sustainability

MDPI

Article

A Novel Approach to Bridging Physical, Cultural, and Socioeconomic Indicators with Spatial Distributions of Agricultural Heritage Systems (AHS) in China

Guilin Liu [1,*] and Domenico M. Doronzo [2]

[1] School of Geography, South China Normal University, Guangzhou 510631, China
[2] National Institute of Geophysics and Volcanology, Vesuvian Observatory, 80124 Naples, Italy; domenico.doronzo@ingv.it
* Correspondence: liuguilin@m.scnu.edu.cn or guilinshiwo@163.com

Received: 2 June 2020; Accepted: 22 August 2020; Published: 26 August 2020

Abstract: This paper aimed at analyzing the spatial distribution and variation of agricultural heritage systems (AHSs) in China. In particular, the spatial relationships between AHS sites and influencing factors were analyzed by employing a spatial analysis approach, i.e., solving for cause–effect relations. Then, two reasonable pathways for protecting AHSs were proposed following this methodology. The results showed that the number of AHS sites in eastern China was larger than in western China. This peculiar distribution is thought to be affected by distinctive natural resource endowments and sociocultural traits of local agricultural systems. Indeed, a series of natural, sociocultural, and economic factors were analyzed to reveal their relationships with AHSs. In China, AHS sites have excellent and unique natural conditions, and their clustered distributions positively correlate with the spatial distribution of high-quality agricultural products and the biological abundance index; on the other hand, they negatively correlate with the relief degree of the land surface and GDP. Further results showed that regions with AHSs were mainly located in rural areas of major Chinese cultural zones. In conclusion, two pathways of implementation of high-quality agricultural products and agro-tourism were proposed in order to play an integrated economic, social, and ecological function for protecting AHSs in China. These scientific findings may encourage local governments to protect AHSs and the transition of rural communities.

Keywords: agricultural heritage systems; spatial analysis; influencing factors; cause–effect relations; spatial distribution; AHS protection

1. Introduction

Rapid economic development is threatening agricultural heritage, biodiversity, and rural society. The pressures of increasing yield and reduced prices force farmers to adopt unsustainable methods and adopt specialist agricultural production methods. These approaches tend to introduce exotic species and to damage traditional agricultural production and the associated culture. As a result, communities in affected rural areas are dragged into a vicious cycle of socioeconomic unrest. In 2002, the concept of Globally Important Agricultural Heritage Systems (hereafter, GIAHSs) was conceptualized and formulated by Parviz Koohafkan of the Food and Agriculture Organization of the United Nations (FAO), and was eventually launched at the World Summit on Sustainable Development [1] to prevent the disappearance of many rural communities, their agriculture-related cultures, and biodiversity against the background of industrialization, modernization, and globalization of agriculture. A GIAHS is a unique land use system and agricultural landscape with rich biological diversity formed by the long-term co-evolution and dynamic adaptation of rural communities and the surrounding environment [2,3] (Figure 1a). Such systems are not only rich in biodiversity, but also meet the requirement of ensuring local economic and social development as well as promoting regional sustainable development [4]. GIAHSs were mainly proposed to promote the global sustainable agricultural development [5] because rural regions with agricultural heritage system (AHS) sites have a series of ecological and social problems, such as ecological degradation, lagging economies, outflow of young laborers, and loss of agricultural landscapes and traditional cultures [6]. The traits of multifunctionality, sustainability, and strategy make GIAHSs and surrounding rural communities adapt to extreme natural conditions and global changes, maintain the livelihood security of residents, and promote sustainable agricultural and rural development [7,8]. The 2030 agenda for sustainable development proposed 17 sustainable development goals (SDGs) for the three aspects of sustainable development: economic development, social progress, and environmental protection [9]. Among the SDGs, Goal 1 and Goal 2 of the SDGs mainly aim to eliminate poverty and hunger, achieve food security, and promote sustainable agriculture [9]. In 2017, the FAO's Scientific Advisory Group (SAG) of GIAHSs also discussed that GIAHSs' contribution to SDGs is one of their future research priorities [8]. Correspondingly, research on and initiatives for GIAHSs mainly connect to Goal 1 and Goal 2 of the SDGs, and mainly focus on rural transitions and sustainable development by proposing potential pathways for GIAHS development and protection. In addition, agricultural and rural development policies at the national or regional level also have an important impact on the protection and development of GIAHSs [10]. China has upgraded the protection of agricultural cultural heritage to government actions [11], and the Ministry of Agriculture and Rural Affairs (MARA) of the People's Republic of China has also issued a regulation on AHSs [12]. The Convention Concerning the Protection of the World Cultural and Natural Heritage issued by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) provides scientific evidence and practices for protecting and monitoring GIAHSs, which have prompted the cooperation of MARA, provincial departments, and bureaus in heritage sites in AHS protection and relevant policies in China [10]. Similarly, the other countries and regions of the world also proposed policies and guided GIAHS applications and protections. For example, agricultural sectors in Japan proposed policies and subsidies on GIAHS protection and sustainable development [11].

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

Figure 1. (**a**) Hani Rice Terraces; (**b**) Qingtian Rice–Fish Co-culture system (https://www.flickr.com/photos/giahs/albums).

Under the UN's SDGs and the national policies of different countries in the world, increasing successful cases of GIAHSs have been reported. For example, after the Qingtian Rice–Fish Co-culture system (RFC) was designated as a GIAHS, the selling price of fish and rice per kg increased by 316.7% and 100% in Longxian village from 2004 to 2013 [13]. This price is higher than the ones for the same products in other production areas and brings higher profits for local residents [14] due to the brand effect in Longxian village, which has been the core village of the Qingtian Rice–Fish Co-culture system. On the other hand, the amounts of chemical fertilizer and pesticide decreased by 34.94% and 86.76% during 2004–2013, respectively [13]. Such increases generally lead to valuable and added-value benefits in that they have a positive impact on the stability, sustainable development, cultural protection, and inheritance of rural communities by contributing to the pride of farmers' culture and attracting local residents to return home and participate in AHS employment [13]. Meanwhile, the local government plays an overall role of coordination and conservation in AHS development, protection, and promotion by providing policies, subsidies, and financial and intellectual support for local residents and communities [15]. This is beneficial as an investment in the mid to long term for the local communities, also because it takes into account the sustainable development goals as defined by the United Nations. Analogously to the Qingtian Rice–Fish Co-culture system, the successful GIAHS cases in the world have had similar situations by raising prices of distinctive agricultural products to drive local economic development, rural community construction, and cultural inheritance, such as Sado's Satoyama in Harmony with Japanese Crested Ibis in Japan [16], the agriculture system in Chiloé Island of Chile [17,18], the agroforestry heritage systems in the mountain oases of Tunisia [19], and the traditional terraced landscapes in Chianti of Italy [20].

From the perspective of their contents, GIAHSs can be divided into material or non-material and tangible or intangible aspects of the cultural heritage of agriculture [21]. GIAHSs and the concept of cultural landscape proposed by the World Heritage Committee [22], which in turn relates to the World Heritage proposed by UNESCO [23], all have quite similar definitions [1]. However, GIAHSs promote dynamic conservation of traditional knowledge systems and their associated culture and landscapes. In addition, the agricultural heritage system has a composite character [24], a living state [1], and a strategic character [25], and it is affected by the natural environment and human social environment. For example, natural resource endowments affecting agricultural practices are water, soil, air temperature, and solar radiance. The biological abundance index [26] can be considered the epitome of natural factors mentioned above according to its calculation process. In addition, special terrain attributes are important for parts of AHS sites, such as rice terrace systems in southwestern China. The relief degree of a land surface also provides the physical habitat for biodiversity. Moreover, socioeconomic and cultural factors also reflect AHS sites and their distributions. The gross domestic product (GDP) is considered an effective indicator for describing socioeconomic activities at the national scale [27], while the geographical indications for agricultural products (hereafter, AGIs) [28] and traditional Chinese villages [29] are indictors for representing the tangible cultural heritage and intangible cultural heritage of agriculture. The traditional Chinese villages refer to villages or settlements that were formed earlier and contain rich historical information, cultural landscapes, and heritage of the Chinese farming civilization [30]. The traditional Chinese villages are not only the space for intangible culture [31], but also a potential rural tourism resource, and they present a traditional agricultural circular economy for sustainable rural development [32]. Thus, traditional Chinese villages can be used as an indicator for characterizing intangible cultural heritage.

Similarly, to assess the land use sustainability, the Integrated Project of the European Union (Sustainability Impact Assessment: Tools for Environmental, Social, and Economic Effects of Multi-Functional Land Use in European Regions, SENSOR) proposed the multi-functionality of land use based on several land use functions and corresponding indictors from the perspectives of economy, society, and environment [33]. Additionally, the Millennium Development Goals (MDGs) of the United Nations proposed eight goals, 18 specific goals, and 48 indicators for global sustainable development [34] from the social, economic, and environmental perspectives. Then, the 2030 Agenda for Sustainable Development proposed 17 sustainable development goals (SDGs) for the three aspects of sustainable development: economic development, social progress, and environmental protection [9]. The UN's SDGs are composed of 17 goals, 169 specific goals, and 232 indicators [35]. From the land use multifunctionality to the SDGs, we summarize that the above-mentioned studies and reports have similar goals for sustainability from the social, economic, and environmental perspectives. Moreover, the selected indicators also correspond to these three perspectives.

For example, GDP is generally used as an important indicator for revealing regional and global variations of economic developments. Meanwhile, intangible and tangible culture indicators are also used for measuring social and cultural developments. Physical factors, such as soil, water, precipitation, solar radiation, terrain, and their derived indicators, are generally used to reveal spatial variations of the environmental perspective on sustainable development. Thus, those above-mentioned indicators influencing GIAHSs correspond exactly to the physical, cultural, and socioeconomic aspects, which form the solid basis of the methodological framework of this article.

After the Qingtian Rice–Fish Co-culture system (Figure 1b) in China was firstly selected as a pilot-designated GIAHS by the FAO in the calendar year 2005 [36], relevant Chinese originations began to attach importance to the application and protection of GIAHSs. A total of 15 GIAHS sites in China have been designated, accounting for 28.85% of Globally Important Agricultural Heritage Systems in the calendar year 2018. Additionally, China has also carried out a selection and protection strategy of nationally important agricultural heritage systems, aiming for AHS site protection. This project was launched in 2012 [37] and currently includes 91 China-Nationally Important Agricultural Heritage System (NIAHS) sites identified by the Ministry of Agriculture of the People's Republic of China.

Given that geographical attributes are defined for each agricultural heritage system, an AHS can be managed and accurately expressed as a point feature in a Geographical Information System (GIS), which can reveal spatial distribution and its variations. Similarly to AHSs, archaeological sites in China [38,39], as well as geographical indications for agricultural products [28], historic and cultural villages [40], the world heritage [41], and intangible cultural heritage [42], are all considered as point features in GIS, and their spatial distribution and related variations have also been analyzed by spatial analysis methods. However, the spatial relationship between distribution of AHS sites in China and physical, cultural, and socioeconomic factors was first reported by means of GIS spatial analysis in this paper. Previous studies on AHSs mainly focused on their definitions [43,44], values [45], ecological compensation [46], comparative studies on AHS conservation in different countries [47], ecosystem services of social–ecological production landscapes [48–50], protection and development [51–53], and tourism analysis [54–56]. These research works were confined to individual AHSs and their corresponding communities, while reports regarding quantitative analyses on the relationship between distributions of natural indicators, human indicators, and AHS sites at a national scale were relatively rare. AHSs represent unique places of conjunction among landscape conservation, tourism increase, international cultural interchange, and green economy [57,58]. Thus, the spatial relationship between AHS sites, traditional villages [59], and AGIs [28] can provide measures for agricultural sustainability and rural development by proposing two pathways: high-quality food and rural tourism. Such links to AHSs can further lead to the protection of traditional villages and the reconstruction of rural communities as a consequence of increased economic, cultural, and ecological benefits for the community. This is because AGIs can generate high-quality products and bring more economic benefits with less agricultural pollution [28]. Meanwhile, AGIs also contain cultural heritage for improving the cultural and sustainable development of rural communities and rural tourism [28].

2. Research Aim

Understanding of the distribution of AHSs at a national scale, in conjunction with universally recognized physical, cultural, and socioeconomic indicators of AHS types, is required to provide those above-mentioned findings and suggestions for governments and agricultural sectors to play a role of overall planning and financial support in AHS protection and development [6]. The rational evaluation of AHS site distribution and its relationship with physical, cultural, and socioeconomic indicators is helpful for AHS protection, inheritance, and sustainable development. Thus, this paper attempts (1) to analyze the spatial distribution of AHS sites; (2) to propose a novel indicator system for revealing effects of integrated physical, cultural, and socioeconomic factors on AHS distribution; and (3) to provide scientific recommendations and guidelines about AHS protection, development, and promotion by stimulating governments and agricultural sectors in China. Our research contributes to AHS protection mainly in that we analyze how integrated physical, cultural, and socioeconomic indicators affect AHSs in China using a novel quantitative analysis model.

3. Material and Methods

3.1. Data Sources

A total of 91 agricultural heritage systems had been designated by the Ministry of Agriculture of the People's Republic of China until June 28, 2017 (Table 1). The data of those agricultural heritage systems were then acquired, including names, site locations, cultivation systems, ethnic groups, and other variables. A detailed description about AHSs in China can be found in [37]. In addition, globally important agricultural heritage systems in the world were obtained from FAO [1] (Table 1). Data on traditional villages in China were obtained from the Global Change Research Data Publishing and Repository [29]. Their site names were provided with accurate geographic locations using Google Maps, and were mapped as point data in the ESRI ArcGIS 10.2 software. Geographical indications for agricultural products registered before the year of 2013 were also obtained and mapped using ArcGIS software [28]. The biological abundance index values for 2005 [26], gridded gross domestic product (GDP) distribution [27] for 2010, and the relief degree of the land surface of China (RDLS) [60] were all collected from the Global Change Research Data Publishing and Repository, and their descriptions can be found in Table 1. The spatial resolution of these gridded data covering China was 1 km. The biological abundance index, ranging from 0% to 100%, indirectly reflects the biological abundance by revealing the difference in species numbers of ecosystems per unit area [26]. Generally, the biological abundance index (BAI) can reflect the different types of ecosystems in a region. A land cover map for the year 2015 was obtained, which was generated by the European Space Agency (Table 1). A detailed description of these data can be found in Table 1.

Table 1. Descriptions of the data in this paper.

Name	Format	Description	Source
Agricultural Heritage Systems (AHSs)	Vector	Locations and attributes of Chinese NIAHSs	http://www.moa.gov.cn/ztzl/zywhycsl/ http://www.fao.org/giahs/giahs-sites/zh/
Traditional Village Distribution	Vector	Locations of traditional Chinese villages during 2012–2014	http://www.geodoi.ac.cn/WebEn/doi.aspx?Id=910
Basic Map	Vector	1:4,000,000 Chinese province-division map	The National Geomatics Center of China
Distribution of Geographical Indications for Agricultural Products (AGIs)	Vector	Reflects the spatial variations of AGIs before 2013	Liu et al. 2016 [28]
Land Cover Data	Grid	Land cover types in 2015 from the Project of Climate Change Initiative Land Cover implemented by European Space Agency	http://maps.elie.ucl.ac.be/CCI/viewer/index.php
Relief Degree of Land Surface of China	Grid	Comprehensive data about regional altitude and surface cutting degree	http://www.geodoi.ac.cn/WebEn/doi.aspx?Id=887
Biological Abundance Index	Grid	Descriptions of the biological abundance in 2005 by revealing the difference in species numbers of ecosystems per unit area	http://www.geodoi.ac.cn/WebEn/doi.aspx?Id=185
GDP Data Distribution	Grid	GDP distribution per 1 km grid in 2010	http://www.geodoi.ac.cn/WebEn/doi.aspx?Id=125

3.2. Methodology

This paper obtained the accurate locations (longitude and latitude) of AHS sites using Google Maps to create a GIS database (Figure 2). Then, statistical methods and GIS were employed to illustrate the distribution and spatial variations of AHS sites in China. In addition, spatial analysis methods were also used to reveal the spatial relationship between AHS sites and influencing factors.

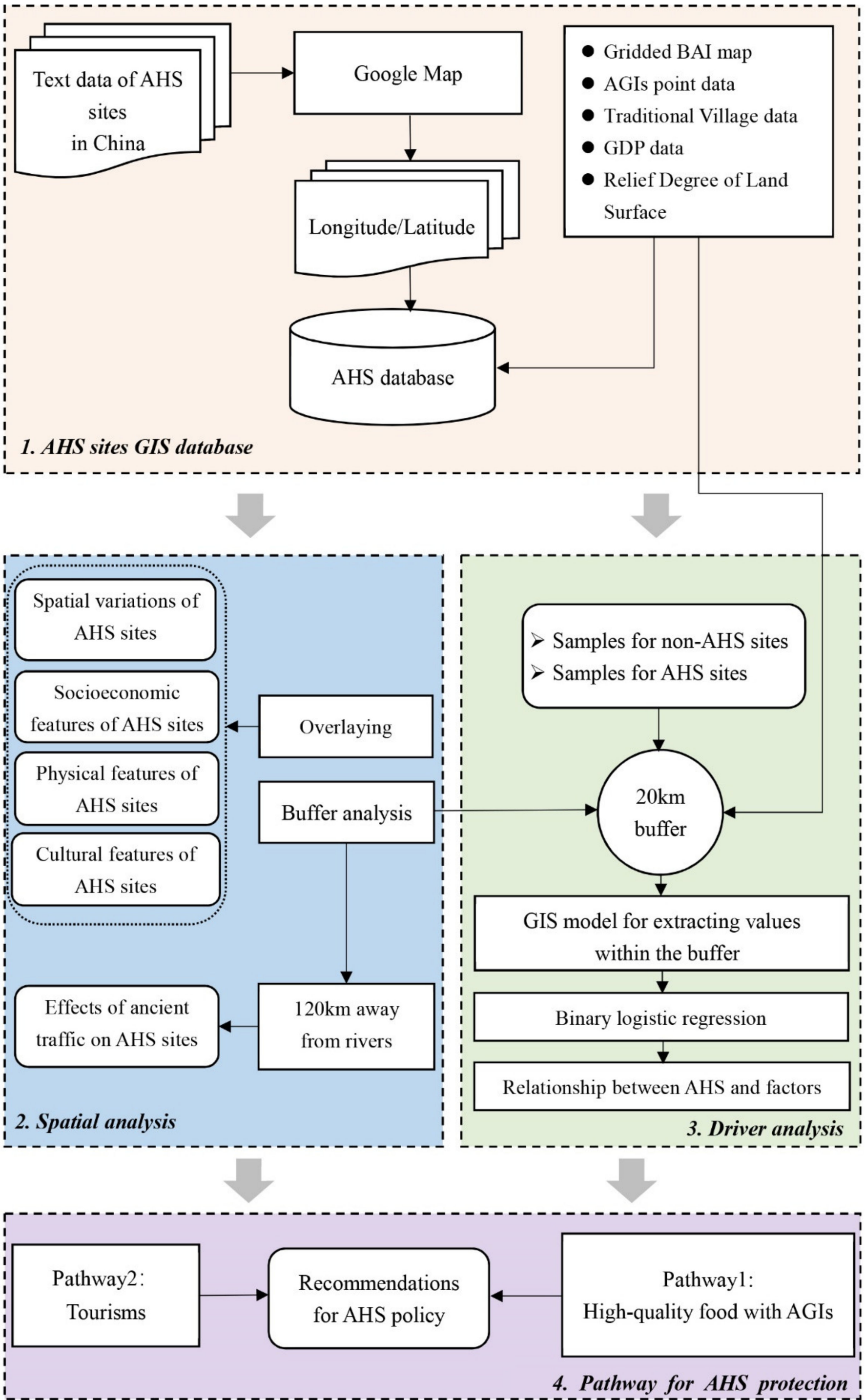


Figure 2. A flowchart as a schematic representation of the research framework followed in this paper.

3.2.1. Identification of Influencing Factors

To understand factors influencing the spatial distribution of AHS sites in China, numerous factors from the perspective of natural resource endowments, cultural traits, and socioeconomic development were proposed (Table 2). Generally, AHS sites have natural resource endowments suitable for crop growth and agricultural development. This paper selected the relief degree of land surface and the biological abundance index as natural factors. The biological abundance index reflects the climate, water, and soil conditions, and the relief degree of land surface was selected to describe the complex and diverse living spaces for agricultural heritage systems. Biodiversity can also affect the distribution and type of AHS to a certain extent. In addition, GDP and cultural factors (including geographical indications of agricultural products and traditional villages) were also selected to reveal their relationships with AHS sites. The tangible cultural heritage was expressed by geographical indications of agricultural products (AGIs) because products of AGIs were considered high-quality products in the rural areas. Regions with AHS sites generally have a low level of economic development, thereby leading to an outflow of young people [61]. Thus, GDP is an important indicator to describe the economic development. In synthesis, these indicators can explain evaluation purposes and quality assessments, and, at the same time, it is easy to obtain their effectiveness in conjunction with the spatial distribution and clustering of data.

Table 2. Selection and definition of influencing indicators.

First Level	Second Level	Corresponding Indicators/Units	References
Physical factors	Terrain complexity	Relief degree of land surface of China, dimensionless	[60]
	Biodiversity	Biological abundance index, dimensionless	[26]
Cultural factors	Tangible cultural heritage	Geographical indications of agricultural products, number	[28]
	Intangible cultural heritage	Traditional villages, number	[29]
Socioeconomic factors	GDP	GDP, Chinese Yuan (CNY)	[27]

3.2.2. GIS Spatial Analysis

To better compare the present results with the literature [6], a shared criterion of classification was used to divide 91 Chinese NIAHS sites into 30 farming system sites, 49 horticulture system sites, 7 mixed system sites, 3 aquaculture system sites, and 2 pastoral system sites. This subdivision was based on the cultivated crop types, agricultural culture, and farming practices of the 91 Chinese NIAHS sites. To guarantee the presence of data for influencing factors in each unit, we generated 59 points without AHSs for samples using ArcGIS software, and selected 86 AHS sites, excluding the 3 aquaculture system sites and 2 pastoral system sites, since these systems are relatively tougher to quantify. The 59 non-AHS sites are evenly distributed and cover areas where AHS sites are less likely to exist. Meanwhile, a 20 km circular buffer for 145 sites was generated to quantitatively analyze the relationship between AHSs and influencing factors.

The AHS site is not strictly a point, but, more broadly, represents a region. Previous research works [13,62–64] have generally used administrative boundaries (e.g., counties, towns, and villages) for the AHS cores and surrounding regions, but a gap actually exists between such boundaries and the real AHS regions. By analyzing different AHS sites, it was found that most of them are concentrated in several towns, and the region is less than the area of a circle with a radius of 20 km. The buffer size, therefore, makes sense, since AHS sites can influence the region within 20 km. Then, values corresponding to selected influencing factors were extracted based on the 20 km buffers. Additionally, the 20 km buffer was used to extract the land cover types mapped by the European Space Agency to reveal the number of land cover types. Then, the spatial relationships between 86 farming, horticulture, and mixed-system sites and land cover types within the 20 km buffers of AHS sites were analyzed.

Spatial distributions and variations of natural endowments vary with the distance from the major rivers in China and, therefore, have a limited scope of influence within the watersheds [65]. On the other hand, due to the important water transportation system in ancient China, the cultural exchange and dissemination along the rivers have similar spatial variations [66]. Thus, the relationship between the Chinese cultural distribution of where AHSs are located and the major rivers in China should be also considered. Meanwhile, we generated 80, 100, and 120 km buffer zones along the major rivers and respectively counted the number of AHS sites within the buffers. About 37.36% of the AHS sites are within the 80 km buffer; the percentage increases to 41.76% in the 100 km buffer and 46.15% in the 120 km buffer. Most AHS sites are concentrated within the 120 km buffer, while no obvious change occurs with a buffer of greater than 120 km. In summary, it is found that the zonally distributed AHS sites are clearly expressed within 120 km buffer zone, which is also within the reasonable scope of influence of the traditional agricultural culture and natural resource endowments. Therefore, this paper selected a 120 km buffer along the major rivers for analyzing the spatial variations of AHS sites.

3.2.3. Binary Logistic Regression Modeling

The existence of AHSs within each buffer was considered a binary variable (0 represents nonexistence of AHS sites, 1 represents existence of AHS sites). AHSs were considered the dependent variable, while the biological abundance index, relief degree of land surface, AGIs, traditional villages, and GDP were independent variables. Then, a binary logistic regression model, which has been comprehensively described [67,68], was employed to quantitatively determine the relative contributions of these independent variables to the AHS distribution.

This regression model fitted the distribution of AHSs and influencing factors well. The standardized logit coefficient and the standardized odds ratio are represented as β and exp (β) in this paper (Table 3). The standardized odds ratio can measure the probability of occurrence of AHSs in each grid when independent variables are changed. If $\beta > 0$ and $\exp(\beta) > 1$, the odds of occurrence of AHSs increase, while the odds decrease when $\beta < 0$ and $\exp(\beta) < 1$. If $\beta = 0$ and $\exp(\beta) = 1$, the odds of AHSs occurring are not affected. To reduce the errors from different units of independent variables in the binary logistic regression model, these independent variables were standardized using the following formula:

$$Par' = \frac{Par - Par_{\min}}{Par_{\max} - Par_{\min}}, \quad (1)$$

where Par and Par' are the original and standardized variable, respectively, and $Par_{\max}$ and $Par_{\min}$ are the maximum and minimum value, respectively.

Table 3. Results of binary logistic regression of AHS distribution.

Independent Variable	β	Significance Probability	Standard Error (β)
Biological abundance index	2.383	0.018	1.005
GDP	7.873	0.034	3.707
RDLS	−1.968	0.043	0.974
AGIs	4.742	0.025	2.110
Traditional village	4.835	0.084	2.798
Constant	−1.534	0.028	0.7

Moreover, we diagnosed the multicollinearity of the selected influencing factors prior to the binary logistic regression model. The results show that the values of the variance inflation factor (VIF) for the selected factors are within the range from 1.07 to 1.27 and less than 2 [69], indicating no multicollinearity among the selected predictors. Thus, the selected indictors can be used for the quantitative analysis using the binary logistic regression model.

4. Results

4.1. Spatial Distribution and Variations of Chinese NIAHS Sites

Most Chinese NIAHS sites are located in the area east of the "Hu Huanyong Line" (Figure 3), which was proposed by a Chinese population geographer, Hu Huanyong [70]. This line divides the territory of China into two parts: eastern and western China [28]. In contrast to western China, eastern China has a historically cultivated civilization. The variety of land cover types within the buffers of farming systems (8–19 types), horticulture systems (7–21 types), and mixed systems (8–16 types) was diverse, while the cropland type dominates within 20 km buffers of those AHS sites, based on the spatial analysis between AHS sites and the land cover map in 2015 by employing ArcGIS software.

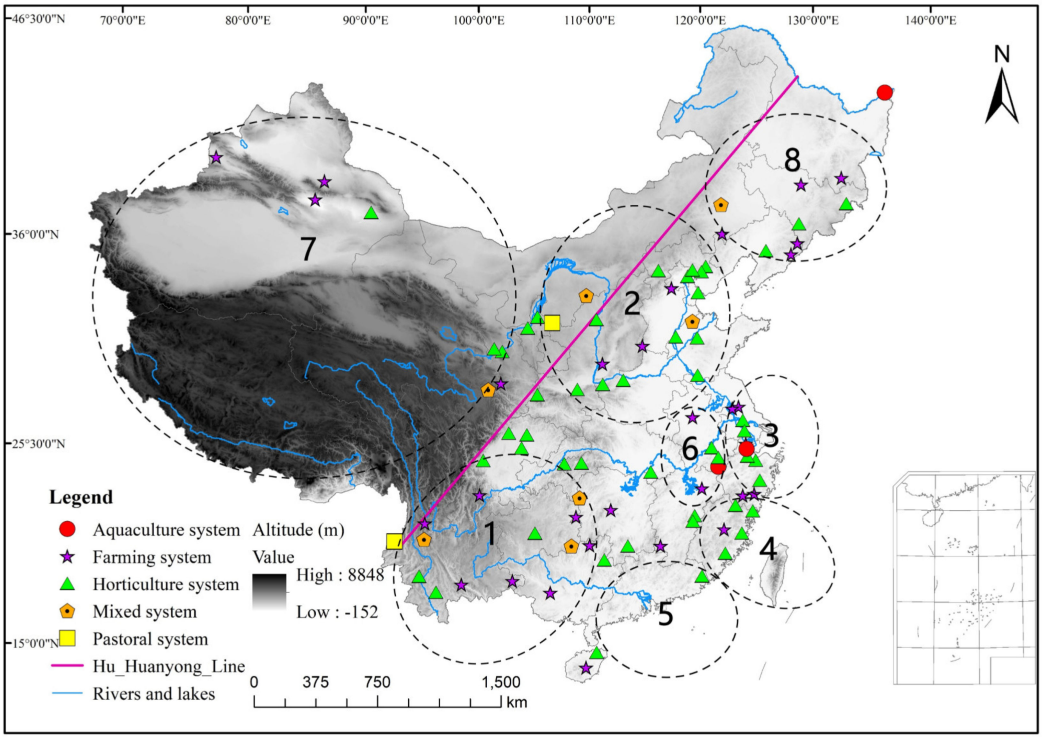


Figure 3. Distribution of China-NIAHS sites in the (1) southwestern multi-ethnic culture district, (2) central culture district, (3) Wu-Yue culture district, (4) Minnan culture district, (5) Lingnan culture district, (6) Huizhou culture district, (7) northwestern multi-ethnic culture district, and (8) northeastern culture district.

All AHS sites were located in regions with altitudes below 3200 m, and most AHS sites occurred within regions with altitudes of less than 1000 m. This is because most crops are not able to healthily grow in regions with higher altitudes. We also found that AHS sites are distributed along the main rivers of China. Therefore, a 120 km buffer was generated based on five rivers, including the Yellow River, the Yangtze River, the Lantsang River, the Pearl River, and the Beijing–Hangzhou Grand Canal, to analyze the spatial relationships between rivers and AHS sites (Figure 4). The result shows that 42 AHS sites (about 46.2%) are completely located in the buffer, and at least five AHS sites are located close to the buffer. In particular, a high distribution density of AHS sites is gathered along the Beijing–Hangzhou Grand Canal, since the artificial canal connects the Yangtze River to the Yellow River. The ancient water transportation network brings a convenient pathway for promoting migration, grain transportation, and economic and cultural exchange between the northern and southern regions of China [71]. Additionally, a concentrated phenomenon of AHS sites appears in the northeastern region of China because the northeastward migration since the year of 1860 (Qing Dynasty of China) has promoted a large-scale reclamation trend and the spread of farming civilization [72]. Zhejiang province has the largest proportion of AHSs with a total of 8, occupying about 8.8% due to the unique agricultural conditions and cultures. The proportion of AHSs in Yunan is 7.7% of those found in China, with a total of 7. However, Tibet, Qinghai, and Inner Mongolia have fewer AHS sites.

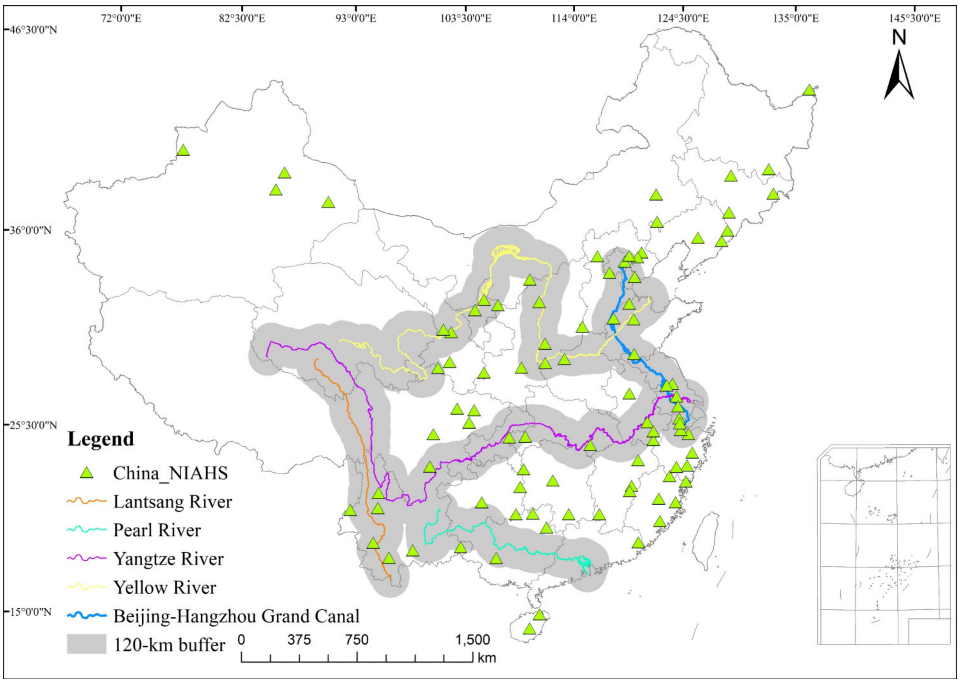
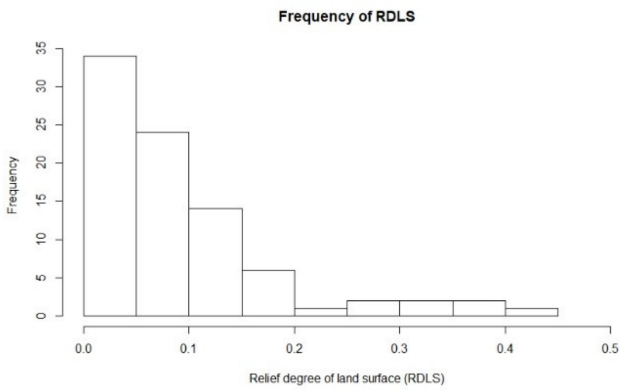


Figure 4. Spatial relationship between rivers and agricultural heritage system (AHS) sites in China.

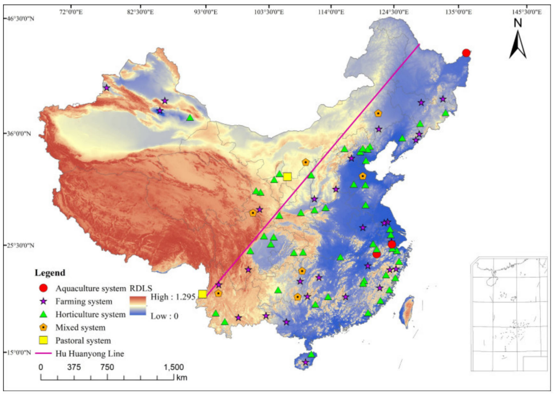
4.2. Effects of Natural Resource Endowments on Chinese NIAHS Distribution

In addition to the elevation factor, the relief degree of land surface is better for characterizing habitat. Generally, most AHS sites were mainly located in areas with an RDLS value of below 0.2 (Figure 5a,b). With the RDLS decreasing from 0.2 to 0, the frequency of AHSs appears to increase; especially in areas with RDLS values of below 0.05, the frequency of AHS sites is the highest. This shows that the most AHS sites occur in the regions with low degrees of relief of land surface. The average RDLS of farming systems in China is about 0.10, while the average RDLS values of horticulture systems and mixed systems are 0.08 and 0.17, respectively.

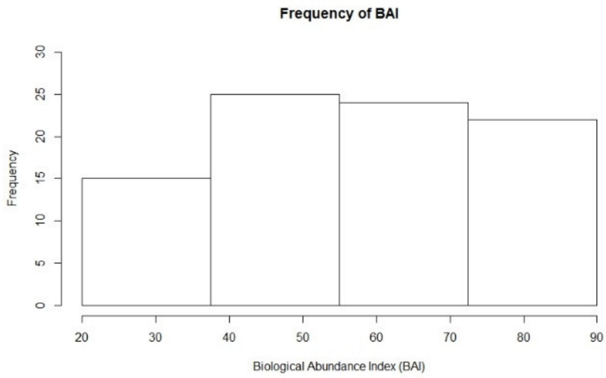


(**a**)

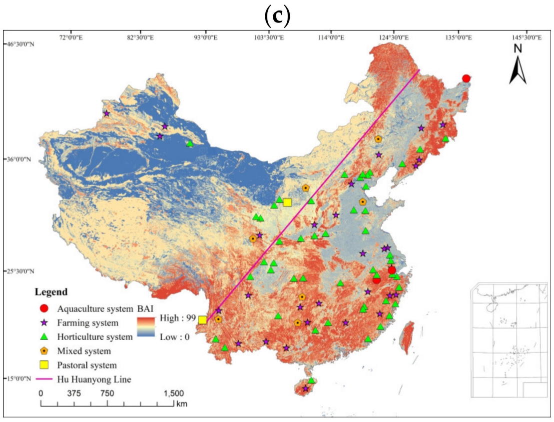
Figure 5. *Cont.*



(**b**)



(**c**)



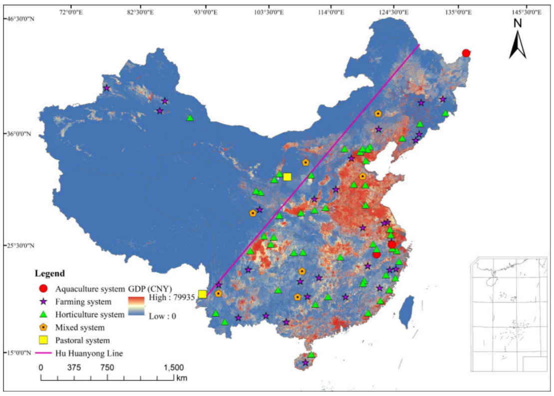
(**d**)

Figure 5. (**a**) Relationships between AHS sites and the distribution of relief degree of land surface (RDLS), (**b**) spatial relationships between AHS sites and the distribution of RDLS, (**c**) relationships between AHS sites and the distribution of biological abundance index (BAI), and (**d**) spatial relationships between AHS sites and the distribution of BAI.

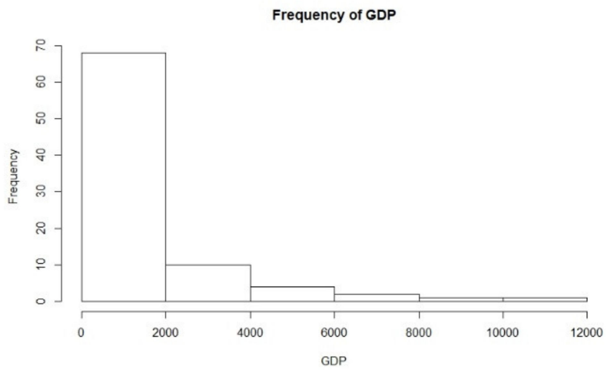
Generally, about 82.6% of AHS sites were mainly located in areas with a biological abundance index value above 37.5 (Figure 5c,d). Relatively rich and diversified biological resources can bring a wealth of agricultural products to the local community [73], and provide the possibility of developing eco-agriculture [74]. Thus, biological richness is also an important indicator for formation and conditions of AHSs. The average biological abundance index of farming systems in China is about 59.87, while the average biological abundance indexes of horticulture systems and mixed systems are 55.48 and 57.96, respectively.

4.3. Effects of the Socioeconomic Factor on Chinese NIAHS Distribution

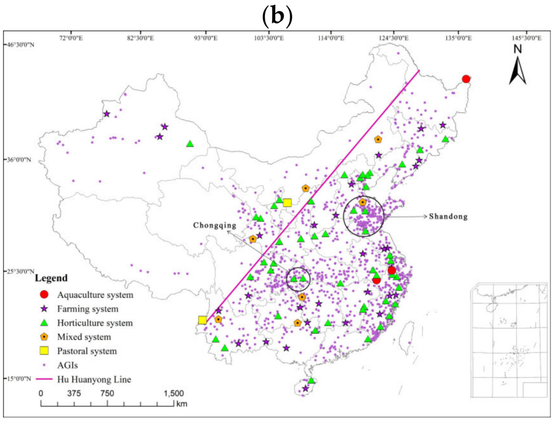
Most AHSs are located in rural regions with low GDP, according to the relationships shown in Figure 6a,b. This result shows that AHSs are typically located in relatively poor regions of China. This is consistent with the result from Min et al. (2007) [75]. The average GDP of farming systems in China is about 699.87 CNY (Chinese Yuan), while the average GDPs of horticulture systems and mixed systems are 1905.06 and 333.89 CNY, respectively. This indicates that horticulture systems generally bring a higher economic output and benefit.



(**a**)

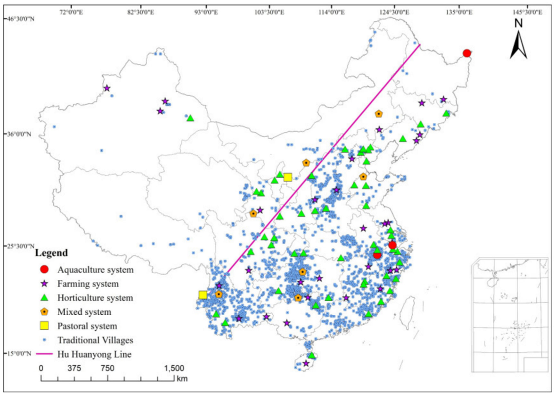


(**b**)



(**c**)

Figure 6. *Cont.*



(**d**)

Figure 6. (**a**) Spatial relationships between AHS sites and the distribution of GDP (Chinese Yuan, CNY), (**b**) relationships between AHS sites and the distribution of GDP (Chinese Yuan, CNY), (**c**) spatial relationships between AHS sites and the distribution of geographic indications of agricultural products (AGIs), and (**d**) spatial relationships between AHS sites and the distribution of traditional Chinese villages (village data from http://www.geodoi.ac.cn/WebEn/doi.aspx?Id=910).

The spatial relationship between GDP and AHSs also shows extreme variations. AHSs in eastern coastal areas are located in an environment with a well-developed economy. Highly developed economies at the periphery of AHSs have facilitated the development of agro-tourism. However, AHSs in central, southwestern, and northwestern China are located in environments with lower GDP. With the rapid development of non-agricultural industries in China [76], a large number of rural laborers have migrated into urban regions for non-agricultural professions, and this has weakened the strength of inheritance and the development of AHSs.

4.4. Effects of Tangible and Intangible Cultural Heritage Factors on Chinese NIAHS Distribution

4.4.1. Relationship between AGIs and AHSs

According to the spatial relationship between AHSs and AGIs, we found that both of them are basically consistent (Figure 6c). However, some AHSs have no geographical indications for agricultural products. Thus, attempts to show that AGIs are connected to good-quality agricultural products need further investigation. High-quality agricultural products have become a requirement for Chinese consumers. Generally, regions with AHSs also have premium agricultural products, and most stakeholders have emphasized the application and protection of AGIs. However, almost no AHSs exist in the areas of Shandong Province and Chongqing Municipality, which are obvious clusters of AGIs. The average number of AGIs for farming systems in China is about 1.1, while the average numbers of AGIs for horticulture systems and mixed systems are 1.61 and 0.86, respectively. Similarly to GDP, relatively more AGI sites are located in the horticulture system region compared to the other systems.

4.4.2. Relationship between AHSs and Traditional Chinese Villages

Unique traditional settlements are also a part of AHSs. Traditional Chinese villages, especially historic and cultural villages, can therefore be used to measure their relationship with AHSs. Figure 6d shows that the spatial distribution of AHSs is basically consistent with the distribution of historic and cultural villages in China. This relationship also reveals that regions with a high density of AHSs, AGIs, and traditional villages are located in the major Chinese cultural regions (Figure 3). These cultural districts not only provide unique cultivation systems, premium products, and historic settlements, but also formed rich intangible cultural heritage, providing basic elements for AHSs. However, only one AHS site exists in the Lingnan cultural region. This shows a great potential possibility for future designations of AHSs, while it is also a challenge due to the gradually abandoned traditional farming civilization in the Lingnan cultural region [77]. The average number of traditional villages for farming systems in China is about 1.3, while the average numbers of traditional villages of horticulture systems and mixed systems are 0.88 and 3.71, respectively. These relationships indicate that relatively more traditional villages are located in the farming system region.

4.5. Quantitative Analysis among AHSs and Influencing Factors

It has been proven above that the formation and distribution of AHSs are both closely related to natural resource endowments, as well as cultural and socioeconomic factors. However, what is the quantitative relationship between them? This article therefore revealed the relationship between AHS sites and these factors by using quantitative analyses, as compared to the qualitative descriptions in previous research. Negative values of standardized logit coefficients of RDLS revealed that a higher relief degree of land surface decreases the likelihood of occurrence of AHSs. Thus, the occurrence of AHS sites in China is lower in regions with a higher relief degree of land surface, which is consistent with the previous qualitative analysis. Conversely, a higher biological abundance index increases the likelihood of occurrence of AHSs. Most AHS sites are in regions with a biological abundance index value of above 42.75 (Figure 5c), which can also support this finding. The significance probability of the biological abundance index, GDP, and AGIs is positively correlated with the occurrence of AHSs ($p < 0.05$), while RDLS is negatively correlated with the occurrence of AHSs ($p < 0.05$). Moreover, the traditional village indicator is not adequately positively correlated with the occurrence of AHSs ($p > 0.05$). The GDP ($\beta = 7.873$) has the greatest effect on the occurrence of AHSs, followed by AGIs ($\beta = 4.742$) and the biological abundance index ($\beta = 2.383$). These findings indicate that the probability of AHS sites is higher in regions with higher GDP and AGI distribution and lower relief degree of land surface. Generally, these regions coincide with eastern China, a region with clustered distribution of AHS sites.

5. Discussion

5.1. Recommendations for AHS Sustainable Development Policy

The government and agricultural sectors have the main responsibility for the development and protection of AHS sites and surrounding rural areas by proposing policies, subsidies, and rural planning. To better manage and protect AHSs, the central government and local governments should coordinate to protect and manage AHSs by legislating and formulating specific measures. Then, compensation and subsidy measures concerning ecological and cultural aspects of AHS should be also reinforced in the following step [78]. In particular, the compensation and subsidies should vary at different AHS sites due to the differences in economic, ecological, and cultural conditions at these AHS sites [79]. Additionally, such protections need a multi-stakeholder mechanism involving governments, scientists, communities and farmers, corresponding enterprises, and social organizations [3,37,80]. Communities play a critical role in the protection of AHSs [81]. Rural communities and their members are therefore encouraged to protect, develop, and inherit agricultural cultural heritages, such as rural settlements, species resources, folklore, agro-processing, and dietary practices, under government guidance and market regulation. In short, adding elements of modern society into the traditional way of life and cultivation thereby protects AHSs through sustainable development.

However, local residents are concerned about the economic benefits brought by AHSs [15]. Therefore, this study proposes two economic pathways—rural tourism and high-quality agricultural products—to improve incomes of local residents and promote the integration of farmers into rural communities. These measures are supported by scientific evidence for the local government and agricultural sectors to maintain the rural communities and inherit the AHSs.

5.1.1. Tourism Planning and Design for AHS Sites

Agricultural production patterns in AHS sites are also about securing livelihoods for generations amongst local residents. However, in the process of modernization, the economic efficiency derived from these traditional patterns is usually less than in non-agricultural industries. According to the spatial relationship between AHSs and GDP, most AHSs were located in regions with lower GDP (Figure 6a,b). A large number of young laborers have therefore migrated into urban areas [82], which has then resulted in local economic backwardness, together with food and livelihood insecurity. Therefore, a reasonable economic development pathway is useful for the protection of AHSs. A similar study [83] also considers that reasonable development of tourism can not only develop the local economy, but can also promote the protection and inheritance of AHSs, which is consistent with the results of this study. An approach that makes AHSs have a living state can sustain their agricultural heritages by supporting their economic function. Enhancing the economic function of AHSs can increase the income of local residents and re-engage numerous young laborers [78] due to the large number of labor-intensive positions required by AHSs [43]. Given a sustainable economic function, the ecological and social functions of AHSs should be further promoted; these, in turn, encourage local residents to protect the environment. On the other hand, the ecological function not only provides an equivalent yield, but also reduces applications of pesticides and chemical fertilizers [84]. Similarly, the social function also maintains a stable community and attracts younger laborers. A reasonable economic development pathway at AHS sites can create more employment opportunities to prompt young laborers to return to their hometowns. Therefore, a sound and reasonable community that includes the aged, middle-aged, and young generations can be re-established to effectively mitigate the "children left behind" phenomenon. Such a benign society, in turn, stimulates young laborers to use their intelligence to promote the economic function of AHSs.

Agro-tourism has long been used to perform an economic function for AHS sites [54]. In addition, the positive effects on the protection of the Qingtian Rice–Fish Co-culture by tourism have been confirmed [82,85]. The integration and development of agricultural heritage tourism resources not only provide an important source for the region's economy, but are also the most effective ways to protect the world's major cultural heritage [75]. In this paper, we found that numerous sites of intangible cultural heritage and historical and cultural villages/towns were located nearby the AHS sites based on their spatial relationships. Meanwhile, the biological abundance index was also high in these regions. These relationships show that regions with AHSs have cultural and natural advantages, which indicated that all AHS sites in China can be suitable for tourism development. These AHS sites were associated with historical and cultural towns/villages and tourist attractions that can be integrated into a perfect tourism chain. Therefore, a mode integrating geographical indications of agricultural products, agricultural cultural heritages, historic and cultural villages/towns, and other tourist attractions is proposed, with customs of minorities being added in the case of minority areas [86]. A similar viewpoint has also been proposed in an overall tourism planning that links AHS sites with intangible cultural heritage [87]. Compared with previous schemes [87], this model is more suited to agro-tourism. The comparison between the distributions of AHS sites and intra-/inter-provincial traffic accessibility of the scenic areas in China [88] indirectly confirmed the high traffic accessibility and convenient traffic conditions in zones surrounding AHS sites. Thus, a well-developed traffic network also provides the feasibility of large-scale AHS tourism development [89]. China's increasingly well-developed high-speed railway has greatly increased the time accessibility of national tourist attractions and the numbers of tourists [90].

5.1.2. Promotion of High-Quality Agricultural Products for AHS Sites

Compared to agro-tourism, developing high-quality agricultural products is more suitable for local economic development and heritage protection because the agricultural landscape in most areas with AHSs has a certain seasonality. This regional imbalance results in a limitation of agro-tourism at the national scale. Temporary and seasonal tourism is not able to support stable development of the local economy. Some scholars have also proposed that the development model for a further integration of agriculture is a reasonable pathway for the development and protection of AHS sites and surrounding rural areas [61,91]. Production and trade of high-quality agricultural products are, by contrast, a stable pathway for improving long-term economic development. This is also consistent with all viewpoints that support the extension of the agricultural product processing chain, as well as the development of high-value-added agricultural products, as recently proposed by some scholars [87,92]. Additionally, well-developed traffic networks, high internet network coverage, and rapid development of the rural service network have also significantly stimulated the development of rural logistics and e-commerce in rural areas. This makes high-quality agricultural products convenient and efficient to send to urban markets and consumers. Meanwhile, in AHSs, the protection of traditional crop seeds with abundant heredity and protection of soil resources from antibiotics and other contaminations in the region are also important. Thus, the development of high-quality agricultural products in different regions with agricultural heritage protection trademarks can protect particular crop seeds and soil resources to increase the added value of agricultural products.

5.2. Implications for Sustainable Development

This article proposes relevant quantitative models and methods to illustrate the relationship between AHS sites and natural, cultural, and socioeconomic factors. One of the outcomes from this work is the use of AGIs as an indicator to reveal their relationship with AHS sites and to promote the prices of agricultural products by using the AGIs themselves. In this article, we preliminarily analyzed the relationship between traditional villages and AHS sites. The traditional village indicator not only reflects the rural production space, but also characterizes intangible cultural heritage. Additionally, AGIs and traditional villages are both key indicators for future pathways of sustainable development. Therefore, these two indicators can reveal cultural drivers in the formation and spatial distribution of AHS sites, which perform better to reveal the detailed spatial relationship between cultural factors and AHS sites. This was done in close connection with a state-of-the-art geospatial analysis method, in agreement with the outcomes of other research [93–95].

This article also concludes that the traditional Chinese villages are clustered nearby AHS sites. This spatial relationship between AHS sites and traditional Chinese villages confirms that AHSs have rich intangible cultural heritage and provide a basis for the development of rural tourism. These findings are also confirmed by similar research on the tourism in traditional Chinese villages [32,96]. The intangible cultural heritage can also arouse the nostalgia of local residents and then attract young people to return to their hometowns to rebuild a harmonious and sustainable village by constructing a rural community with a reasonable age distribution of residents. This is also consistent with the questionnaire and survey results from six traditional villages by Chen et al. (2020) [97]. In addition, high spatial correlation between AHS sites and AGI distribution shows that AHS sites and surrounding rural regions have adequate endowments of high-quality agricultural products, which make rural communities and agricultural product brands of AHS sites nationally and globally known, and also promote rural revitalization and sustainable development. The similar results reported in Italy [98], Turkey [99], China [28], Vietnam [100], and Association of Southeast Asian Nations (ASEAN) countries [101] also confirm our findings that AGIs are an effective pathway for rural sustainable development.

Meanwhile, the findings of this article about agricultural product development and rural tourism near the AHS sites were also confirmed by other microscale studies [14,61,102]. This analysis can also provide a data foundation for potential assessment of the development of AHS tourism and the agricultural product processing industry, as well as scientific evidence for future rural planning. Additionally, we can also preliminarily conclude the potential of possible AHS designation through the spatial relationship between physical, cultural, and socioeconomic factors and existing AHS sites. These results also provide scientific evidence for local government to discover, evaluate, and apply for AHSs, which could resolve the problems of unclear AHS sites in China [103]. These results are encouraged by the fact that local communities living close to the above-mentioned GIAHS sites in Japan, Chile, Tunisia, and Italy benefit from international cultural interchange and profit increases as a consequence of the conservation of local tangible and intangible products. In summary, the spatial relationships between AHS sites and physical–cultural–socioeconomic factors discovered by this paper also confirm that the promotion, protection, and utilization of GIAHSs can fully achieve the second goal of the SDGs at the regional and global scale.

5.3. A Universal Approach: Advantages and Limitations

Compared to previous studies [93,95], this research is not limited to the study of a few specific AHS types, and has used a robust and generic model to reveal the spatial relationships between AHS sites and the surrounding physical, cultural, and socioeconomic factors. This is also the original contribution of this article. The quantitative analyses between AHS sites and physical, cultural, and socioeconomic factors provide scientific evidence for sustainable agricultural development, agricultural cultural heritage protection, and traditional settlements. The approach and framework employed in this paper can be applied in other areas with a strong universality and robustness. In particular, the schemes for solving the sustainable development of AHS proposed in this paper are worth adopting by decision-makers at other AHS sites.

In this study, we propose a novel indicator system of integrated physical, cultural, and socioeconomic factors to evaluate their spatial relationships with AHS sites; however, the lack of refined indicators and their corresponding spatial data inevitably lead to limitations of the quantitative model. In the future, more spatialized indicators will be used to improve the accuracy and mechanism of the model, as well as to further promote a wholly refined research. Meanwhile, a more precise boundary for each AHS site and spatialized indicators with higher spatial resolution could also be considered for improving the accuracy of the model presented in this study.

6. Conclusions

Most AHS sites in China are located in eastern China, especially in the Zhejiang and Yunan provinces. By analyzing the relationships between AHSs and natural resource endowments and cultural and socioeconomic factors, AHS sites were found to be mainly located in rural regions of major Chinese cultural zones. The existence of most AHS sites is related to the biological abundance index, AGIs, GDP, and RDLS. The development of agro-tourism and the promotion of high-quality agricultural products with geographical indications were two economic pathways, and were proposed to promote sustainable development of the local agricultural circular economy. On the other hand, they also promote the return of young people to build age-appropriate rural communities to efficiently inherit and protect agricultural cultural heritage, and then achieve sustainable rural development under the UN's SDGs. Additionally, the legislation, state policies and subsidies, and multi-stakeholder organizations of AHSs were also critical pathways for AHS conservation. These results provide scientific evidence for decision-makers for AHS conservation. Additionally, these scientific findings can also encourage local governments to participate in the protection of AHSs and the transitions of rural communities.

Author Contributions: Conceptualization, G.L.; Funding acquisition, G.L.; Methodology and data analysis, G.L.; Writing—original draft, G.L.; Writing—review & editing, D.M.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the National Natural Science Foundation of China (NSFC) (grant number: 41901349), the Startup Foundation for Talented Scholars in South China Normal University (grant number: 8S0472), and Foundation for Young Innovation Talents in Higher Education of Guangdong, China (Natural Science) (grant number: 2018KQNCX054).

Acknowledgments: We are grateful for the Data Sharing Infrastructure of Earth System Science and Global Change Research Data Publishing and Repository in China for sharing data. We thank the editors and three anonymous reviewers for providing their constructive suggestions on this manuscript.

Conflicts of Interest: The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

1. Koohafkan, P.; Altieri, M.A. *Globally Important Agricultural Heritage Systems: A Legacy for the Future*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2011.
2. FAO. *Globally Important, Ingenious Agricultural Heritage Systems (GIAHS), First Stakeholder Workshop and Steering Committee Session, Rome, Report*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2002.
3. Koohafkan, P. Conservation and adaptive management of globally important agricultural heritage system (GIAHS). *Resour. Sci.* **2009**, *31*, 4–9.
4. Sun, Y.H.; Min, Q.W.; Cheng, S.K.; Zhang, Z.; Jiao, W.J.; He, L.; Yang, H.L.; Liu, S. The temporal and spatial suitability assessment in the tourism resources development of agricultural heritage system: Taking Congjiang County in Guizhou Province as a Case. *Resour. Sci.* **2009**, *31*, 942–949, (In Chinese with English Abstract).
5. Min, Q.W.; Zhang, B.T. Review on conservation and development study of important agricultural heritage system in China. *J. Agric.* **2018**, *8*, 221–228.
6. Zhang, C.Q.; Liu, M.C. Challenges and countermeasures for the sustainable development of nationally important agricultural heritage. *J. Resour. Ecol.* **2014**, *5*, 390–394.
7. Fuller, A.M.; Min, Q. Understanding agricultural heritage sites as complex adaptive systems: The challenge of complexity. *J. Resour. Ecol.* **2013**, *4*, 195–201. [CrossRef]
8. Min, Q. Research priorities, problems and countermeasures of important agricultural heritage systems and their conservation. *Chin. J. Eco-Agric.* **2020**. [CrossRef]
9. UN. *Transforming Our World: The 2030 Agenda for Sustainable Development*; United Nations: New York, NY, USA, 2015.
10. Jiao, W.; Zhao, G.; Min, Q.; Liu, M.; Yang, L. Building a monitoring system for Globally Important Agricultural Heritage Systems (GIAHS) based on the monitoring experience of World Heritage. *Chin. J. Eco-Agric.* **2020**. [CrossRef]
11. Zhang, C.; Chen, L.; Zhang, Y. The counterparty participation mechanism in the protection of Japanese agricultural cultural heritage and its policy inspiration. *World Agric.* **2015**, *12*, 108–111. (In Chinese)
12. Ministry of Agriculture and Rural Affairs of the People's Republic of China. Regulation on Important Agricultural Heritage Systems[EB/OL]. 2015. Available online: http://www.moa.gov.cn/sjzz/zhengfasi/fagui/201509/t20150907_4818823.htm (accessed on 14 August 2015).
13. Liu, W.; Min, Q.W.; Bai, Y.; Liu, M. Impact of the GIAHS designation to local development and counter measures. *World Agric.* **2014**, *422*, 89–93, (In Chinese with English Abstract).
14. Berweck, S.; Koohafkan, P.; Cruz, M.J.R.D.; Qingwen, M.; Wenjun, J.; Yehong, S.; Moucheng, L. Conceptual framework for economic evaluation of globally important agricultural heritage systems (GIAHS): Case of Rice-Fish Co-Culture in China. *J. Resour. Ecol.* **2013**, *4*, 202–211. [CrossRef]
15. He, S.Y.; Li, H.Y.; Min, Q.W. Is GIAHS an effective instrument to promote agrosystem conservation? A rural community's perceptions. *J. Resour. Ecol.* **2020**, *11*, 77–86.
16. Zhang, Y.X.; Jiao, W.J.; Liu, M.C.; Min, Q.W. Experiences of Japanese agricultural heritage conservation and development. *World Agric.* **2017**, *3*, 139–142.
17. Bai, Y.Y.; Min, Q.W.; Liu, M.C. Foreign successful experiences and suggestions to China's GIAHS conservation and management. *World Agric.* **2014**, *6*, 78–82.
18. Rodriguez, R.P.; Zhang, Y.X. Traditional sustainable agriculture in Chiloe. *China Investig.* **2019**, *1*, 80–85.
19. Santoro, A.; Venturi, M.; Maachia, S.B.; Benyahia, F.; Corrieri, F.; Piras, F.; Agnoletti, M. Agroforestry heritage systems as agrobiodiversity hotspots. The case of the mountain oases of Tunisia. *Sustainability* **2020**, *12*, 4054. [CrossRef]
20. Santoro, A.; Venturi, M.; Agnoletti, M. Agricultural heritage systems and landscape perception among tourists. The Case of Lamole, Chianti (Italy). *Sustainability* **2020**, *12*, 3509. [CrossRef]
21. Wang, S.M.; Lu, Y. China's agricultural heritage research: Progress and change. *Agric. Hist. China* **2010**, *1*, 3–11.
22. UNESCO World Heritage Centre. Cultural Landscapes: The Challenges of Conservation. In Proceedings of the Common Responsibility Associated Workshops, Ferrara, Italy, 11–12 November 2002.
23. UNSECO. Convention Concerning the Protection of the World Cultural and Natural Heritage. In Proceedings of the General Conference of UNESCO, Paris, France, 17–21 November 1972; Available online: http://whc.unesco.org/en/conventiontext/ (accessed on 15 August 2020).

24. Min, Q.; Sun, Y.; Frankvan, S.; Liang, L.; Cruz, M.J.R.D. The GIAHS-Rice-Fish culture: China project framework. *Resour. Sci.* **2009**, *31*, 10–20, (In Chinese with English Abstract).
25. Koohafkan, P.; Cruz, M.J.D. Conservation and adaptive management of Globally Important Agricultural Heritage Systems (GIAHS). *J. Resour. Ecol.* **2011**, *2*, 22–28.
26. Guo, C.X.; Chun, Y.Q.; Sun, W. *Biological Abundance Index Data with 1 km Resolution in China (BioIndex_China_1985&2005)*; Global Change Research Data Publishing and Repository: Beijing, China, 2015. [CrossRef]
27. Huang, Y.H.; Jiang, D.; Fu, J.Y. *1 km Gridded GDP Distribution Dataset in China (GDP Grid-China)*; Global Change Research Data Publishing and Repository: Beijing, China, 2014. [CrossRef]
28. Liu, G.L.; Zhang, Q.; Yin, G.; Musyimi, Z. Spatial distribution of geographical indications for agricultural products and their drivers in China. *Environ. Earth Sci.* **2016**, *75*, 612. [CrossRef]
29. Yu, L.; Liu, J.; Cao, Q.Y.; Ding, Y.D.; Liao, Q.X.; Tang, M.J.; Fu, M. *Spatial Distribution Dataset of 2555 Chinese Traditional Villages [DB/OL]*; Global Change Research Data Publishing & Repository: Beijing, China, 2018. [CrossRef]
30. Sun, J. Traditional villages: Theoretical connotation and development path. *Tour. Trib.* **2017**, *32*, 1–3.
31. Liang, B.; Xiao, D. *Conservation of Space of Intangible Cultural Heritage in Traditional Villages*; South Architects Ltd.: Christchurch, New Zealand, 2016; Volume 3, pp. 90–93.
32. Li, J.; Wang, X.; Li, X. Spatial distribution characteristics and influencing factors of Chinese traditional villages. *Econ. Geogr.* **2020**, *40*, 143–153.
33. Pérez-Soba, M.; Petit, S.; Jones, L.; Bertrand, N.; Briquel, V.; Omodei-Zorini, L.; Contini, C.; Helming, K.; Farrington, J.H.; Mossello, M.T.; et al. Land use functions—A multifunctionality approach to assess the impact of land use changes on land use sustainability. In *Sustainability Impact Assessment of Land Use Changes*; Helming, K., Pérez-Soba, M., Tabbush, P., Eds.; Springer: Berlin/Heidelberg, Germany, 2008; pp. 375–404. [CrossRef]
34. Zhang, J.; Wang, S.; Zhao, W.; Liu, Y.; Fu, B. Research progress on the interlinkages between the 17 Sustainable Development Goals and their implication for domestic study. *Acta Ecol. Sin.* **2019**, *39*, 8327–8337.
35. Allen, C.; Metternicht, G.; Wiedmann, T. Initial progress in implementing the Sustainable Development Goals (SDGs): A review of evidence from countries. *Sustain. Sci.* **2018**, *13*, 1453–1467. [CrossRef]
36. Min, Q.W.; Sun, Y.H.; Shi, Y.Y. GIAHS project and its implementation in China. *J. Resour. Ecol.* **2010**, *1*, 94–96.
37. Min, Q.W.; Zhang, Y.X.; Jiao, W.J.; Sun, X.P. Responding to common questions on the conservation of agricultural heritage systems in China. *J. Geogr. Sci.* **2016**, *26*, 969–982. [CrossRef]
38. Li, F.; Zhu, C.; Jiang, F.Q.; Li, B.; Wang, X.H.; Cao, B.; Zhao, X.F. Archaeological sites distribution and its physical environmental settings between ca 260-2.2ka BP in Guizhou, Southwest China. *J. Geogr. Sci.* **2014**, *24*, 526–538.
39. Wang, F.; Zhang, X.L.; Yang, Z.P.; Luan, F.M.; Xiong, H.G.; Wang, Z.G.; Shi, H. Spatio-temporal characteristics of cultural sites and an analysis of their driving forces in the Ili River Valley in historical periods. *Acta Geogr. Sin.* **2015**, *70*, 796–808, (In Chinese with English Abstract).
40. Li, Y.J.; Chen, T.; Wang, J.; Wang, D.G. Temporal-spatial distribution and formation of historic and cultural villages in China. *Geogr. Res.* **2013**, *32*, 1477–1485, (In Chinese with English Abstract).
41. Yu, Z.J.; Tian, X.L.; Chen, Y.L. Analysis of characteristics and cause of spatial distribution of the world heritage in China. *J. Nat. Resour.* **2015**, *30*, 1762–1777.
42. Cheng, Q.; Ling, S.P. Geographical distribution and affecting factors of the intangible cultural heritage in China. *Sci. Geogr. Sin.* **2013**, *33*, 1166–1172, (In Chinese with English Abstract).
43. Li, W.H.; Min, Q.W.; Sun, Y.H. Discussion on the scientific research of natural and cultural heritage. *Geogr. Res.* **2006**, *25*, 561–569.
44. Han, Y.P.; Liu, J.P. Some Concepts Related to Agricultural Heritage. *Anc. Mod. Agric.* **2007**, *3*, 111–115.
45. Sun, Y.H.; Min, Q.W.; Cheng, S.K. Value of the GIAHS-China traditional rice-fish system. *Chin. J. Eco-Agric.* **2008**, *16*, 991–994, (In Chinese with English Abstract). [CrossRef]
46. Liu, M.C.; Xiong, Y.; Yuan, Z.; Min, Q.W.; Sun, Y.H.; Fuller, A.M. Standards of ecological compensation for traditional eco-agriculture: Taking rice-fish system in Hani Terrace as an example. *J. Mt. Sci.* **2014**, *11*, 1049–1059. [CrossRef]
47. Yiu, E.; Nagata, A.; Takeuchi, K. Comparative study on conservation of agricultural heritage systems in china, Japan and Korea. *J. Resour. Ecol.* **2016**, *7*, 170–179.

48. Barrena, J.; Nahuelhual, L.; Báez, A.; Schiappacasse, I.; Cerda, C. Valuing cultural ecosystem services: Agricultural heritage in Chiloé island southern Chile. *Ecosyst. Serv.* **2014**, *7*, 66–75. [CrossRef]
49. Nahuelhual, L.; Carmona, A.; Laterra, P.; Barrena, J.; Aguayo, M. A mapping approach to assess intangible cultural ecosystem services: The case of agriculture heritage in Southern Chile. *Ecol. Indic.* **2014**, *40*, 90–101. [CrossRef]
50. Hashimoto, S.; Nakamura, S.; Saito, O.; Kohsaka, R.; Kamiyama, C.; Tomiyoshi, M.; Kishioka, T. Mapping and characterizing ecosystem services of social-ecological production landscapes: Case study of Noto, Japan. *Sustain. Sci.* **2015**, *10*, 257–273. [CrossRef]
51. Min, Q.W.; Zhang, D.; He, L.; Sun, Y.H. Agri-cultural heritage research and conservation practices in China: Progresses and perspectives. *Resour. Sci.* **2011**, *33*, 1018–1024, (In Chinese with English Abstract).
52. Yuan, Z.; Lun, F.; He, L.; Cao, Z.; Min, Q.W.; Bai, Y.Y.; Liu, M.C.; Cheng, S.K.; Li, W.H.; Fuller, A.M. Exploring the state of retention of traditional ecological knowledge (TEK) in a Hani rice terrace village, Southwest China. *Sustainability* **2014**, *6*, 4497–4513. [CrossRef]
53. Zhang, Y.X.; Min, Q.W.; Li, H.Y.; He, L.L.; Zhang, C.Q.; Yang, L. A Conservation approach of Globally Important Agricultural Heritage Systems (GIAHS): Improving traditional agricultural patterns and promoting scale-production. *Sustainability* **2017**, *9*, 295. [CrossRef]
54. Sun, Y.H.; Jansen-Verbeke, M.; Min, W.Q.; Cheng, S.K. Tourism Potential of Agricultural Heritage Systems. *Tour. Geogr.* **2011**, *13*, 112–128. [CrossRef]
55. Wu, J.Z.; Li, Y.H.; Xiong, L.M. A research review of study on agricultural heritage in China. *Chin. Agric. Sci. Bull.* **2012**, *28*, 302–306.
56. Vafadari, K. Review: Planning sustainable tourism for agricultural heritage landscapes. *Ritsumeikan J. Asia Pac. Stud.* **2013**, *32*, 75–89.
57. Chen, B.; Qiu, Z.; Usio, N.; Nakamura, K. Tourism's impacts on rural livelihood in the sustainability of an aging community in Japan. *Sustainability* **2018**, *10*, 2896. [CrossRef]
58. Kajihara, H.; Zhang, S.; You, W.; Min, Q. Concerns and opportunities around cultural heritage in East Asian Globally Important Agricultural Heritage Systems (GIAHS). *Sustainability* **2018**, *10*, 1235. [CrossRef]
59. Liu, B.C.; Luo, X.L. Research on the model of sustainable development and utilization ancient village heritage. *Agric. Hist. China* **2014**, *4*, 130–136.
60. You, Z.; Feng, Z.M.; Yang, Y.Z. *Relief Degree of Land Surface Dataset of China (1 km) [DB/OL]*; Global Change Research Data Publishing & Repository: Beijing, China, 2018. [CrossRef]
61. Zhang, Y.X.; Li, X.D.; Min, Q.M. How to balance the relationship between conservation of Important Agricultural Heritage Systems (IAHS) and socio-economic development? A theoretical framework of sustainable industrial integration development. *J. Clean. Prod.* **2018**, *204*, 553–563. [CrossRef]
62. Bai, Y.Y.; Sun, X.P.; Tian, M.; Fuller, A.M. Typical water-land utilization GIAHS in low-lying areas: The Xinghua Duotian Agrosystem example in China. *J. Resour. Ecol.* **2014**, *5*, 320–327.
63. Jiang, M. Study on the Tourism Potentiality of Global Important Agricultural Heritage Systems: Jia County's Ancient Zaoyuan in Shaanxi Province. Master's Thesis, Chang'an University of China, Xi'an, China, 2015.
64. Bai, Y.Y.; Lun, F.; Cao, Z.; He, L.; Liu, X.C.; Liu, M.C. Agricultural production in Hani Rice Terraces System and related threats: A case study of Zuofu and Mitian Villages in Honghe County, China. *Chin. J. Eco-Agric.* **2012**, *20*, 698–702. [CrossRef]
65. Chen, M.; Hu, J.; Qiu, X. Factors analysis of intangible cultural heritage's spatial distribution characteristics in Hubei Province. *J. HuaZhong Normal Univ. Nat. Sci.* **2019**, *53*, 415–424, (In Chinese with English Abstract).
66. Yu, Z. The distribution of China's key national heritage tourism resources and its development and protection. *Econ. Geogr.* **2011**, *31*, 312–316, (In Chinese with English Abstract).
67. Cheng, J.Q.; Masser, I. Urban growth pattern modeling: A case study of Wuhan city, PR China. *Landsc. Urban Plan.* **2003**, *62*, 199–217. [CrossRef]
68. Braimoh, A.K.; Vlek, P.L.G. Land-cover change trajectories in Northern Ghana. *Environ. Manag.* **2005**, *36*, 356–373. [CrossRef]
69. Wheeler, D.; Tiefelsdorf, M. Multicollinearity and correlation among local regression coefficients in geographically weighted regression. *J. Geogr. Syst.* **2005**, *7*, 161–187. [CrossRef]
70. Hu, H.Y. The distribution of population in China. *Acta Geogr. Sin.* **1935**, *2*, 33–74, (In Chinese with English Abstract).
71. Mao, F.; Nie, Y.P.; Chen, S.P. Great ecotypic and cultural project—Recognition of Grand Canal. *Geoinf. Sci.* **2008**, *10*, 511–519, (In Chinese with English Abstract).

72. Ye, Y.; Fang, X.Q.; Ren, Y.Y.; Zhang, X.Z.; Chen, L. Cropland cover change in Northeast China during the past 300 years. *Sci. China Ser. D-Earth Sci.* **2009**, *52*, 1172–1182. [CrossRef]
73. He, L.; Min, Q.W.; Zhang, D. Evaluation models for multifunctionality of agriculture and their applications: A case study on Qingtian County in Zhejiang Province, China. *Resour. Sci.* **2010**, *32*, 1057–1064, (In Chinese with English Abstract).
74. Xie, J.; Wu, X.; Tang, J.J.; Zhang, J.E.; Luo, S.M.; Chen, X. Conservation of traditional rice varieties in a Globally Important Agricultural Heritage System (GIAHS): Rice-Fish Co-culture. *Agric. Sci. China* **2011**, *10*, 754–761. [CrossRef]
75. Min, Q.W.; Sun, Y.H.; Cheng, S.K.; Wang, X.H. Primary study on the features and development of GIAHS's tourism resources. *Econ. Geogr.* **2007**, *5*, 856–859.
76. Liu, G.L.; Zhang, L.C.; You, H.L. Spatiotemporal dynamics of arable land in the Nanjing metropolitan region. *Environ. Earth Sci.* **2015**, *73*, 7183–7191. [CrossRef]
77. Guo, S.H.; Situ, S.J. The value and utilization of mulberry-dike-fish-pond in the Pearl River Delta in perspective of the agricultural heritage. *Trop. Geogr.* **2010**, *30*, 452–458, (In Chinese with English Abstract).
78. Zhao, L.J.; Xu, W.S.; Sun, Y.H.; Min, Q.W.; He, L. On the conservation of China's agricultural heritage systems. *Chin. J. Eco-Agric.* **2012**, *20*, 688–692, (In Chinese with English Abstract). [CrossRef]
79. Yao, Y. Protection of Agricultural Cultural Heritage and Promotion of Its Brand Value. Farmers' Daily 2016. Available online: http://finance.china.com.cn/roll/20160806/3846831.shtml (accessed on 7 December 2016).
80. Cruz, M.J.D.; Koohafkan, P. Globally important agricultural heritage systems: A shared vision of agricultural, ecological and traditional societal sustainability. *Resour. Sci.* **2009**, *31*, 905–913.
81. Sun, Y.H.; Cruz, M.J.D.; Min, Q.W.; Li, M.C.; Zhang, L.Y. Conserving agricultural heritage systems through tourism: Exploration of two mountainous communities in China. *J. Mt. Sci.* **2013**, *10*, 962–975. [CrossRef]
82. Fuller, A.M.; Min, Q.W.; Jiao, W.J.; Bai, Y.Y. Globally Important Agricultural Heritage Systems (GIAHS) of China: The challenge of complexity in research. *Ecosyst. Health Sustain.* **2015**, *1*, 1–10. [CrossRef]
83. Zhang, A.P. Evolution disparities of agricultural land use behavior of different types of farmers in agricultural heritage tourism destinations: A case study of Hani terraces. *Tour. Trib.* **2020**, *35*, 51–53.
84. Xie, J.; Hu, L.L.; Tang, J.J.; Wu, X.; Li, N.N.; Yuan, Y.G.; Yang, H.S.; Zhang, J.E.; Luo, S.M.; Chen, X. Ecological mechanisms underlying the sustainability of the agricultural heritage rice-fish coculture system. *PANS* **2011**, *108*, 1381–1387. [CrossRef]
85. Sun, Y.H.; Min, Q.W.; Cheng, S.K.; Wang, X.H. Relationship between tourism resources development and regional social and economic development in agricultural heritage site: Taking Traditional Rice-Fish Agriculture of Qingtian County as an example. *Resour. Sci.* **2006**, *28*, 138–144, (In Chinese with English Abstract).
86. Sun, Y.H.; Min, Q.W.; Zhong, L.S.; Cheng, S.K.; Zhang, D.; Long, D.X. Agricultural heritage tourism development in Minority areas: Taking Congjiang County in Guizhou Province as a case China Population. *Resour. Environ.* **2009**, *19*, 120–125.
87. He, S.Y.; Li, H.Y.; Min, Q.W. Conservation approaches of protected area bused on value identification: Taking Xinghua Duotian Agricultural Heritage System of Jiangsu Province as an example. *Res. Herit. Pres.* **2019**, *4*, 23–28, (In Chinese with English Abstract).
88. Wang, S.B.; Guo, J.K. Spatial measure of traffic accessibility and market potential of the National Scenic Areas. *Geogr. Res.* **2016**, *35*, 1714–1726.
89. Yin, Y.; Zhou, Y.H. Agricultural tourism layout in Jiangsu province. *Resour. Sci.* **2012**, *34*, 2409–2417.
90. Jiang, H.B.; Liu, J.G.; Jiang, J.L. An analysis of the accessibility of China's tourist attractions under the impact of high-speed railway. *Tour. Trib.* **2014**, *29*, 58–67.
91. Zhang, Y.X.; Min, Q.M. Exploration of models of integrated industrial development in important agricultural heritage systems sites. *Study Nat. Cult. Herit.* **2019**, *4*, 61–65, (In Chinese with English Abstract).
92. Zhang, C.Q.; Min, Q.W.; Zhang, H.Z.; Zhang, Y.X.; Tian, M.; Xiong, Y. Analysis on the rural households livelihoods aiming at the conservation of agricultural heritage system. *China Popul. Resour. Environ.* **2017**, *27*, 169–176, (In Chinese with English Abstract).
93. Han, Z.W. Geographical distribution and affecting factors of the important agricultural heritage systems in China. *Chin. J. Agric. Resour. Reg. Plann.* **2017**, *38*, 97–104, (In Chinese with English Abstract).
94. Mou, Y.; Yu, J. On the spatial distribution features of national important agricultural heritage systems. *Hubei Agric. Sci.* **2018**, *57*, 103–107, (In Chinese with English Abstract).

95. Liu, H.T.; Luo, M.; Xu, M.; Liu, Y.N.; Chen, B.Q.; Chen, W.; Huang, B. Gini coefficient-based spatial distribution features of GIAHS and their influence factors. *Chin. J. Eco-Agric.* **2020**. (In Chinese with English Abstract). [CrossRef]
96. Gao, J.; Wu, B. Revitalizing traditional villages through rural tourism: A case study of Yuanjia Village, Shaanxi Province, China. *Tour. Manag.* **2017**, *63*, 223–233. [CrossRef]
97. Chen, X.; Huang, R.; Hong, X.; Hu, X.; Li, D.; Shen, W. The measurement of xiangchou and its resource value in traditional village tourism destinations: A case study in Southern Jiangsu. *J. Nat. Resour.* **2020**, *35*, 1602–1616, (In Chinese with English Abstract).
98. Zhang, Y.; Xu, K.; Liu, H.; Jin, Z. Experiences and implications of using geographical indications to promote rural revitalization from Italy. *Chin. Soft Sci.* **2019**, *12*, 53–61.
99. Nizam, D.; Tatari, M.F. Rural revitalization through territorial distinctiveness: The use of geographical indications in Turkey. *J. Rural Stud.* **2020**. [CrossRef]
100. Hoang, G.; Le, H.T.T.; Nguyen, A.H.; Dao, Q.M.T. The impact of geographical indications on sustainable rural development: A case study of the Vietnamese Cao Phong Orange. *Sustainability* **2020**, *12*, 4711. [CrossRef]
101. Marie-Vivien, D. Protection of geographical indications in ASEAN countries: Convergences and challenges to awakening sleeping geographical indications. *J. World Intellect. Prop.* **2020**, *23*, 328–349. [CrossRef]
102. He, L.; Min, Q.W. The role of multi-functionality of agriculture in sustainable tourism development in globally important agricultural heritage systems (GIAHS) sites in China. *J. Resour. Ecol.* **2013**, *4*, 250–257.
103. Li, W.H. Agri-cultural heritage research and conservation practices: Progress and perspectives. *J. Agro-Environ. Sci.* **2015**, *34*, 1–6, (In Chinese with English Abstract).