sustainability

MDPI

Article

The Spatial Distribution and Impacts of Organic Certificates in Southwest China

Haixia Guo [1], Yike Li [2], Meiting Hou [3] and Xie Wang [4,5,*]

[1] Key Laboratory of the Philosophy and Social Sciences of Sichuan Province on the Monitoring and Evaluation of the Utilization of Rural Land, Chengdu Normal University, Chengdu 611130, China; guohaixia05@gmail.com
[2] Ecological Restoration and Biodiversity Conservation Key Laboratory of Sichuan Province, Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610041, China; liyk@cib.ac.cn
[3] China Meteorological Administration Training Centre, Beijing 100081, China; houmt@outlook.com
[4] Institute of Agricultural Resources and Environment, Sichuan Academy of Agricultural Sciences, Chengdu 610066, China
[5] Southwest Key Laboratory of Mountain Agricultural Environment, Ministry of Agriculture and Rural Areas, Beijing 100097, China
* Correspondence: wangxiechangde@hotmail.com

Abstract: Organic farming is a good choice for agricultural development in southwest China under the trade-off between environmental protection and agricultural development. However, no researcher has investigated the current state and development of organic agriculture in southwest China. As a result, this paper explored the spatial structure of organic agriculture in southwest China by examining the distribution of organic certificates, as well as the environmental and socioeconomic impacts. The results show a dramatically uneven distribution of certified organics among different provinces, cities, and organic certificate types. On the province scale, Guizhou has the highest number (1174) and density (73.40 per 10^{10} m^2) of organic certificates. On the city scale, Zunyi and Chengdu have the highest densities (218.77 and 342.52 per 10^{10} m^2, respectively). Most of the certified organics are plants, accounting for 76.95%. The spatial distribution of organic farming is influenced by the interaction of several factors, including precipitation, temperature, GDP, highway density, gross agriculture output, agriculture machinery, and rural employed persons. However, the related and determinant factors of organic certificate distribution vary greatly across different regions, spatial scales, economic development levels, and agricultural development statuses. For the entirety of southwestern China, the factors significantly related to the distribution of organic certificates are GDP, highway density, gross agriculture output, agriculture machinery, and rural employed persons. However, these factors are GDP, gross agriculture output, agriculture machinery, and rural employed persons for Sichuan, and gross agriculture output and rural employed persons for Guizhou. Factors constraining the development of organic agriculture in regions with better economic and agricultural conditions are much fewer than in poorer regions. All of the nine selected variables, except global radiation, are significantly related to organic certificate distribution in regions with better economic conditions, while none of them had a significant correlation with organic certificate distribution in poorer regions. Furthermore, climate is no longer a constraint in regions with better agricultural conditions. These findings are of great significance for the development and research of organic agriculture in southwest China. The development of organic agriculture in southwest China requires consideration of both the combination of multiple factors and the stage of regional economic and agricultural development.

Keywords: organic farming; unevenness; government policy; economic condition; agricultural condition

Citation: Guo, H.; Li, Y.; Hou, M.; Wang, X. The Spatial Distribution and Impacts of Organic Certificates in Southwest China. *Sustainability* **2023**, *15*, 14663. https://doi.org/10.3390/su152014663

Academic Editor: Victor Kavvadias

Received: 8 September 2023
Revised: 29 September 2023
Accepted: 6 October 2023
Published: 10 October 2023

1. Introduction

Southwest China is one of the 35 biodiversity hotspots in the world [1], and the upstream or source area of the Yangtze River, Pearl River, and other southwest rivers in China.

It is both a key global biodiversity protection region and an important ecological security barrier area of China [2]. The southwestern region has 16 of the 64 important functional zones defined, including four important zones for water conservation, four important zones for soil conservation, and eight important zones for biodiversity protection, according to the National Ecological Functional Zoning (Revised Version) published by the Chinese Ministry of Environmental Protection and the Chinese Academy of Sciences. As a result, for Southwest China, environmental protection is a key task of regional development [3]. Additionally, on 7 May 2022, the Ministry of Agriculture and Rural Affairs (MAA) and the National Development and Reform Commission (NDRC) released the "Implementation Plan for Reducing Emissions and Sequestration in Agricultural Rural Implementation Program" in order to meet China's commitment to peak carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060 [4]. The environmental pressures on Southwest Chinese agriculture are thus further increased. Southwest China is also one of China's most hilly regions and has a complicated topography [5]. Large-scale, mechanical agricultural development is not feasible in such an environment.

Organic products are foods produced by methods that comply with the standards of organic farming and production, which restrict the use of certain pesticides and fertilizers in the farming methods used to produce such products, and typically do not involve the use of processes involving irradiation, industrial solvents, or synthetic food additives [6]. In recent years, organic farming has continued to increase throughout the world [7]. Data from The World of Organic Agriculture Statistics and Emerging Trends 2023 show that organic food sales reached the 125 billion Euro mark in 2021, and the total organic area has increased to almost 76 million hectares, representing 1.6 percent of agricultural land worldwide [8].

China has a long history of organic farming practices, but the study of organic farming did not begin until the 1980s [9,10]. In 1994, the Organic Food Development Center of SEPA was founded to motivate the development of organic farming. In 2001, the Technical Specification for Organic Food (HJ/T80—2001) was enacted, setting the first organic food standards in China. In 2002, the China Organic Food Certification Center (COFCC) was founded, becoming the first domestic organic accreditation agency in China. Currently, 115 agencies in China have been granted certification by the China Certification and Accreditation Administration to certify organic products. In 2012, China established the National Certification and Accreditation Information Public Service Platform to manage the information on organic food, and both organic certification agencies and certificates of organic production are published on this platform. Since then, China's organic agriculture has been growing sustainably, and now China has the seventh greatest organic agricultural land area (over 2.4 million hectares) and the third largest organic market (10.2 billion euros) in the world [1].

A large body of data suggests that organic farming is more environmentally friendly than conventional farming because it conserves more biodiversity, promotes the growth of soil organic matter, and reduces the loss of soil nutrients [11,12]. On the other hand, organic farming requires more labor than conventional farming and is particularly suited to smaller farms [13]. These benefits are exactly what southwest China's agricultural production needs. In fact, organic farming in southwest China has developed effectively in recent years. According to published data, Yunnan, Sichuan, and Guizhou ranked second, fifth, and sixth in terms of organic certificates in China in 2021.

Understanding the spatial distribution of organic agriculture and its underlying correlations is critical for future organic agriculture expansion, identifying possible development zones, and improving access to organic agriculture. As early as 1989, Fisher analyzed barriers to the adoption of organic farming using questionnaires, interviews, and secondary information [14]. Since then, numerous studies have used a number of methods to investigate the factors influencing the conversion to organic agriculture, including farm typology, binomial and multinomial logit techniques, and decision trees, among others [15–18]. During this period, little research has been conducted on the spatial distribution of organic agriculture and its underlying environmental correlations. One of the

first scientists to investigate the geographic dispersion of organic agriculture was Brian. Using officially published secondary data, he examined the changing patterns of organic farming between 1993 and 1997 in England and Wales [19]. Following Brian, Bichler and his team investigated the localization of organic farms in Denmark and the factors that affected it [20,21]. Many investigations have since analyzed the geographic distribution of organic agriculture and the environmental, economic, and social factors that influence it. In England, for instance, Gabriel et al. (2009) examined how environmental conditions affected the spatial aggregation of organic farming [6]. The regional spread of organic farming in Ireland and its affecting elements were examined by Läpple and Cullinan (2012) [22]. Žiga Malek et al. (2019) mapped the global organic farming distribution and its related factors by using publicly available registers of organic farmers [23]. However, there are few studies on the development of organic agriculture in southwest China, and only a few studies on the development of organic agriculture in Sichuan, Yunnan, and Guizhou, respectively, and few have analyzed the factors affecting the development of organic agriculture in these regions [24–28]. Against this background, this study investigates the number, spatial distribution, and influencing factors of organic certificates in southwest China, with the aim of providing a theoretical basis for research and decision-making on the development of organic agriculture in southwest China.

2. Materials and Methods

2.1. Study Area

The study area is located at 21.2°–36.4° N, 83.9°–112.1° E and covers an area of 2,470,000 km^2 in Sichuan, Yunnan, Guizhou, Chongqing, and Tibet, including 54 cities (autonomous prefectures). There are many different types of climates in the study area, including subtropical monsoon, plateau mountain, and tropical monsoon. The topography of the area exhibits a remarkable level of distinctiveness. The Sichuan Basin and adjacent mountains, the intermediate high mountains and hills of the Yunnan–Guizhou Plateau, the high mountains of the Qinghai–Tibet Plateau, etc., are just a few examples of the distinctive landforms of this region.

2.2. Data Collection

Information about organic certificates, such as certified farm names, addresses, certified scopes, products, and certification authorities, as well as a list of organic accreditation agencies, was collected from the National Certification and Accreditation Information Public Service Platform.

Nine variables representing climate, environment quality, economic conditions, traffic conditions, and agriculture conditions were considered. They were as follows (Table 1).

Table 1. List of variables influencing the distribution of organic farming.

Variables	Index	Description	Dimension
Precipitation	X_1	Average annual Precipitation of each city (mm)	Climate condition
Temperature	X_2	Average annual temperature of each city (°C)	
Global radiation	X_3	Average annual global radiation of each city (10^6 J/m^2)	
Air quality composite index	X_4	A dimensionless index Calculated from $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO and O_3.	Environment condition
Gross domestic product	X_5	GDP, Gross Domestic Product per capital (Yuan/person)	Economic condition
Highway density	X_6	Length of highways per unit area (km/km^2)	Traffic condition
Gross agriculture output	X_7	Annual gross output value of agriculture, forestry, animal husbandry and fishery of each city (10^4 Yuan)	Agriculture condition
Agriculture machinery	X_8	Total annual power of agriculture machinery of each city (kw)	
Rural employed persons	X_9	Total annual employed persons in the country of each city (10^4 persons)	

Data on the economics, agriculture, traffic situation, climate, and environment quality of each city were collected from the Statistics Yearbook, the Statistical Bulletin on National Economic and Social Development, and the Environment Bulletin of Sichuan, Yunnan,

Guizhou, Chongqing, and Tibet. Global radiation data were downloaded from the National Meteorological Science Data Center.

2.3. Research Methods

ArcMap 10.4 (Esri, Redlands, CA, USA) was used to visualize the spatial distribution of organic certificates and calculate the global radiation of each city in southwest China. SPSS was used to explore the factors influencing the distribution of organic certificates in southwest China, as well as the correlations between the underlying factors and the distribution of organic certificates.

3. Results

3.1. The Distribution of Organic Certificates

In southwest China, a total of 3570 organic certificates were searched, with over 95% coming from Guizhou, Sichuan, and Yunnan (1174 from Guizhou, 1185 from Sichuan, and 1010 from Yunnan). Guizhou had the most organic certificates, as well as the greatest density (73.40 per 10,100 m^2). Sichuan and Yunnan had similar densities. Yunnan had a density of 26.36 per 10,100 m^2, whereas Sichuan had a density of 24.38 per 10,100 m^2. Tibet had the lowest number and density, indicating a lag in organic farming in this region (Figure 1).

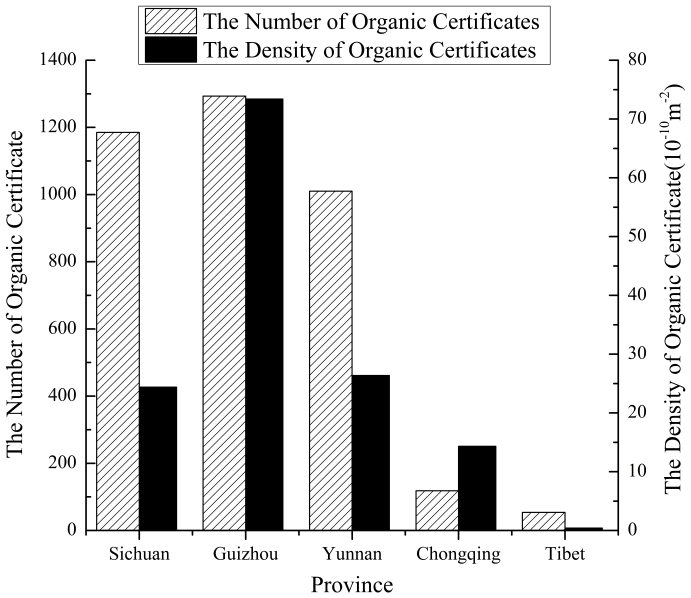

Figure 1. The number and density of organic certificates in each province (or province-level municipality).

Figure 2 shows the uneven distribution of the number and density of organic certificates in each city. The number of organic certificates was divided into five classes in this study. Zunyi and Chengdu had the largest number (673 and 491, respectively), and both belonged to the first class, accounting for 36.1% of the total organic certificates. Seven cities, including Puer, Tongren, Bijie, Chongqing, Kunming, Qiandongnan, and Xishuangbanna, with numbers ranging from 100 to 199, belonged to the second class. Thirty-five further cities with numbers less than 100 belonged to the third and fourth classes.

The density of organic certificates was also divided into five classes. The highest densities were found in Zunyi and Chengdu (218.77 and 342.52 per 10^{10} m^2, respectively). However, none of the fifty-two cities belonged to the second class (densities ranging from 100.00 to 199.99). Thirty-four cities, or more than half of all the cities, fell into the third class and had densities between 50.00 and 99.99.

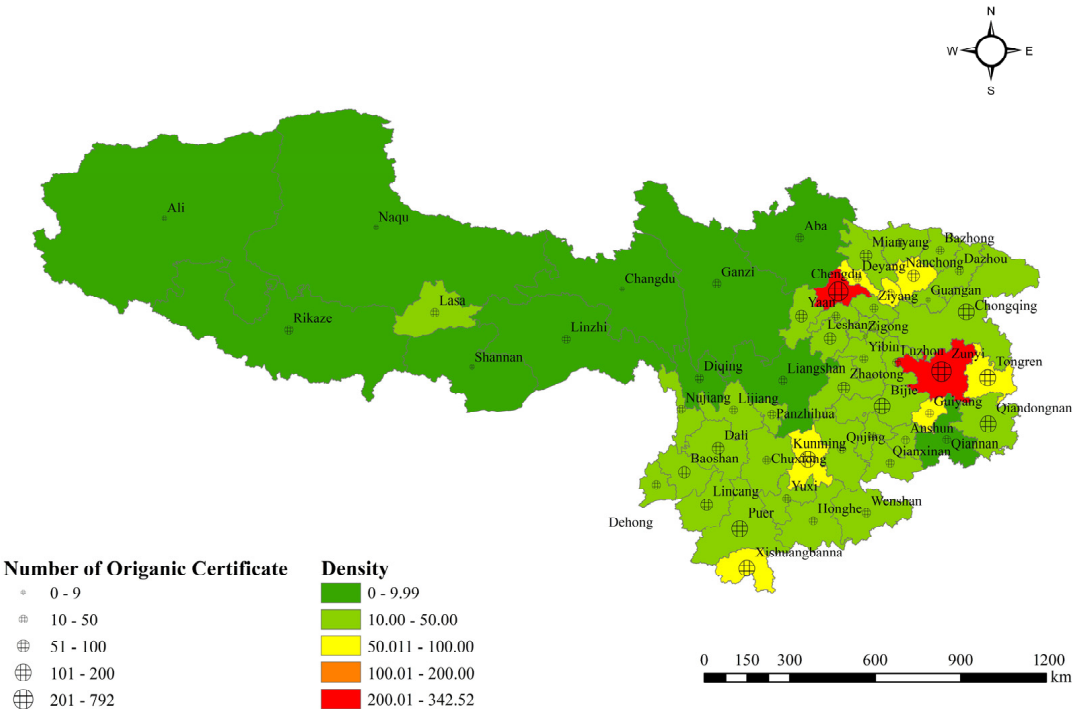

Figure 2. The distribution of the number and density of organic certificates in each city.

The aforementioned findings pointed to a strikingly unequal distribution of organic certificates in southwest China at both the provincial and municipal levels.

3.2. The Number of Each Type of Organic Certificate

In this study, organic certificates were divided into five categories based on the national certification and accreditation information public service platform: livestock, processed products, wild plants, plants, and aquatic products. The majority of certified organics in southwest China were plant-based, accounting for 76.95%. The animal, wild plant, and aquatic product ratios were all less than 5% (Table 2).

Table 2. The number and ratios of each type of organic certificate.

Type of Organic Certificate	Number of Organic Certificate	Proportion
Livestock	172	4.82%
Processed products	530	14.85%
Wild plant	70	1.96%
Plant	2747	76.95%
Aquatic product	51	1.43%

Plant was the most widespread category in all five provinces (or province-level municipalities). In Tibet, livestock was the second most widespread type, and there were no aquatic products. In all the other four provinces, processed products were the second most common, and Yunnan had nearly half of the processed products in southwest China, accounting for 44.34% of the total, with processed tea accounting for more than half (63.83%), including yellow tea, black tea, white tea, green tea, Pu'er tea, and so on. Sichuan had the most livestock certificates, accounting for 52.91%, with pork, beef, and chicken accounting for 74.73% (Figure 3).

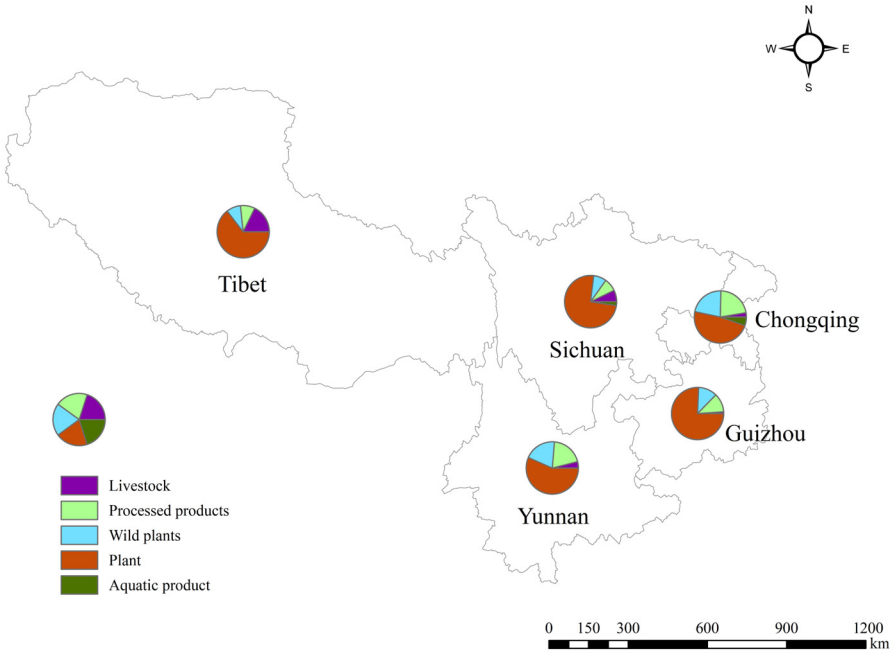

Figure 3. The number of each type of organic certificate in each province.

3.3. Factors Influencing the Distribution of Organic Certificates

3.3.1. Factors Affecting the Distribution of Organic Certificates in Different Geographic Regions

The analysis found that GDP, road density, rural employed persons, gross agricultural output, and agricultural machinery were all substantially related to the distribution of organic certification in southwest China. This meant that economic and agricultural levels in this region had a considerable impact on the distribution of organic agriculture. However, when the data were studied at the provincial (autonomous prefectural) scale, it was discovered that, except for Sichuan, there was no clear association between the economic level and the distribution of organic certificates in Yunnan, Guizhou, and Tibet. Except for Sichuan and Guizhou, no substantial association between agricultural development and organic certificates in Yunnan and Tibet was observed. These findings revealed that the factors impacting the development of organic certification differed significantly between provinces (autonomous prefectures) in the southwestern region (Table 3).

Table 3. Correlations between the distribution of organic certificates and the nine variables in different geographical regions (Pearson correlation).

Region	Index	X_1	X_2	X_3	X_4	X_5	X_7	X_8	X_9
Southwest China	the number of organic certificates	0.151	0.11	−0.089	0.062	0.282 *	0.331 *	0.341 *	0.377 **
	the density of organic certificates	0.213	0.073	−0.043	0.283	0.418 **	0.309 *	0.19	0.315 *
	N	54	54	54	54	54	47	54	54
Sichuan	the number of organic certificates	−0.081	−0.069	−0.323	0.269	0.533 *	0.601 **	0.599 **	0.819 **
	the density of organic certificates	0.053	−0.123	−0.229	0.385	0.589 **	0.621 **	0.518 *	0.811 **
	N	21	21	21	21	21	21	21	21
Yunnan	the number of organic certificates	0.348	0.381	0.071	−0.138	−0.088	0.23	0.208	0.167
	the density of organic certificates	0.373	0.335	0.12	0.089	0.081	0.073	−0.043	0.034
	N	16	16	16	16	16	16	16	16
Guizhou	the number of organic certificates	0.073	−0.551	0.008	0.232	−0.005	0.729 *	0.45	0.683 *
	the density of organic certificates	0.06	−0.603	0.121	0.345	0.154	0.637	0.31	0.576
	N	9	9	9	9	9	9	9	9
Tibet	the number of organic certificates	0.495	0.489	0.072	\	0.351	0.508	0.694	0.228
	the density of organic certificates	0.4	0.631	0.54	\	0.569	0.175	0.189	−0.054
	N	7	7	7	7	7	7	7	7

Note: ** indicates significant correlation at the 0.01 level (two-tailed); * indicates significant correlation at the 0.05 level (two-tailed).

The stepwise regression analysis revealed that rural employed persons were the key factor determining the distribution of organic certificates in southwest China, with $Y_{SW} = 0.377X + 33.166$ (Y_{SW} representing the number of organic certificates, X representing the number of rural employed persons). The coefficient of determination (R) was 0.377, and the *p*-value was less than 0.01, indicating that organic certificates were significantly influenced by rural employed persons. The analysis of Sichuan and Guizhou found that $Y_{SC} = 0.819X - 68.384$ (R = 0.819, $p < 0.01$) and $Y_{GZ} = 0.729Z - 203.503$ (R = 0.729, $p < 0.05$), where Y_{SC} and Y_{GZ} represent the number of organic certificates in Sichuan and Guizhou, respectively, X represents the number of rural employed persons, and Z represents the gross agriculture output. This demonstrated that the number of organic certificates in Sichuan was determined mostly by rural employed persons, whereas in Guizhou, it was primarily influenced by the gross agriculture output.

3.3.2. Factors Influencing the Distribution of Organic Certificates across Different Economic Levels

The cities in the research area were divided into two categories based on GDP using the K-means clustering method: high GDP (GDP-H) regions and low GDP (GDP-L) regions. The number and density of organic certificates differed significantly between the two categories, according to the analysis (Table 4).

Table 4. Differences in the distribution of organic certificates between high and low GDP regions.

Index	Region	N	Average	Standard Error	F	P	df
The number of organic certificates	GDP-H	16	113.13	47.159	13.431	0.001	52
	GDP-L	38	46.32	6.601			
The density of organic certificates	GDP-H	16	63.40614355	22.51815996	13.71	0.001	52
	GDP-L	38	22.83302641	3.013415683			

The parameters impacting organic certificate distribution varied across the two categories as well. None of the identified environmental-economic-social parameters were substantially associated with the number or density of organic certificates in high GDP regions. However, in low GDP regions, four variables, including precipitation, temperature, agriculture machinery, and rural employed persons, were significantly correlated with the number of organic certificates, and all factors except global radiation and agriculture machinery were significantly correlated with the density of organic certificates (Table 5).

Table 5. Correlations between the distribution of organic certificates and the nine variables in high and low GDP regions (Pearson correlation).

Region	Index	X1	X2	X3	X4	X5	X6	X7	X8	X9
GDP-H	the number of organic certificates	−0.083	−0.068	−0.143	0.014	0.13	0.18	0.287	0.296	0.316
	the density of organic certificates	−0.061	−0.128	−0.143	0.196	0.329	0.286	0.287	0.296	0.316
GDP-L	the number of organic certificates	0.411 *	0.454 **	−0.015	0.233	0.228	0.054	0.271	0.456 **	0.361 *
	the density of organic certificates	0.595 **	0.412 *	0.179	0.556 **	0.482 **	0.587 **	0.377 *	0.166	0.415 **

Note: ** indicates significant correlation at the 0.01 level (two-tailed); * indicates significant correlation at the 0.05 level (two-tailed).

3.3.3. Factors Influencing the Distribution of Organic Certificates under Different Levels of Agricultural Development

The regions were divided into two categories based on gross agriculture output, agriculture machinery, and rural employed persons using the K-means clustering method: high agricultural level regions (HAR) and low agricultural level regions (LAR). The number of organic certificates was found to be significantly different between the two regions, but not in their density (Table 6).

Table 6. Differences in the distribution of organic certificates between high and low agricultural level regions.

Index	Region	N	Average	Standard Error	F	P	df
the number of organic certificates	LAR HAR	23 30	29.83 92.2	5.133 25.787	5.771	0.02	51
the density of organic certificates	LAR HAR	23 30	19.86349416 47.03224436	4.094498288 12.43263109	2.652	0.11	51

According to the correlation study, the factors influencing the distribution of organic certificates differed between the two types of regions. In regions with lower agricultural levels, except for global radiation and agriculture machinery, all other factors showed significant correlations with the density or number of organic certificates. However, in regions with higher agricultural levels, only the economic level and agricultural level showed a significant correlation with the distribution of organic certificates, while precipitation, temperature, global radiation, and highway density all showed no obvious correlation with both the number and density of organic certificates (Table 7).

Table 7. Correlations between the distribution of organic certificates and the nine variables in high and low agricultural level regions (Pearson correlation).

Region	Index	X1	X2	X3	X4	X5	X6	X7	X8	X9
LAR	the number of organic certificates	0.510 *	0.634 **	0.116	0.344	0.253	0.117	0.409	0.291	0.215
	the density of organic certificates	0.693 **	0.678 **	0.192	0.633 **	0.544 **	0.639 **	0.736 **	0.073	0.595 **
HAR	the number of organic certificates	−0.293	−0.099	−0.123	0.061	0.355	0.012	0.369 *	0.463 **	0.659 **
	the density of organic certificates	−0.227	−0.22	−0.113	0.332	0.602 **	0.251	0.543 **	0.349	0.769 **

Note: ** indicates significant correlation at the 0.01 level (two-tailed); * indicates significant correlation at the 0.05 level (two-tailed).

4. Discussion

4.1. The Spatial Distribution of Organic Certificates

According to the findings of this study, there was a substantial imbalance in the spatial distribution of organic certificates at both province (municipality) and city (state) scales.

At the provincial (municipality) scale, Guizhou, Sichuan, and Yunnan provinces accounted for 95% of organic certificates in southwest China. Guizhou had the most organic certificates and the highest density. However, its GDP ranked second to last, indicating that the key factor affecting the development of organic agriculture in southwest China may not be the economic level. In 2005, Guizhou released the Opinions on Accelerating the Development of Efficient Agriculture with Modern Mountain Characteristics, which outlined the goal of creating a big province of pollution-free green organic agriculture. In 2017, the Guizhou Green Agricultural Products "Quanyong" Project Work Plan (2017–2020) was announced. Encouraged by these policies, the number of organic certificates in Guizhou rose to the second largest in China at the end of 2018. Government policy has been proven to be an important factor affecting agricultural production [29]. In China, legislation is a key motivator for farmers to choose ecological agriculture [30]. Despite its poor economic situation, Guizhou today has the second-highest number of organic certificates in China thanks to significant government assistance.

On the city scale, the disparity in the spatial distribution was more obvious. Chengdu and Zunyi had a density of organic certificates greater than 200 per 10^{10} m^2, whereas the other fifty-two cities were all less than 100 per 10^{10} m^2. Regional concentrations of organic farming have been observed in many regions. Many factors, including agricultural policy, consumer demand, economic condition, latitude, area, and human population, etc., influence farmers' adoption of organic farming in the region [23,31,32]. According to research from the organic food production, information network, and certification center, organic agriculture in China is likewise marked by a significant degree of unevenness [33–36].

However, few studies have been conducted to investigate the causes of China's highly uneven distribution.

Furthermore, the number of organic certificates from different classes varied greatly. Nearly 80% of the organic certificates were for plants. Organic certificates for livestock, aquatic products, processed products, and wild plants were all quite limited. This is consistent with the characteristics of organic products in China, where organic products are mainly plant products, while animal products are scarce, and primary products are the main products, with few processed products [37,38]. The amount of each type of organic certificate also exhibited clear regional variations. For example, most of the processed product certificates were from Yunnan, mainly for tea, while more than half of the organic livestock certificates were from Sichuan. This disparity may be due to the differences in development goals among these provinces. Yunnan was previously one of China's top producers of organic beef and mutton, according to the study by Liu Qiang [39]. However, with policy support such as funds for green tea development, organic tea has been well developed, and Yunnan's organic tea area and products ranked first in China in 2021.

4.2. What Affects the Spatial Distribution of Organic Certificates

The spatial distribution of organic farming is determined by the interaction of a number of factors [6,22,37,39], which is consistent with the findings of this paper. The spatial distribution of organic agriculture in southwest China was found to be highly related to climate conditions, economic level, transportation conditions, and agricultural level. Furthermore, the study found that the factors influencing the distribution of organic certificates varied greatly among regions, spatial scales, economic development levels, and agricultural development status.

The factors impacting organic certificate distribution varied among provinces (autonomous prefectures) according to this study. For example, factors significantly related to the distribution of organic certificates in Sichuan were GDP, gross agriculture output, agriculture machinery, and rural employed persons, whereas the factors in Guizhou were gross agriculture output and rural employed persons. The spatial distribution of organic farming is based on the interaction of various factors. Since combinations of those variables varied among regions, great variation of the determining factors would be observed [6,22,23]. Except for related factors, the key determining factors in Sichuan and Guizhou were also different. In Sichuan, the factor determining the distribution of organic certificates was rural employed persons, but it was gross agriculture output in Guizhou. According to this study, 82.9% of the variation in the number of Sichuan organic certificates could be explained by rural employed persons. In comparison to conventional agriculture, organic agriculture is more labor-intensive and presents greater opportunities for rural employment [13,40,41]. This could be the cause of the significant positive correlations between rural employed persons and the organic certificate distribution in both Sichuan and Guizhou, as well as the reason why rural employed persons were the determining factor of organic certificate distribution in Sichuan. In Guizhou, 72.9% of the organic certificate number could be explained by gross agricultural output. Gross agricultural output is an indicator of the level of agricultural development. A high degree of agricultural development implies an adequate agricultural employment population, better agricultural production techniques, infrastructure, and industrial network, which might attract more organic enterprises and facilitate the circulation of products [28]. Therefore, in this study, there were significant positive correlations between gross agricultural output and the number of organic certificates in Guizhou, Sichuan, and southwest China.

In addition, in this study, the factors impacting organic certificate distribution varied across geographical scales. Factors influencing organic certificate distribution in the entire southwest region differed from those in each province. Similar results have been found in other studies on the distribution of organic agriculture. According to the research of Žiga Malek et al. (2019), the effects of precipitation and temperature on the distribution of organic agriculture varied depending on the geographical scale of the study area [23].

Scale dependence in the distribution status of organic agriculture was also noted by Ilbery and Maye (2011) [19]. Although organic agriculture was clearly clustered at the regional level, no appreciable geographical clustering was found within any county [32]. Scale dependence is a popular theory to explain spatial complexity and variety. It arose due to the fundamental dependency between scale and pattern, as well as between pattern and process [42,43]. For example, farmers' adoption of organic farming is highly spatially dependent, resulting in large variations in organic farm distribution between regions and scales [35,44–46].

Moreover, factors influencing the distribution of organic certificates varied across different levels of economic and agricultural development, according to this study. Agricultural ecosystems have multiple functions, including agricultural production, ecosystem supporting services, regulation of water and climate, as well as aesthetic and cultural services [47,48]. The shifting demand for agricultural ecosystem functions at different phases of socio-economic development would lead to diverse structures of agricultural production forms [49], subsequently influencing the spatial layout of organic agriculture. Furthermore, with the development of the economy, improvements in infrastructure, market forces, and agricultural policy, along with changes in agricultural production technology, all influence the distribution of organic agriculture. It has been revealed that there were notable disparities in the factors impacting the spatial distribution of organic agriculture between developing and developed regions [23]. In this study, factors limiting the growth of organic agriculture were much less in regions with better economic conditions than in poorer regions. Except for global radiation, all of the nine selected variables were significantly related to organic certificate distribution in regions with better economic conditions, whereas none were significantly connected to organic certificate distribution in poorer regions. This may be because, as the economy has developed, factors such as the consumer market and politics have replaced climate, economic, and infrastructure conditions as the main limiting factors to the development of organic farming. Similarly, as agriculture developed, natural constraints were broken by the development of technology and infrastructure, and climate was no longer a constraint, thus lessening the constraints of organic agriculture development.

In summary, the distribution of organic certificates in southwest China is dramatically uneven with a high degree of aggregation. There are many influencing factors related to the number of organic certificates, and these factors change with the spatial scale, economic level, and agricultural level. Therefore, it is necessary to take into account a combination of factors, as well as the region in which the policy is to be implemented and the stage of regional economic and agricultural development, when developing an organic agriculture development strategy. In addition, policy is expected to play an important role in determining the spread of organic agriculture in southwest China; however, this study did not include it among the factors, which is a major limitation of this study. Therefore, the influence of policy should be considered in future studies of organic agriculture in southwest China and in China as a whole.

5. Conclusions

The study investigated the distribution of organic certificates and its influencing factors. The conclusions of this paper are as follows:

First, southwest China showed a significant imbalance in the spatial distribution of organic certificates. Ninety-five percent of the organic certificates in the five provinces are concentrated in Guizhou, Sichuan, and Yunnan; among the fifty-four cities, Chengdu and Zuiyi account for 36.1% of the total number of organic certificates; and the majority of the certified organics, or 76.95 percent, are plants.

Second, a few variables, such as precipitation, temperature, GDP, highway density, gross agricultural output, agriculture machinery, and rural employed persons, showed a clear association with the distribution of organic certificates in Southwest China, suggesting

that the spatial distribution of organic farming in southwest China was influenced by the interaction of environmental and socioeconomic factors.

Thirdly, there were significant regional, topographical, economic, and agricultural differences in the factors affecting the distribution of organic certificates. The distribution of organic certificates was considerably influenced by different factors in southwest China, Sichuan, Guizhou, Yunnan, and Tibet, demonstrating a strong scale dependence. In addition, the factors hindering the development of organic agriculture were significantly lower in areas with better economic and agricultural conditions than in areas with worse conditions, suggesting that there is greater resistance to its development in areas with worse economic and agricultural conditions.

Author Contributions: Conceptualization, X.W.; Software, M.H.; Data curation, Y.L.; Writing—original draft, H.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Project of Sichuan Province Key Lab for Bamboo Pest Control and Resource Development (17ZZ013), and Project of Sichuan Provincial Science and Technology Department (2020JDR0183).

Data Availability Statement: Data obtained from the National Certification and Accreditation Information Public Service Platform and the National Meteorological Science Data Center can be downloaded from http://www.cx.cnca.cn and http://data.cma.cn/ with permission. Statistical data of climate, economy, and agriculture can be downloaded from the statistical offices of each province.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Marchese, C. Biodiversity hotspots: A shortcut for a more complicated concept. *Glob. Ecol. Conserv.* **2015**, *3*, 297–309. [CrossRef]
2. Shi, X.-W.; Zhang, L.; Zhang, J.-J.; Ouyang, Z.-Y.; Xiao, Y. Priority area of biodiversity conservation in Southwest China. *Chin. J. Ecol.* **2018**, *37*, 3721.
3. The Chinese Ministry of Environmental Protection, the Chinese Academy of Science. Announcement on the Publication of the National Ecological Functional Zoning (Revised Version). Available online: https://www.mee.gov.cn/gkml/hbb/bgg/201511/t20151126_317777.htm (accessed on 5 October 2023).
4. Ministry of Agriculture and Rural Affairs of the People's Republic of China; National Development and Reform Commission of the People's Republic of China. Implementation Program for Carbon Sequestration and Emission Reduction in Rural and Agricultural Areas. Available online: http://www.moa.gov.cn/govpublic/KJJYS/202206/P020220630331656855638.pdf (accessed on 5 October 2023).
5. Cao, W.; Tao, H.; Kong, B.; Liu, B.; Sun, Y. Automatic Recognition of Geomorphology in Southwest China Based on DEM Data Segmentation Research on Automatic Recognition of Landform Morphology. *China Soil Water Conserv.* **2011**, 38–41.
6. Gabriel, D.; Carver, S.J.; Durham, H.; Kunin, W.E.; Palmer, R.C.; Sait, S.M.; Stagl, S.; Benton, T.G. The spatial aggregation of organic farming in England and its underlying environmental correlates. *J. Appl. Ecol.* **2009**, *46*, 323–333. [CrossRef]
7. Shennan, C.; Krupnik, T.J.; Baird, G.; Cohen, H.; Forbush, K.; Lovell, R.J.; Olimpi, E.M. Organic and conventional agriculture: A useful framing? *Annu. Rev. Environ. Resour.* **2017**, *42*, 317–346. [CrossRef]
8. Willer, H.; Trávníčekm, J.; Meier, C.; Schlatter, B. *The World of Organic Agriculture Statistics and Emerging Trends 2023*; Druckerei Hachenburg: Hachenburg, Germany, 2023.
9. King, F.H. *Farmers of Forty Centuries: Permanent Agriculture in China, Japan and Korea*; CreateSpace Independent Publishing Platform: Scotts Valley, CA, USA, 1911.
10. Erping, W. The development of organic agriiculture in china and organic product certification and supervision. *Chin. J. Agric. Resour. Reg. Plan.* **2014**, *35*, 70–74.
11. Tuomisto, H.L.; Hodge, I.; Riordan, P.; Macdonald, D.W. Does organic farming reduce environmental impacts?—A meta-analysis of European research. *J. Environ. Manag.* **2012**, *112*, 309–320. [CrossRef]
12. Reganold, J.P.; Wachter, J.M. Organic agriculture in the twenty-first century. *Nat. Plants* **2016**, *2*, 15221. [CrossRef]
13. Finley, L.; Chappell, M.J.; Thiers, P.; Moore, J.R. Does organic farming present greater opportunities for employment and community development than conventional farming? A survey-based investigation in California and Washington. *Agroecol. Sustain. Food Syst.* **2018**, *42*, 552–572. [CrossRef]
14. Fisher, P. Barriers to the Adoption of Organic Farming in Canterbury. Master's Thesis, Lincoln College, University of Canterbury, Canterbury, UK, 1989.
15. Padel, S. Conversion to organic farming: A typical example of the diffusion of an innovation? *Sociol. Rural.* **2001**, *41*, 40–61. [CrossRef]

16. Daskalopoulou, I.; Petrou, A. Utilising a farm typology to identify potential adopters of alternative farming activities in Greek agriculture. *J. Rural. Stud.* **2002**, *18*, 95–103. [CrossRef]
17. Fairweather, J.R. Understanding how farmers choose between organic and conventional production: Results from New Zealand and policy implications. *Agric. Hum. Values* **1999**, *16*, 51–63. [CrossRef]
18. Burton, M.; Rigby, D.; Young, T. Analysis of the determinants of adoption of organic horticultural techniques in the UK. *J. Agric. Econ.* **1999**, *50*, 47–63. [CrossRef]
19. Ilbery, B.; Holloway, L.; Arber, R. The geography of organic farming in England and Wales in the 1990s. *Tijdschr. Econ. Soc. Geogr.* **1999**, *90*, 285–295. [CrossRef]
20. Bichler, B.; Häring, A.M.; Dabbert, S.; Lippert, C. Determinants of Spatial Distribution of Organic Farming in Germany. In Proceedings of the Researching Sustainable Systems, Adelaide, SA, Australia, 21–23 September 2005.
21. Frederiksen, P.; Langer, V. Localisation and concentration of organic farming in the 1990s–the Danish case. *Tijdschr. Econ. Soc. Geogr.* **2004**, *95*, 539–549. [CrossRef]
22. Läpple, D.; Cullinan, J. The development and geographic distribution of organic farming in Ireland. *Ir. Geogr.* **2012**, *45*, 67–85. [CrossRef]
23. Malek, Ž.; Tieskens, K.F.; Verburg, P.H. Explaining the global spatial distribution of organic crop producers. *Agric. Syst.* **2019**, *176*, 102680. [CrossRef]
24. Yuan, J.; Yan, Q.; Hhuang, P.; Ding, Y. Factors Influencing Farming Households'adoptions of Organic Farming in Guizhou Province: A case from W village, Guiyang. *Guizhou Agric. Sci.* **2009**, *37*, 216–218.
25. Li, B.; Kang, P.; Dan, H.; Jin, Y.; Wang, Z. Problems of Chinese Organic Certification and Supervision System—Based on the Perspective of Organic Agriculture Market Cultivation of Yunnan Province. *J. Anhui Agric. Sci.* **2016**, *44*, 211–214.
26. Sun, J.; Sun, W.; Chen, Z.; Zhao, C. Yunnan Organic Agriculture Products Certification Status and Analysis. *J. Anhui Agri. Sc.* **2015**, *43*, 299–300, 329.
27. Yan, T. Analysis of factors affecting farmers'intention to reduce fertilization under organic certification system. *J. Arid. Land R. Esources Environ.* **2019**, *33*, 29–34.
28. Wang, H.; Wang, Y.; Liu, H.; Wang, Z. Spatial Dependence and Influencing Factors Analysis of Organic Agricultural Enterprise Bases in China: A Case Study of Sichuan Province. *Chin. J. Agric. Resour. Reg. Plan.* **2023**. Available online: http://kns.cnki.net/kcms/detail/11.3513.S.20230714.1624.002.html (accessed on 5 October 2023).
29. Binswanger, H. The policy response of agriculture. *World Bank Econ. Rev.* **1989**, *3* (Suppl. S1), 231–258. [CrossRef]
30. Huang, W.Q.; Wu, L.; Hu, J. Deternimants of farmers' willingness and behavior to engage in ecological circular agriculture: Market returns or policy incentives? *China Popul. Resour. Environ.* **2017**, *27*, 69–77.
31. Lu, C.-F.; Cheng, C.-Y. Impacts of spatial clusters on certified organic farming in Taiwan. *Sustainability* **2019**, *11*, 2637. [CrossRef]
32. Brian Ilbery, D.M. Clustering and the spatial distribution of organic farming in England and Wales. *Area* **2011**, *43*, 31–41.
33. Li, Y.P.; Wang, Y.H.; Gu, B.X. The Spatial Distribution and Impact of Organic Certification Information Center in China. *Appl. Mech. Mater.* **2013**, *361*, 136–144. [CrossRef]
34. Xie, B.; Qin, J.; Yang, H.; Wang, X.; Wang, Y.-H.; Li, T.-Y. Organic aquaculture in China: A review from a global perspective. *Aquaculture* **2013**, *414*, 243–253. [CrossRef]
35. Yu, L.; Ping'an, X.; Liang, Y. Agglomeration and spatial dependence of organic agriculture in China. *Chin. J. Eco-Agric.* **2021**, *29*, 440–452.
36. Lu, Y.; Xiang, P. Spatial effects and influencing factors of organic agriculture in China. *Jiangsu J. Agric. Sci.* **2021**, *37*, 1583–1591.
37. Jiao, X.; Xin, X.; Guo, Q.; Xiu, W. Research on the development path of organic agriculture under the strategy of Rural Revitalization. *Agric. Econ.* **2022**, 15–17.
38. Zhuo, M. Development, Question and Countermeasure of Organic agriculture in China. *Chin. Agric. Sci. Bull.* **2006**, *22*, 338–342.
39. Liu, Q.; Meng, Q.; Li, X.; Xia, Z. Development status, problems, countermeasures and prospects of China's organic livestock and poultry industry. *Chin. J. Anim. Sci.* **2010**, *46*, 43–47.
40. Jouzi, Z.; Azadi, H.; Taheri, F.; Zarafshani, K.; Gebrehiwot, K.; Van Passel, S.; Lebailly, P. Organic Farming and Small-Scale Farmers: Main Opportunities and Challenges. *Ecol. Econ.* **2017**, *132*, 144–154. [CrossRef]
41. Qiao, Y.; Halberg, N.; Vaheesan, S.; Scott, S. Assessing the social and economic benefits of organic and fair trade tea production for small-scale farmers in Asia: A comparative case study of China and Sri Lanka. *Renew. Agric. Food Syst.* **2015**, *31*, 246–257. [CrossRef]
42. Steffan-Dewenter, I.; Münzenberg, U.; Bürger, C.; Thies, C.; Tscharntke, T. Scale-Dependent Effects of Landscape Context on Three Pollinator Guilds. *Ecology* **2002**, *83*, 1421–1432. [CrossRef]
43. Cushman, S.A.; Landguth, E.L. Scale dependent inference in landscape genetics. *Landsc. Ecol.* **2010**, *25*, 967–979. [CrossRef]
44. Läpple, D.; Kelley, H. Spatial Dependence in the Adoption of Organic Drystock Farming in Ireland. *Eur. Rev. Agric. Econ.* **2015**, *42*, 315–333. [CrossRef]
45. Allaire, G.; Poméon, T.; Maigné, E.; Cahuzac, E.; Simioni, M.; Desjeux, Y. Territorial analysis of the diffusion of organic farming in France: Between heterogeneity and spatial dependence. *Ecol. Indic.* **2021**, *59*, 70–81. [CrossRef]
46. Lu, Y.; Xiang, P.; Yu, L. Influencing factors and spatial effects of organic agriculture adoption: Based on survey data of farmers in Xinjiang. *Chin. J. Eco-Agric.* **2022**, *30*, 153–165.

47. Swinton, S.M.; Lupi, F.; Robertson, G.P.; Hamilton, S.K. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. *Ecol. Econ.* **2007**, *64*, 245–252. [CrossRef]
48. Swift, M.J.; Anderson, J.M. Biodiversity and Ecosystem Function in Agricultural Systems. In *Biodiversity and Ecosystem Function*; Schulze, E.-D., Mooney, H.A., Eds.; Springer: Berlin/Heidelberg, Germany, 1994; pp. 15–41.
49. Yin, R.; Li, X.; Fang, B. The Relationship between the Spatial and Temporal Evolution of Land Use Function and the Level of Economic and Social Development in the Yangtze River Delta. *Int. J. Environ. Res. Public Health* **2023**, *20*, 2461–2483. [CrossRef] [PubMed]