.89	2897.65	2155.00	2238.55	2181.07	2282.96	2186.33	2155.46	2194.25	2345.05	2395.52	2404.90	2493.73	2508.55
L8	RMB	973.43	859.68	1428.00	1564.02	2118.50	1565.99	1333.29	1282.80	1340.82	1104.40	1657.50	1717.17	1477.58	1176.69	1472.93	1521.33
L9	RMB	5255.36	4864.77	6738.17	7174.56	9151.06	7228.05	6394.63	6179.11	6433.01	5572.27	7410.38	7587.88	6946.48	5888.36	6847.72	6980.52
L10	kg	973.90	949.58	933.77	916.56	904.56	908.23	855.53	838.24	887.42	860.45	865.73	854.58	921.96	906.09	885.01	869.80
L11	kgce	17.89	18.45	22.49	21.46	5.16	5.53	5.27	5.60	5.98	5.92	6.13	6.71	9.68	9.96	11.30	11.26
L12	kg	147.41	175.40	226.48	243.60	114.07	148.09	107.55	142.11	75.33	70.21	76.97	73.05	112.27	131.23	137.00	152.92
L13	kgce	29.65	29.87	30.61	30.28	28.12	28.35	28.34	28.50	27.95	27.97	28.05	28.19	28.58	28.73	29.00	28.99
L14	kg	1775.66	1734.64	1841.46	1869.68	2372.67	2127.31	2134.96	2059.25	2072.79	1992.07	2309.43	2295.88	2073.71	1951.34	2095.28	2074.94
L15	kgce	25.15	27.08	33.80	30.77	11.42	13.48	13.37	14.80	9.85	10.04	10.71	12.01	15.47	16.87	19.29	19.19
L16	–	6.32	6.47	7.05	7.06	4.85	5.56	5.41	5.62	5.66	5.33	7.20	7.52	5.61	5.79	6.56	6.73
L17	–	3.48	3.37	2.95	3.14	4.55	4.35	3.89	3.53	4.39	4.18	3.96	3.52	4.14	3.97	3.60	3.39
L18	–	2.01	2.44	1.71	1.60	0.98	1.59	1.24	1.80	1.70	1.50	0.88	0.92	1.56	1.84	1.28	1.44
L19	–	0.34	0.37	0.39	0.43	0.48	0.55	0.38	0.51	0.52	0.39	0.33	0.34	0.45	0.44	0.37	0.42
L29	–	20.45	19.19	20.93	21.18	21.22	20.04	20.61	20.00	21.16	21.34	21.98	22.57	20.94	20.19	21.17	21.25
L21	–	3.79	3.39	4.44	4.62	4.91	4.34	4.30	4.15	4.41	4.23	4.92	5.11	4.37	3.99	4.55	4.63

References

Adhikari, B., Falco, S., Lovett, J.C., 2004. Household characteristics and forest dependency: evidence from common property forest management in Nepal. Ecol. Econ. 48 (2), 245–257.

Barrios, E., 2007. Soil biota, ecosystem services and land productivity. Ecol. Econ. 64 (2), 269–285.

Chen, F.H., Dong, G.H., Zhang, D.J., Liu, X.Y., Jia, X., An, C.B., Ma, M.M., Xie, Y.W., Barton, L., Ren, X.Y., Zhao, Z.J., Wu, X.H., Jones, M.K., 2015. Agriculture facilitated permanent human occupation of the Tibetan Plateau after 3600 B.P. Science 347 (6219), 248–250.

Chen, Q., 2014. Advanced Econometrics and Stata Application. Higher Education Press, Beijing (in Chinese).

Dale, V.H., Polasky, S., 2007. Measures of the effects of agricultural practices on ecosystem services. Ecol. Econ. 64 (2), 286–296.

Darnhofer, I., Schneeberger, W., Freyer, B., 2005. Converting or not converting to organic farming in Austria: farmer types and their rationale. Agric. Hum. Values 22 (1), 39–52.

Duan, A.M., Xiao, Z.X., 2015. Does the climate warming hiatus exist over the Tibetan Plateau? Sci. Rep. 5, 13711.

Duan, J., Xu, Y., Sun, X.Y., 2019. Spatial patterns and their changes of grain production, grain consumption and grain security in the Tibetan Plateau. J. Nat. Resour. 34 (4), 673–688 (in Chinese).

Du, M., Kawashima, S., Yonemura, S., Zhang, X.Z., Chen, S.B., 2004. Mutual influence between human activities and climate change in the Tibetan Plateau during recent years. Glob. Planet. Chang. 41 (3/4), 241–249.

Fleischer, A., Tchetchik, A., 2005. Does rural tourism benefit from agriculture? Tour. Manag. 26 (4), 493–501.

Georg, V., Oliver, K., Ariane, W., 2020. Hazard from Himalayan glacier lake outburst floods. Proc. Natl. Acad. Sci. USA 117 (2), 907–912.

Harris, R.B., 2010. Rangeland degradation on the Qinghai-Tibetan Plateau: a review of the evidence of its magnitude and causes. J. Arid Environ. 74 (1), 1–12.

Hoang, T.T.H., Van Rompaey, A., Meyfroidt, P., Govers, G., Vu, K.C., Nguyen, A.T., Hens, L., Vanacker, V., 2020. Impact of tourism development on the local livelihoods and land cover change in the Northern Vietnamese highlands. Environ. Dev. Sustain. 22 (2), 1371–1395.

Hoefle, S.W., 2016. Multi-functionality, juxtaposition and conflict in the Central Amazon: will tourism contribute to rural livelihoods and save the rainforest? J. Rural Stud. 44, 24–36.

Huang, B., Shi, X., Yu, D., Oborn, I., Blomback, K., Pagella, T., Wang, H.J., Sun, W.X., Sinclair, F.L., 2006. Environmental assessment of small-scale vegetable farming systems in peri-urban areas of the Yangtze River Delta Region, China. Agric. Ecosyst. Environ. 112 (4), 391–402.

Hua, X.B., Yan, J.Z., Zhang, Y.L., 2017. Evaluating the role of livelihood assets in suitable livelihood strategies: protocol for anti-poverty policy in the Eastern Tibetan Plateau, China. Ecol. Indic. 78, 62–74.

Ichinose, Y., Higuchi, H., Kubo, R., Nishigaki, T., Kilasara, M., Shinjo, H., Funakawa, S., 2020. Adaptation of farmland management strategies to maintain livelihood by the Chagga people in the Kilimanjaro highlands. Agric. Syst. 181, 102829.

Jendoubi, D., Hossain, M.S., Giger, M., Tomićević-Dubljević, J., Ifejika Speranza, C., 2020. Local livelihoods and landusers' perceptions of land degradation in northwest Tunisia. Environ. Dev. 33, 100507.

Kelly, A.H., Stephen, M.C., Eric, F.L., 2018. The demise of caterpillar fungus in the Himalayan region due to climate change and overharvesting. Proc. Natl. Acad. Sci. USA 115 (45), 11489–11494.

Kemp, D.R., Han, G.D., Hou, X.Y., Michalk, D.L., Hou, F.J., Wu, J.P., Zhang, Y.J., 2013. Innovative grassland management systems for environmental and livelihood benefit. Proc. Natl. Acad. Sci. USA 110 (21), 8369–8374.

Liu, H., Mi, Z., Lin, L., Wang, Y.H., Zhang, Z.H., Zhang, F.W., Wang, H., Liu, L.L., Zhu, B., Cao, G.M., Zhao, X.Q., Sanders, N.J., Classen, A.T., Reich, P.B., He, J.S., 2018. Shifting plant species composition in response to climate change stabilizes grassland primary production. Proc. Natl. Acad. Sci. USA 115 (16), 4051–4056.

Li, M.Q., Liu, S.L., Sun, Y.X., Liu, Y.X., 2021. Agriculture and animal husbandry increased carbon footprint on the Qinghai-Tibet Plateau during past three decades. J. Clean. Prod. 278, 123963.

Looga, J., Jürgenson, E., Sikk, K., Matveev, E., Massikamäe, S., 2018. Land fragmentation and other determinants of agricultural farm productivity: the case of Estonia. Land Use Policy 79, 285–292.

Mousa, A., Karwan, S., 2020. Tourism wetlands and rural sustainable livelihood: the case from Iran. J. Outdoor Recreat. Tour. 30, 100284.

Qi, W., Liu, S.H., Zhou, L., 2020. Regional differentiation of population in Tibetan Plateau: insight from the "Hu Line". Acta Geogr. Sin. 75 (2), 255–267 (in Chinese).

Randelli, F., Martellozzo, F., 2019. Is rural tourism-induced built-up growth a threat for the sustainability of rural areas? The case study of Tuscany. Land Use Policy 86, 387–398.

Rongna, A., Sun, J.X., 2020. Integration and sustainability of tourism and traditional livelihood: a rhythmanalysis. J. Sustain. Tour. 28 (3), 455–474.

Salvo, G., Simas, M., Pacca, S., Guilhoto, J.J.M., Tomas, A.R.G., Abramovay, R., 2015. Estimating the human appropriation of land in Brazil by means of an Input-Output Economic Model and Ecological Footprint analysis. Ecol. Indic. 53, 78–94.

Shackleton, C.M., Shackleton, S.E., Buiten, E., Bird, N., 2007. The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. For. Policy Econ. 9 (5), 558–577.

Shao, J.A., Huang, Z.L., Deng, H., 2018. Characteristics of nonpoint source pollution load from crop farming in the context of livelihood diversification. J. Geogr. Sci. 28 (4), 459–476.

Shen, S., Wang, H., Quan, Q.H., Xu, J., 2019. Rurality and rural tourism development in China. Tour. Manag. Perspect. 30, 98–106.

Simpson, E.H., 1949. Measurement of diversity. Nature 163, 688.

Solomon, A., Antonio, S., Gloria, D.C., Nicholas, S., Adriana, I., 2019. Heterogeneous impact of livelihood diversification on household welfare: cross-country evidence from Sub-Saharan Africa. World Dev. 117, 278–295.

Suh, S., 2004. A note on the calculus for physical input-output analysis and its application to land appropriation of international trade activities. Ecol. Econ. 48 (1), 9–17.

Su, M.M., Wall, G., Wang, Y.N., Min, J., 2019. Livelihood sustainability in a rural tourism destination-Hetu Town, Anhui Province, China. Tour. Manag. 71, 272–281.

Taboada, C., Garcia, M., Gilles, J., Pozo, O., Yucra, E., Rojas, K., 2017. Can warmer be better? Changing production systems in three Andean ecosystems in the face of environmental change. J. Arid Environ. 147, 144–154.
Van Ittersum, M.K., Rabbinge, R., 1997. Concepts in production ecology for analysis and quantification of agricultural input-output combinations. Field Crop. Res. 52 (3), 197–208.
Wang, C.C., Yang, Y.S., 2012. An overview of farmers' ' livelihood strategy change and its effect on land use/cover change in developing countries. Prog. Geogr. 31 (6), 792–798 (in Chinese).
Wayessa, G.O., 2020. Impacts of land leases in Oromia, Ethiopia: changes in access to livelihood resources for local people. Land Use Policy 97, 104713.
Xi, J.C., Wang, X.G., Kong, Q.Q., Zhang, N., 2015. Spatial morphology evolution of rural settlements induced by tourism A comparative study of three villages in Yesanpo tourism area, China. J. Geogr. Sci. 25 (4), 497–511.
Xi, J.C., Zhao, M.F., Ge, Q.S., Kong, Q.Q., 2014. Changes in land use of a village driven by over 25 years of tourism: the case of Gougezhuang village, China. Land Use Policy 40 (40), 119–130.
Yang, L., Liu, M.C., Lun, F., Min, Q.W., Li, W.H., 2019b. The impacts of farmers' ' livelihood capitals on planting decisions: a case study of Zhagana Agriculture-Forestry-Animal Husbandry Composite System. Land Use Policy 86, 208–217.
Yang, L., Liu, M.C., Min, Q.W., Li, W.H., 2018. Specialization or diversification? The situation and transition of households' ' livelihood in agricultural heritage systems. Int. J. Agric. Sustain. 16, 455–471.
Yang, L., Yan, J.Z., Wang, P., Wang, H., 2019a. Impacts of climate change on the reclamation of farmers and herdsmen in the Tibetan Plateau. Acta Ecol. Sin. 39 (10), 3655–3669 (in Chinese).
Yu, H., Song, S.Y., Liu, J.Z., Li, S., Zhang, L., Wang, D.J., Luo, S.J., 2017. Effects of the Qinghai-Tibet railway on the landscape genetics of the endangered Przewalski's gazelle (Procapra przewalskii). Sci. Rep. 7 (1), 17983.
Zhang, H.Y., Fan, J.W., Wang, J.B., Cao, W., Harris, W., 2018. Spatial and temporal variability of grassland yield and its response to climate change and anthropogenic activities on the Tibetan Plateau from 1988 to 2013. Ecol. Indic. 95, 141–151.
Zhang, Q., Ma, L., Zhang, Z.H., Xu, W.H., Zhou, B.R., Song, M.H., Qiao, H.A., Wang, F., She, Y.D., Yang, X.Y., Guo, J., Zhou, H.K., 2019. Ecological restoration of degraded grassland in Qinghai-Tibet alpine region: degradation status, restoration measures, effects and prospects. Acta Ecol. Sin. 39 (20), 7441–7451 (in Chinese).
Zhang, F.F., Zhao, X.Y., 2015. A review of ecological effect of peasant's livelihood transformation in China. Acta Ecol. Sin. 35 (10), 3157–3164 (in Chinese).
Zhao, X.Y., 2013. Environmental impact of different livelihood strategies of farmers: a case of the Gannan Plateau. Sci. Geogr. Sin. 33 (5), 545–552.