

# ANALYSIS OF AGRICULTURAL DEVELOPMENT PLANNING IN LOW HILLY RED SOIL REGION BASED ON PLANTING STRUCTURE

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**Abstract.** The main aim of this study is to increase the income of farmers, and to further elaborate the development of low hilly red soil resources and cultivate industries with regionalized agricultural characteristic. By performing principal component analysis of the main agricultural products and determining the influencing factors of the main agricultural products in the low hilly red soil in the region of Jinhua and three key agricultural planting areas, the following conclusion can be drawn: we should expand the scale of land management, improve the basic construction of irrigation and water conservancy, promote the development of agricultural land consolidation projects, and implement the construction of agricultural ecological protection, so as to improve agricultural output and improve agricultural production performance.

**Keywords:** *the income of farmers, industrial layout, the potential of land resources, Zhejiang Province, agricultural production performance*

## Introduction

With the rapid development of Zhejiang's economy, the situation surrounding land resources is becoming increasingly tense (Song, et al., 2012), the contradiction between people and land is becoming more and more prominent, the speed of agricultural development is slowing down, the comparative benefits of agriculture are declining, and the influence of land is growing over the industrial and agricultural production of Zhejiang Province and the sustainable development of the national economy (Zhang, 2011). It leads to some important influencing factors as the foundation of the national economy, agriculture is the basis and precondition for the existence and development of other industries such as commercial trade and crafts. (Gao, 2006). The potential method to accelerate the development of land reserved resources has become an important engine for promoting Zhejiang's economic development (Lü et al., 2000).

In the hilly areas of Zhejiang Province, the low hilly red soil is spread over most of the province's cities. For a long time, due to the long-term unreasonable management of low hilly red soil, single operation, deforestation, unreasonable land reclamation, excessive mining and quarrying (Shen et al., 2013), out-of-control population growth, combined with harsh climatic conditions (serious drought) and the inherent vulnerability of low-valve red soil ecosystems, make the above-mentioned huge advantages and potentials of low hilly red soil not only fully exerted, but also initiate various resources and ecological environment degradation processes (Chen, 2004). On the contrary, it is becoming more and more serious, and the contradiction between people and land is becoming more and more prominent (Zhang, 2013). At present, the development of low hilly red soil agriculture faces the following problems:

First, people increase their land demand, and the contradiction between people and land is prominent (Dai, 2005). The per capita cultivated land and agricultural labor force is extremely limited, the quality is poor, and the development investment is large. With

the development of the market economy, it only pays attention to economic opening, but neglects the comprehensive development of resources (Zeng et al., 2006). The phenomenon of arable land abandonment is quite common, and the encroachment and pollution of cultivated land in the development zone is also increasing (Zhang, 2014). The serious slippage of grain production, coupled with the rapid growth of the population, the contradiction between the reverse development of man and land is quite sharp, and agriculture is shrinking.

Second, the agricultural structure is unreasonable and the advantages of the hills have not been realized. In terms of landform and landscape composition, Zhejiang Province has the characteristics of “seven mountains (Deng and Zhang, 2003), one water and two fields”, with mountains and hills as the main body, and low hilly red soil areas accounting for about 38% of Zhejiang Province. In the use of land resources, the long-term implementation of the cropping industry as the main food-centred single unreasonable agriculture “model” is only concentrated on the valley plains, mountains and inter-valley valleys (Ni, 1982), basins and low hills. The relatively intensive agricultural operation was carried out in the gently-sloping section of the (Taiwan) area, while the vast mountains and hills in Zhejiang Province were basically idle or insufficient due to extensive management.

Third, the soil resources are degraded and the ecological environment is seriously damaged. The long-term unreasonable development and utilization of resources, combined with harsh climatic conditions, especially severe seasonal rains and droughts, as well as special soil and site characteristics, have led to and exacerbated Zhejiang Province, especially in the densely populated low-lying red soil agricultural areas. Soil erosion and fertility declined, and other processes of soil and agro-ecosystem degradation occurred as well. Therefore, strengthening the management and development of low hilly red soil and improving the agricultural output of low hilly red soil region are effective ways to improve the agricultural benefits of Zhejiang Province.

The low hilly soil region is affected by natural conditions such as topography, climate, parent material and hydrology, and human production activities. It has obvious regional characteristics. Different soil textures and physical and chemical properties determine the development and utilization of land by humans. By understanding the characteristics of various planting types, soil resources development can be rationalised and a stable and virtuous cycle of the soil system can be achieved. Taking the acceleration of agriculture and rural modernization as the starting point focus should be on increasing farmers’ income (Jong, 2001), taking market as the guide and relying on science and technology to develop low hilly red soil resources and cultivating industries with regionalized agricultural characteristic. According to the objective needs of social and economic development and regional nature, social, economic, technological and ecological conditions, close focus should be on adapting to the new requirements of agricultural development, facing the needs of the province's internal and external markets, giving play to regional advantages, accelerating the adjustment of agricultural industrial structure, planting agricultural products that can meet market demand, and developing and managing low-lying red soil resources. It is of great practical significance to analyze the planting structure of agricultural products in the low hilly red soil region. This study is based on overall planning, keeping the social economic and ecological benefits unified, adapting to local conditions, maintaining the characteristics of land and agricultural utilization, safe production, efficiency, optimizing resources,

comprehensive development and other principles, in the main distribution area of low hill red soil in Zhejiang Province.

## Materials and methods

### *Literature review*

China was one of the first countries to conduct land type research. As early as the 5th century BC, there were records of land type division. According to records, Zhou Li in the Warring States Period divided the land of the country into five categories: Shanlin, Kawasaki, Hill, Wenyan and Yuan. According to the topography, the “People in the Pipeline” divides the national land into three categories: “Putian”, “Hill” and “Mountain”. The determination of land type is very comprehensive.

#### *(1) About land type division*

Since the 1930s, many countries have conducted various investigations and studies on land types and land resource utilization in order to increase grain production and comprehensive development and utilization of land. Former Soviet geographer Berger published his book on “The Soviet Landscape Geography Zone” is a comprehensive exposition of landscape geography, the idea of comprehensive research on land and a systematic theoretical summary of the comprehensive features of land from a geographical perspective.

In the late 1950s, with the full development of China’s natural zoning work, some geographers conducted land type surveys and cartographic studies at different scales. For example, Yan Qinshang’s research (Yan, 2012; Rawat et al., 2019) on landscape mapping in the Kangding, Jiulong, and Yajiang areas of the Tibetan area, such as Isachinko, etc.; Yang Newzhang’s to the west of the Tolahai River in the Qaidam Basin and the Malcommi in western Sichuan Research on the natural landscape of the Yaluolin area.

Since the 1990s, land type research has begun to be combined with practical work, and the scope has gradually focused on small and medium-sized areas. At the same time, significant progress has been made in land cover change and landscape ecology. The main researches of this period were the followings: Zhang (2000), Wang et al. (2000), Junior et al. (2019), Yang (2001), etc. applied remote sensing images, multi-source remote sensing data and other image data to the extraction of land types. Papers by Liu (1990), Shen (1992), Jiao et al. (2005), Liu and Li (2009), Khanchoul and Boubehziz (2019) studied the land types and mappings of the Oasis area in the Hexi Corridor, the agro-pastoral interlaced zone, the hilly area and the Loess Plateau in the arid regions. Liu Wei (2004), Yang et al. (2002), Fu et al. (2001), Liu and Chen (2002), Dali and Kamarudin (2018), proposed corresponding theoretical methods and zoning schemes for China’s ecological zoning research. Wang et al. (2001), Cai (2001), Wang and Bao (1999) discussed scales for land use/land cover change, driving force by investment intensity of manpower and physical resources, the social economic output level, the intensity of natural disasters disturbance and educational level of workers.

#### *(2) Indicators on the classification of land types*

As early as the early 1960s, some developed countries (Xie et al., 2008) and some international organizations (Huang and Cai, 2005) began to use the relevant indicator

system to evaluate economic and social development issues in macroeconomic and social research.

From the perspective of evaluation indicators, after the 1970s, the selection of representative indicator systems (Chen and Tao, 2000) to comprehensively evaluate various issues has become an indispensable and important means in modern management. Yu (2002) and others examined the issue from the point of view of developed agriculture, civilized farmers, affluent rural areas and good environment, Chen et al. (1993), etc. from the status of agriculture in macroeconomics and society, the living standards and quality of farmers, modern technology in agricultural production, application and agricultural production efficiency; Jiang (1997) observed procedures from production efficiency, management level, modern technology application and rural living standards; and other aspects of agricultural modernization, rural industrialization and rural urbanization (Cheng, 1999). The evaluation index system of agricultural modernization has been constructed in terms of output and socio-economic culture (Liang and Wenshun, 2019). Xu and Wu (1994), Tao (2018) and others established five aspects of system structure macro standards, production efficiency, agricultural production technology standards, comprehensive benefits and farmers' living standards (Xia and Li, 2000); Zhang Yuwu et al. established county-level eco-agricultural indicator system from three aspects: resource utilization evaluation, structural evaluation and functional benefit evaluation. Huang et al. (1995), Ma Kangyu, Gu Jianmin and others established an assessment indicator system for high-yield, high-quality and high-efficiency agriculture. Sun et al. (1995) and others have established a comprehensive evaluation index system for ecological agriculture from the aspects of system structure, system function and system efficiency, high yield, high efficiency, benign circulation and sustainable development, resource utilization, ecological function benefit, economic function benefit and social benefit (Ilyas et al., 2019).

From the indicator system, the number of specific indicators range from a few to dozens. Peng (1994) used nine indicators when evaluating the agro-ecological development of the central and sub-tropical agriculture in eastern China and the agro-ecological types of the county; Li et al. (2005) used 34 indicators for the evaluation of the agricultural ecosystem in Fujian Province; Qin Huibao was in the hilly area (Zhou et al., 2017; Asghar et al., 2018). The evaluation of village-level eco-agricultural systems used 26 indicators (Xia, 2013; Wali et al., 2018).

### *(3) Study on low hilly red soil and classification*

The research on the development and utilization of low-hill red soil is firstly the discussion of resource characteristics (Huang et al., 2014; Ogunyele et al., 2018). As a comprehensive low-hill and gentle slope resource of comprehensive natural economic geography complex, the use of low-hill and gentle slope resources varies from vertical to horizontal (Shen et al., 2013). The vertical space difference mainly reflects the characteristics of altitude sunshine hours, temperature, precipitation (Huang and Tang, 2015) and other significant differences in climate resources. From the perspective of horizontal space differences (Wang and He, 2005), it mainly reflects the obvious differences in development costs, significant differences in natural geography and socio-economic conditions (Jia, 2016).

Secondly, the research focuses on the development potential of low hilly red soil resources. From the perspective of environmental analysis, land degradation, vegetation

cover, soil fertility, soil erosion, and small watershed management are the main problems in the low hilly red soil region (Fang et al., 2010). Geostatistical method was used to study the spatial and temporal variability of soil fertility in the subtropical low hilly red soil region of China (Yin, 2006), and the effects of different utilization methods on soil fertility were analyzed and discussed. The development potential was mainly related to area, aspect, slope and land use. Factors such as status, altitude, and soil texture were also associated (Deng et al., 2017). Taking the typical low hilly red soil region in the Fuyang area of Hunan Province as the research area, the seasonal intercropping of soil moisture content in the long-term experimental plots of different fertilizer ratios in red soil dryland in low hilly areas (Pang, 2015) and its relationship with meteorological factors were studied (Chai, 1997). The variation of soil moisture in typical red soil areas was analyzed.

There is also agricultural planting research in the low hilly red soil region (Shi et al., 2018). The existing low hilly red soil industry development is mainly based on fisheries, forestry, conversion town construction land and ecological agriculture (Wu, and Chen, 2016). There are also test forests in the low hilly red soil area with a number of tree species, and the tree species with good economic and ecological benefits are screened out, which provides a basis for the rational development of low hilly red soil and intensive management of forestry (Wang et al., 2017). Based on the research of the basic characteristics of red soil in Poyang Lake and surrounding economic zones, it is pointed out that the layout of red soil is unreasonable in development and utilization, the production is simple (Bao et al., 2006), the level of forestry production is very low, and the cultivation of cultivated land is lacking, resulting in low yield and instability (Han et al., 2013), soil erosion and other issues.

In summary, for more than a century, domestic and foreign scholars have conducted various researches on land types for different research purposes, with different research techniques and means, so that they gradually mature in theory and method with the development of science and technology. With progress, I began to make extensive use of computer technology (Wang and Tao, 2012). China's research on the quantitative evaluation of agro-ecosystems is mainly focused on the evaluation of the establishment of the indicator system. There is still a lot of room for the understanding of the system as a whole and for the study of multi-level and multi-dimensional systems (Xu et al., 2016). In addition to improving agricultural soil infrastructure, improving agricultural infrastructure, and changing agricultural processing logistics (Chen et al., 2005) and branding, modern agricultural management practices, such as refined agriculture and facility agriculture, are inevitable for low-hill red soil (Ma and Wang, 2010). Regional agricultural development puts forward new requirements. Based on the type of land planting, this paper establishes a more comprehensive and scientific evaluation system of agricultural development, and applies land type planning better in land evaluation research. How to improve the agricultural planting structure in the low hilly regions? The development of the red soil region provides a direction.

### ***Research methods***

Since the last century, scientists from all fields have conducted extensive research on land resource changes and cover from their respective disciplines, and have shown a trend of multi-disciplinary cooperation (She, 2014). Principal component research is a core issue in the change of land resource utilization. The main component refers to the main cause of changes in land resource utilization. Since principal component research

plays a very important part in the simulation of land resource utilization change (Jia et al., 2001), it has attracted the attention of many scholars at the beginning. Some scholars have analyzed the spatial and temporal changes of land resource utilization in China by establishing mathematical models (Xu, 2017), using principal component analysis models to evaluate the level of cultivated land use in Chongqing, and discovering the inadequacies of land resource utilization in Chongqing and exploiting the land resources of the city. Suggested countermeasures occurred soon. Some scholars have used principal component analysis to evaluate the use of cultivated land in Changsha City, and put forward relevant suggestions on agricultural planting varieties and development directions to promote the effective use of cultivated land in Changsha (Zhu et al., 2018). Based on these studies, this paper intends to use the principal component analysis method to analyze the agricultural development strategy of low hilly red soil region, and provide reference for agricultural planting varieties and categories.

### *(1) Principle of principal component analysis*

Principal component analysis is a common method of data processing. Principal component analysis mainly uses the main factors in a set of data to analyze (Shi and Han, 2013), and transforms many research variables involved in evaluation and analysis into several external variables that have major influences, reducing the complexity of the research. Since 1901, the British mathematician Pearson introduced the principal component and the variables involved in the evaluation (Li and Ye, 2001), this method has been gradually promoted, and after long-term evolution and development, principal component analysis has been applied in data analysis in many fields.

Principal Component Analysis (PCA) (Zhang and Liu, 1995) is a comprehensive method of data dimensionality reduction. Its principle is to transform a series of related index variables into several main principal component index variables by statistical analysis to replace the original complex variables (Liu, 1998). Its mathematical model is a random vector group  $M = (M_1, \dots, M_r)$ . After orthogonal transformation, the transformed matrix  $N$  is obtained. In the matrix  $N$ , the components (Lu, 2000) are linearly independent, and the variance of the first component of  $N$  is the largest, the second is the next.

### *(2) Steps of principal component analysis*

The steps of principal component analysis are as follows:

The first step is to suppose that there are  $A$  research areas, and the original sample matrix  $X$  of the  $B$  selection index is as follows (Eq. 1):

$$X = (X_{ij}) \quad A \times B, \quad i = 1, 2, \dots, A, \quad j = 1, 2, \dots, B \quad (\text{Eq.1})$$

The second step is to compute the correlation matrix  $R_b \times b$ , its eigenvalue  $\lambda$  and the normalized eigenvector  $e_j$ . The principal component  $T_i$  is obtained as follows (Eq. 2):

$$T_i = X e_j \quad (\text{Eq.2})$$

In the third step, the contribution of the  $j$  principal component variance is 85%~95%, and the first  $Q$  principal component  $T_1, T_2, \dots, T_q$ , then the principal component  $Q$  can be used to reflect the information of the original  $B$  indicators. The contribution rate formula (Eq. 3) is as follows:

$$a = \sum_{i=1}^q a_i \quad (\text{Eq.3})$$

The fourth step is to get the comprehensive score  $W$  for agricultural planting in different regions (Eq. 4).

$$W = aX_1 + bX_2 + \dots + xX_x \quad (\text{Eq.4})$$

where  $X$  represents the eigenvector of eigenvalues;  $a$  and  $B$  are standardized data of original index.

## Results

In order to further improve the benefit of comprehensive exploitation and utilization of red soil resources in low hilly areas, and to improve the ecological environment, agricultural productivity and soil and water conservation capacity of red soil areas in low hilly areas, the internal driving factors of red soil management and development in low hilly areas in Zhejiang Province were studied.

### Research area

The low hilly red soil defined by the Zhejiang Provincial Reclamation Bureau refers to the hilly red soil area with the lower limit of the slope (Zhang, 2001), 250 m in the north, 300 m in the east and the middle, and 350 m in the south. In addition to Jiaying City, the remaining 10 cities in the province are distributed.

The scope of this study is Jinhua City, located in the eastern half of the Jinyu Basin in Zhejiang Province. It belongs to the mid-subtropical region and is a key area for the development of low hill red soil in Zhejiang Province, including Wucheng District, Jindong District and Lanxi City under the jurisdiction of Jinhua City. Dongyang City, Yongkang City, Wuyi County, Pujiang County, and Chun'an County have a total of 8 counties and cities.

Low-hill red soil is most widely distributed (Wu and Chen, 1995) and characteristic in the area of Jinhua City in Zhejiang Province. There are a total of 16.3814 million units (mu) of land, including 2,911.3 thousand mu of low hilly red soil, accounting for 17.77% of the total land area. The soil types are roughly divided into three categories: red sand soil, purple sand soil and yellow gluten mud, which are distributed at the bottom of the Jinyu Basin. Low hilly red soil resources, due to its unique natural conditions, have become the main potential of agricultural development in Zhejiang Province. In the low hilly red soil area of Jinhua City, the improved soil methods such as land modification, green manure cultivation and straw returning to the field have been continuously applied. The crops such as tea and fruits have developed rapidly, the income of farmers has increased, the income from agricultural efficiency has increased significantly, and the social economy has continued to develop in general. This study

uses the agricultural production resource data of the counties and cities under Jinhua City to analyze and evaluate the development and utilization potential of low hilly red soil, and provide decision-making basis for better utilization of low hilly red soil resources.

### ***Index selection***

The establishment of the indicator system in practical application is not necessarily based on a certain theory. It is often necessary to use a variety of theories in combination. The key is to meet certain research purposes and tasks, so that the indicator system can fully reflect the status and substance of the system. The scientific nature of the indicator system ultimately depends on the extent to which the researcher understands the system. In order to improve the functions of the sustainable indicator system, in the construction of the indicator system and the selection of indicators, according to the principles of science, comparability, operability, and simplicity should be selected by the principal component analysis indicators. In the establishment of indicators, the main areas of Jinhua City are considered. The existing agricultural planting structure data, first, the area planted with crops, and the second is the crop yield. Through the data of two types in recent years, the total area of crops, food crops, grains, beans are finally selected. Indicators such as vegetables, potatoes, rapeseed, medicinal herbs, watermelon, mulberry, tea, citrus, peach, and other fruits were selected to explore the laws of agricultural planting in Jinhua City, and better guide agricultural planting and industrial development.

### ***Data collection and audit***

The statistical yearbook of Jinhua City in 2014 was selected as the data source (Zhang, 2001), and the data of agricultural planting area in the study area was selected as the research data of affecting the development of low hilly red soil.

In order to ensure the quality of the data and lay a foundation for further analysis, it is necessary to audit the statistical data. The completeness and accuracy of the original data obtained from the direct investigation shall be examined. Audit integrity is mainly to check whether the unit or individual is missing, whether the survey items or indicators are completed and so on. The accuracy of audit is mainly to check the embodiment of the survey data in the objective truth of statistical information.

### ***Sample descriptive statistics***

Based on the sown area data of grain (*Table 1*) and main cash crops (*Table 2*) in Jinhua City, this paper analyzes the main driving factors of the development of red soil in hilly area by quantitative method, and summarizes the change law of utilization and quality of red soil in hilly area, so as to guide the management and development of red soil in hilly area better, and realize the cultivated land while increasing the productivity of red soil in hilly area. High efficiency and sustainable utilization provide scientific basis for the sustainable development of regional social economy.

### **Discussion**

According to the local economic and social development needs and the suitability orientation of low hilly red soil, according to local conditions and overall arrangement,

the rational utilization direction is determined, and the principle of “agriculture is suitable, forestry is suitable, garden is suitable” is adhered to, so as to give full play to the comprehensive benefits of low hilly red soil resources.

**Table 1.** Agricultural acreage of low hilly red soil region in Jinhua city in 2014 (unit: hectare)

	Total area	Grain	Cereals	Beans	Potatoes	Rape	Medicinal materials	Vegetable	Watermelon
Jinhua	56439	28287	22233	3047	3007	4877	10	8402	1703
Wuyi	30644	18565	14835	2025	1705	2677	142	5356	817
Pujiang	23928	13564	8800	2343	2421	2790	77	4184	844
Panan	17454	8164	2455	1471	1945	107	4502	3355	660
Lanxi	47065	23069	16817	4141	2111	9089	119	5600	1027
Dongyang	46613	31321	24381	3860	3080	1467	2082	5707	971
Yiwu	30684	17464	11068	3029	3367	1027	94	7277	1124
Yongkang	19298	12984	10529	1148	1307	497	121	2603	831
Total	272125	153418	111118	21064	18943	22531	7147	42484	7977

**Table 2.** Planting area of mulberry orchard in hilly red soil region of Jinhua city in 2014 (unit: hectare)

	Mulberry	Tea	Orange	Peach	Other fruits
Jinhua	9	1975	3001	959	6345
Wuyi	862	6411	501	166	1949
Pujiang	173	2215	340	50	3048
Panan	246	5078	6	76	772
Lanxi	1038	1232	1630	464	9817
Dongyang	342	3176	615	205	3488
Yiwu	116	727	968	489	3633
Yongkang	368	249	951	287	3776
Total	3154	21063	8012	2696	32828

### **Index description**

All the indicators included factors such as grain, vegetables, fruits and other cash crops, as shown (*Table 3*), for their mean, maximum, minimum and standard deviation.

### **Index principal component extraction**

Taking Wucheng District, Jindong District, Lanxi City, Dongyang City, Yongkang City, Wuyi County, Pujiang County and Pan'an County under the jurisdiction of Jinhua City as the samples, taking the standardized data in the tables as the evaluation data, using SPSS statistical analysis software to process the data, the correlation coefficient matrix of the indices and the characteristics of the matrix are obtained. The information of eigenvalue, variance contribution rate and factor load matrix are extracted by principal component analysis, which contains a lot of information of original variables. After factor analysis of the standardized data in the table, the correlation coefficient matrix, variance of each eigenvalue, cumulative contribution rate and factor load matrix are transformed.

**Table 3.** Descriptive statistics of main crops in sample counties (unit: hectare)

	Case number	Minimum	Maximum	Average value	Standard deviation
Total area	8	17454	56439	34015.625	14377.12199
Grain	8	8164	31321	19177.25	7928.8857
Cereal	8	2455	24381	13889.75	7221.53934
Beans	8	1148	4141	2633	1076.8365
Potatoes	8	1307	3367	2367.875	729.6127
Rape	8	107	9089	2816.375	2960.57451
Medicinal materials	8	10	4502	893.375	1616.06258
Vegetable	8	2603	8402	5310.5	1930.62262
Watermelon	8	660	1703	997.125	319.16742
Mulberry	8	9	1038	394.25	365.16014
tea	8	249	6411	2632.875	2152.50482
orange	8	6	3001	1001.5	943.03234
Peach	8	50	959	337	298.99164
Other fruits	8	772	9817	4103.5	2808.93254
Case number	8				

### Factor analysis

The total planting area of crops, grain crops, cereals, legumes, potatoes, rapeseed, medicinal materials, vegetables, watermelon, mulberry, tea, fruit trees, citrus, peach and other 14 variables as the analysis indicators have a certain degree of representativeness, the specific situation is shown in *Table 3*. After the above variables are put into SPSS statistical analysis software, the correlation coefficient matrix between the original variables and the correlation analysis results are obtained. From the correlation coefficient matrix, different degrees of correlation were revealed among the 14 influencing factors, and the correlation coefficients among other factors are in different distribution states.

*Table 4* shows the common degree of variables of the 14 primitive variables. The index of variable commonality can reflect the degree of dependence of multiple variables on all common factors extracted. From *Table 4*, except for variables X1, X2, X9, X10, X12 greater than 90%, the common degree of all other variables are less than 90%, but higher than 65%, which fully shows that the common factor we extracted can contain most of the information of the original variables, the extraction result will be very satisfactory.

According to the requirements of principal component analysis, as long as the eigenvalue is greater than 1, and the cumulative contribution rate is higher than 80%, it can become the principal component. From the column of the eigenvalues and variance cumulative contribution rate (*Table 5*), we can see that the first three cumulative contribution rates have reached 84.076%. Therefore, the three principal components selected in this study are the first, second and third three common factors. The variance contribution rate of the three principal components after rotation is given in the factor load matrix. From this contribution rate, we can see that although the contribution rate of the three common factors after rotation has changed, the total cumulative variance contribution rate of the three factors has not changed, it is still 84.076%.

**Table 4.** Common degree of variables

	Initial	Extract
X <sub>1</sub>	1.000	.977
X <sub>2</sub>	1.000	.902
X <sub>3</sub>	1.000	.807
X <sub>4</sub>	1.000	.804
X <sub>5</sub>	1.000	.802
X <sub>6</sub>	1.000	.869
X <sub>7</sub>	1.000	.561
X <sub>8</sub>	1.000	.848
X <sub>9</sub>	1.000	.942
X <sub>10</sub>	1.000	.932
X <sub>11</sub>	1.000	.648
X <sub>12</sub>	1.000	.921
X <sub>13</sub>	1.000	.883
X <sub>14</sub>	1.000	.875

**Table 5.** Cumulative contribution of eigenvalue and variance

Component	Initial eigenvalue			Extraction of sum of squares		
	Total	Variance%	Cumulative %	Total	Variance %	Cumulative %
1	7.763	55.451	55.451	7.763	55.451	55.451
2	2.271	16.224	71.675	2.271	16.224	71.675
3	1.736	12.401	84.076	1.736	12.401	84.076
4	.898	6.413	90.489			
5	.666	4.758	95.246			
6	.522	3.727	98.974			
7	.144	1.026	100.000			
8	0.000000000000004488	0.00000000000003206	100.000			
9	0.000000000000008075	0.00000000000006218	100.000			
10	0.000000000000006023	0.00000000000004302	100.000			
11	0.000000000000003404	0.00000000000002431	100.000			
12	-0.000000000000003773	-0.00000000000002695	100.000			
13	-0.000000000000001603	-0.00000000000001145	100.000			
14	-0.000000000000004554	-0.00000000000003253	100.000			

According to the previous results, because the contribution rate of the first common factor is especially large, the common factor (the first principal component) in the index X1 total crop area, X2 grain crop area, X3 grain area, X4 legume area, X8 vegetable area, X9 watermelon area and other indicators, these are mainly planting food crops and vegetables (*Table 6*). Cultivated land, therefore, farmland in Jinhua City plays a larger role, so we need to focus on the management and development of cultivated land.

The second common factor (the second principal component) is evident in the index X5 potato area, X6 rape area, X10 mulberry area, X12 orchard area, X13 citrus area, X14 peach orchard area and other indicators. Among these six indicators, four are mainly reflected in economic forest and fruit products, therefore to strengthen, economic forest and fruit development still needs to be obtained.

The third public factor (the third principal component) is obvious in the index X11 tea garden area, X7 medicinal materials planting area, and has a direct relationship with the characteristic agricultural industry in Jinhua, especially in Pan'an County, the development of Chinese medicinal materials is beneficial and needs to be concerned. To sum up, the factors covered by these three principal components also agree with the previous qualitative analysis.

**Table 6.** Factor load matrix

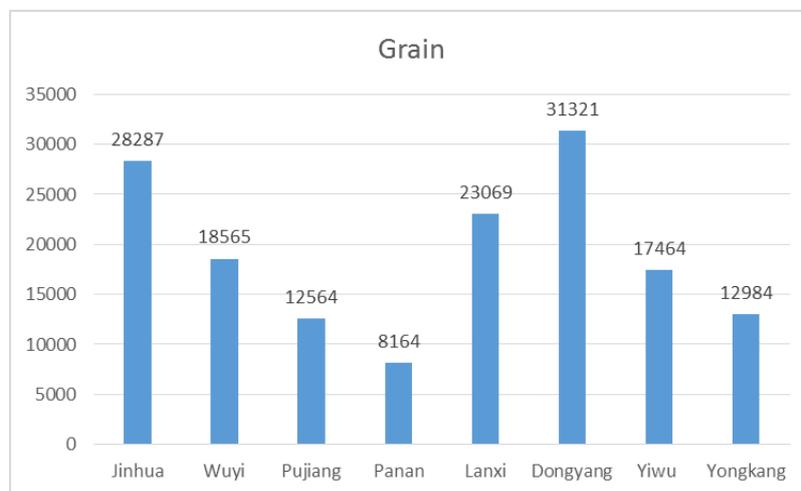
	Component		
	One	Two	Three
X <sub>1</sub>	.948	.053	.274
X <sub>2</sub>	.851	-.003	.422
X <sub>3</sub>	.822	.053	.357
X <sub>4</sub>	.788	.178	.389
X <sub>5</sub>	.599	-.605	.276
X <sub>6</sub>	.670	.645	-.057
X <sub>7</sub>	-.511	-.244	.490
X <sub>8</sub>	.850	-.319	.155
X <sub>9</sub>	.892	-.333	-.191
X <sub>10</sub>	.003	.939	.224
X <sub>11</sub>	-.401	.059	.696
X <sub>12</sub>	.496	.778	-.263
X <sub>13</sub>	-.049	.876	-.338
X <sub>14</sub>	-.212	.851	-.326

### **Analysis**

Land use zoning is one of the main basis for determining land use and adopting specific land use measures. Through the use of land division, various agricultural production layouts can be reasonably arranged, that is, rationally planning the production sectors such as plantation, forestry, animal husbandry, and the spatial distribution of various production categories in various industries in order to obtain a certain area. Planting should involve as much quality agricultural products as possible on the land to achieve the best economic benefits and comprehensive social benefits. The layout of agricultural production in a region is inseparable from two conditions: the land type structure of the region and the hydrothermal conditions of the region, that is, the land quality level of the region. On the basis of the regional land quality level, according to the land type structure, reasonable determination of the local production development direction, combined with the appropriate utilization, transformation and protection measures, will greatly promote the production and ecological protection of the region. Therefore, in the basic soil of the above-mentioned evaluation results of land planting structure, to provide scientific theoretical and practical basis for promoting the efficient development of agriculture, combined with the local economic situation, the agricultural development strategy of the low hilly red soil region of Jinhua City is summarized in the followings:

*(1) Traditional agriculture such as grain in the low hilly red soil region*

The agricultural land in the low hilly red soil area of Jinhua City plays a relatively large part (Liao et al., 2017), has a long development time, and has many development projects. It is suitable for long-term stable development and enhances the level of low hilly red soil development. As shown in *Figure 1*, Dongyang City, Jinhua City and Lanxi are the county-level administrative units with the largest grain planting area (*Fig. 1*). The low hilly red soil areas in these blocks are relatively flat, the agricultural supporting facilities are more comprehensive, and the agricultural basic conditions are better compared to other areas. More obvious benefits can be generated in the development of cultivated land. In the plain area, the slope is slow, the human activity is the strongest, and the land use diversity is the most abundant. According to the potential of soil resources and crop varieties it is required to optimize production system management, achieve intensive farmland management, develop precise agriculture, and ensure efficient use of resources. Dry land that can be realized by artificial water diversion can be transformed into paddy fields, which can not only obtain higher yield and economic income than dry farming, but also reduce soil erosion, improve soil properties and increase nutrient accumulation. Strengthening the production of food crops is the basis for the development of agriculture, the premise of agricultural industrialization, and the necessary condition for the rapid and stable economic development of Jinhua City.

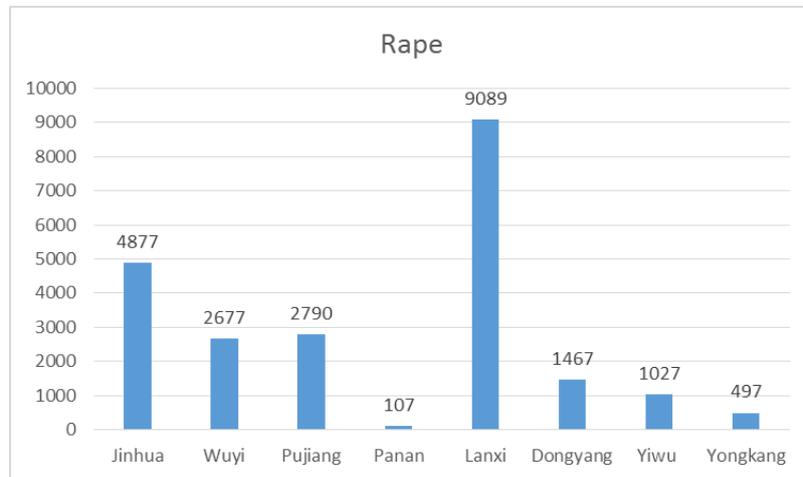


**Figure 1.** The grain sown area of each county in Jinhua city (unit: hectare)

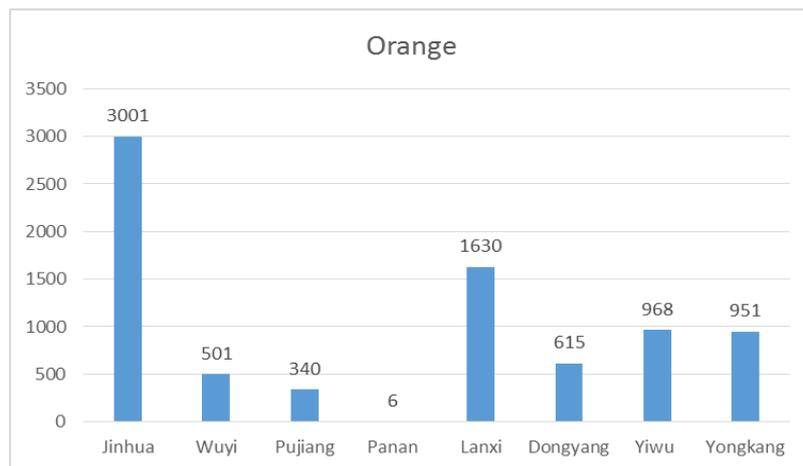
*(2) Economic forest fruit production in the low hilly red soil region*

It is suggested to focus on and support local specialty products such as tea, camellia oil and citrus. The rapeseed planting area in Lanxi City, Jinhua City and Pujiang County ranks in the top three, and the citrus planting area in Jinhua City, Lanxi City, Yiwu City and Yongkang City is larger compared to other areas (*Figs. 2 and 3*). The economic forestry and fruit industry in Jinhua City has not formed a local regional brand, and there are no local agricultural regional brands such as Changshan Huyou, Yuhuan Wendan and Xianju Yangmei. The quality of citrus, tea and camellia products in Jinhua is not lost to foreign products (Yang et al., 2019). It has a long history and a good industrial foundation. On the basis of analyzing the status quo of land use distribution,

correctly understand the suitability of regional topographic conditions and the characteristics of soil types, the rational layout of land use in the region can be explored, the land use structure can be optimized, and optimal allocation and intensive use of low hilly soil resources can be provided. In the next stage of low hilly-red soil management development it is suggested to focus on strengthening the development of economic crops and economic forest fruit, improve agricultural output, build local brand agriculture, and improve the comparative benefits of low hilly red soil governance development.



**Figure 2.** Rape planting area of each county in Jinhua city (unit: hectare)

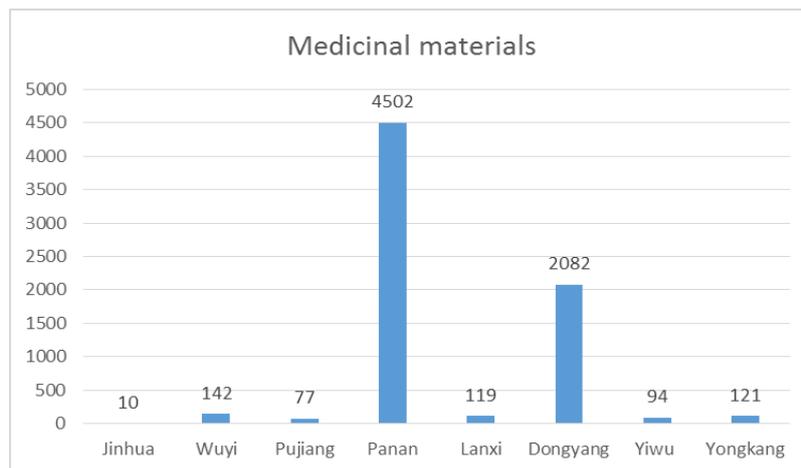


**Figure 3.** Orange planting area of each county in Jinhua city (unit: hectare)

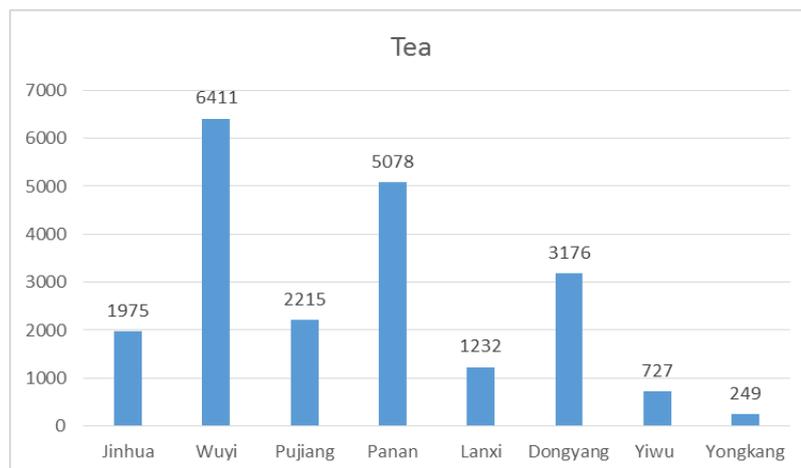
### (3) The development of Jinhua characteristic agriculture in the low hilly red soil region

The unique natural conditions such as topography, land and water have created a distinctive geographical environment, forming a regional brand of agricultural products such as Jinhua bergamot and Chun'an Chinese herbal medicine. The tea planting area in Wuyi County, Chun'an County and Dongyang City ranks in the top three in the city (Figs. 4 and 5). Most of Jinhua City's medicinal materials are planted in Chun'an

County and Dongyang City, and there are Chinese herbal medicines in Chun'an. In the trading market, the Dapanshan National Chinese Herbal Medicine Nature Reserve has promoted the cultivation of medicinal materials in the adjacent Dongyang City. Jinhua City should focus on supporting the development of characteristic agriculture. Under certain technical, economic and ecological environment conditions, the existing red soil resources that can be exploited and utilized can be rationally developed, and the characteristic agricultural industries should be upgraded through technical measures such as agriculture, water conservancy and biology. The completion of the characteristic agricultural product industry has expanded the production scale, optimized the variety structure, improved the product grade, increased the added value of agricultural products, and fully exerted the social benefits of the project (Yu and Wu, 2018).



**Figure 4.** Medicinal herbs area of each county in Jinhua city (unit: hectare)



**Figure 5.** Tea planting area of each county in Jinhua city (unit: hectare)

## Conclusion

This study is based on overall planning, keeping the social economic and ecological benefits unified, adapting to local conditions, maintaining the characteristics of land and agricultural utilization, safe production, efficiency, optimizing resources, comprehensive

development and other principles, and it involves the main distribution area of low-hill red soil in Zhejiang Province. The planting structure was analyzed and it was considered that the rational layout of different landform units was strengthened and the potential of land resources was fully explored. It is necessary to actively develop precision agriculture in the plain area and reduce the occupation of construction land on low hilly red soil. Low-mountain hilly areas should vigorously develop a complex ecosystem of forest and fruit combination, so that grain should be grainy, forest should be forested, fruit should be fruitful, and rational layout should be achieved to achieve the best ecological, economic and environmental effects.

In the next stage of the development of low-hill red soil governance, Jinhua City was regarded as a model project of low hilly red soil agriculture, which involves the followings: (1) Expanding the scale of land management for farmers. Fully understand the importance and urgency of large-scale operation of low hilly red soil land, changing the concept of land use (Le et al., 2017), transforming the economic development mode, and adjust and optimize the economic structure. Strengthening planning guidance, tapping the potential of stocks of low hilly red soil, and increasing the scale of land use. Speeding up the transformation of land to large-scale utilization and improving the land use efficiency of low hilly red soil. (2) Improving the construction of farmland water conservancy infrastructure. In the development of characteristic agriculture in the low hilly red soil region, it is necessary to promote the construction and management of farmland water conservancy projects in the low hilly red soil region, and to increase the end-canal system reform in large and medium-sized irrigation districts, and accelerate the construction of small-scale drainage facilities. It is appropriate to take the form of incentives and subsidies to fully mobilize the enthusiasm of farmers to build farmland water conservancy projects.

(3) Promoting the development of agricultural land consolidation projects. Through the method of finishing low hilly red soil area, the low hilly red soil resources are levelled and the water conservancy facilities, field protection forests, and field roads in the development area are constructed. Reaching Tian Chengfang, the canal is connected, the road is connected, the forest is net, and the irrigation is carried out. The requirements of the row have led to a significant improvement in farmland production conditions. Continuously increasing the effective arable land area and improving the comprehensive agricultural production conditions are also suggested.

(4) Implementing agro-ecological protection projects in low hilly red soil areas, improving the management methods for various types of funds for ecological compensation, incorporating ecological protection indicators for low hilly red soil into comprehensive evaluation system for economic and social development and establishing a comprehensive evaluation system for leading cadres, inspiring internal motivation of the cadres and the masses at all levels to protect the ecological environment. Finally, we will improve the comprehensive agricultural production conditions, change the agricultural planting structure, and achieve the goal of improving agricultural output value and improving agricultural production performance.

In the future the planting structure will be analyzed further and more effective agricultural development planning will be proposed, which will not be limited in low hilly red soil region, but other regions will also be involved to provide reference for further studies.

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