

# Research on Countermeasures for Mechanization of Agricultural Advantageous and Characteristic Industries in Wencheng Mountainous Area

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**Abstract.** Based on the data of agricultural machinery equipment statistics over the years, this paper analyzes the current situation of agricultural mechanization in agricultural advantageous and characteristic industries such as high-altitude rice, tea, vegetables, and fruits in Wencheng County, Zhejiang Province. In 2022, the comprehensive mechanization level of rice cultivation and harvest in Wencheng County was 70.2%, while the average level in Wenzhou City was 87.4%. Rui'an City mainly composed of plains reached as high as 94.8% and Leqing City mainly composed of plains reached as high as 84.1%. In 2022, the mechanization level of tillage link of rice in the Wencheng mountainous area reaches 99.6%, which is little difference from the plain area. However, there is a significant difference between the plain and mountainous areas in the sowing and transplanting links. In 2022, the rice transplanting rate in Wencheng County was only 14.8%, significantly lower than the average level of 62.38% in Wenzhou, and far lower than Rui'an (77.3%) and Leqing (73.6%). In 2022, the machine harvest level of rice in Wencheng County was 86.4%, lower than that of Rui'an City (95.4%) and Yueqing City (98.8%). At present, the comprehensive mechanization level of the rice and tea industries in Wencheng is high, but the mechanization level of the vegetable and fruit industries is very low with the sowing and transplanting, field management, and harvesting processes being mainly manual operations. The article analyzes the geographical, policy, industrial, equipment, and technological bottlenecks of agricultural mechanization in Wencheng County, and proposes corresponding countermeasures to break the bottlenecks.

**Keywords:** Wencheng Mountain Area; Agriculture; Advantageous and characteristic industries; Mechanization; Bottleneck; Cracking strategy.

## 1. Introduction

Agricultural mechanization can greatly improve agricultural production efficiency, reduce labor intensity and labor costs, effectively alleviate the current situation of increased labor costs and shortage of labor resources, and is the direction of modern agricultural development[1]. Wencheng County, Zhejiang Province is a typical mountainous county with 82.5% mountain land of the total area. The territory has distinct four seasons, abundant rainfall, no severe cold in winter, and no scorching heat in summer. The complex terrain and landforms form a rich and diverse agricultural microclimate, producing some unique agricultural products and advantageous industries such as rice, vegetables, fruits, and tea[2]. However, due to many bottleneck factors such as mountainous geography, technology, policies, industries, and benefits, the degree of agricultural mechanization is relatively low, labor intensity is high and benefits of are low, which restricts the development of those industries [3] [4]. This article combines the annual report data of agricultural machinery equipment in Wencheng County from 2012 to 2021 for 11 consecutive years to study and analyze the current status and trends of agricultural mechanization development in advantageous industries such as high-altitude rice, tea, vegetables, and fruits in the county, and proposes some countermeasures and suggestions to solve the problems.

## **2. Characteristics of advantageous industries in Wencheng Mountain Area**

### **2.1 Alpine Rice Industry**

Wencheng County is located in the mountainous area of southern Zhejiang Province, with a beautiful ecological environment, fresh air, and no industrial pollution. The quality of the agricultural ecological environment is suitable for the production of pollution-free green agricultural products. In 2022, Wencheng County had 18226.7 ha of annual crop planting area, including 49200 ha of rice planting area, accounting for 27.04%. Developing alpine green rice has certain ecological resource advantages. "Keli" rice has won the first green food certification of Grade A green rice in Zhejiang Province, and Xinglu rice has won the title of green agricultural product in Zhejiang Province. The high mountain terrace green rice bases can be arranged in towns and townships over an altitude of 650 meters, such as Eryuan, Nantian, and Baizhangji. The medium and low mountain green rice bases can be arranged in towns and townships such as Huangtan, Xikeng, Shanxi and Guishan.

### **2.2 Alpine vegetable industry**

Wencheng has a good foundation for the development of alpine vegetable industry, such as glutinous yam, eggplant, water bamboo, ginger, fresh edible soybean, cucumber, and pepper. It has formed a mountain platform alpine vegetable industry cluster belt in the areas of Nantian and Eryuan. Wencheng County is one of the top ten mountain vegetable demonstration counties in Zhejiang province, one of the key mountain eggplant counties in the province, and one of the industries listed in the "Regional Layout Plan for Featured and Advantage Agricultural Products in Zhejiang Province". In 2008, the People's Government of Zhejiang Province recognized Nantian Town of Wencheng County as a strong agricultural featured and advantageous industrial town in Zhejiang Province; In 2009, the People's Government of Wenzhou awarded Nantian Town and Eryuan Township of Wencheng County as the strong townships and towns with agricultural characteristics and advantageous industries in Wenzhou City; In 2019, the People's Government of Zhejiang Province identified Eryuan Town, Wencheng County, as only one of the strong agricultural towns with high mountain vegetable and fruit characteristics in Zhejiang Province. In recent years, Wencheng's alpine vegetables have developed rapidly. In 2022, the total output of vegetables in the county was 162700 tons.

### **2.3 Fruit industry development**

Fruit is another advantageous and characteristic industry in Wencheng, with a total fruit output of 52000 tons in 2022. Wencheng fruit is best known for its red bayberry, which is characterized by rapid development, high concentration, large scale, excellent quality, early harvest time, and green and pollution-free. From 1994 to 2018, the area of red bayberry in Wencheng County increased from 604.6 ha to 4267 ha, and the total output also increased from 2400 tons to 17274 tons. Shanxi Town is the largest town for red bayberry production in Wencheng County, and was listed as a provincial-level strong agricultural town for red bayberry production in 2019. "Wencheng Yangmei" has been recognized as a regional public brand, and has successfully registered as a geographical indication certification trademark. It has successively obtained a series of honorary titles such as regional famous brand products in Zhejiang Province, regional famous agricultural products in Zhejiang Province, and red bayberry in Zhejiang Province. The specialized red bayberry cooperatives in the region have also registered some red bayberry brand trademarks such as "Million Mountain", "Huangkui", "Yangshan", "Meishanshan", "Yangnong", and "Sanjieshan". Yangshan red bayberry has won the title of provincial famous agricultural product, and Huangkui red bayberry has won the title of municipal famous agricultural product. With the advantage that Wencheng County is the second largest hometown of overseas Chinese in Zhejiang Province, Wencheng red bayberry has been sold well in the European market for many years. In 2018,

Wencheng red bayberry obtained the FDA food certification for the first time and began exporting to the United States and Canada.

## 2.4 Tea industry

The cultivation of tea in Wencheng has a long history, which can be traced back to the Western Jin Dynasty and has been popularized in the Tang and Song dynasties. In 1949, the total area of tea gardens in the county was 280 ha, with a total output of about 200 tons. In the early 1950s, the government encouraged tea production, and the area and output of tea increased year by year. By 1959, it had grown to 346.7 ha, with an annual output of 257 tons. From 1959 to 1961, in the face of three years of natural disasters, some farmers dug tea plant and planted grain, resulting in a sharp decrease in the area of tea plantations throughout the county. In 1961, the area decreased to 206.7 ha, with a yield of 100 tons. Since 1963, the government has adopted supportive policies of tea production, resulting in a rapid increase in the area of tea gardens throughout the county. Since 2000, the Government of Wencheng County have increased their guidance and support for the tea industry, and tea production has gradually developed towards improved varieties, large-scale production, and high-quality brands. In 2022, the tea output of Wencheng County will reach 500 tons, including nearly 200 tons of famous and high-quality tea, with an output value of nearly 10 million yuan. "Wencheng Tribute Tea" is a famous historical and cultural tea, which is said to have been named by the founding emperor of the Ming Dynasty, Zhu Yuanzhang. In the 1990s, the Agricultural Bureau of Wencheng County organized the systematic excavation, research and development of "Wencheng Tribute Tea", restoring and developing the historical famous tea "Wencheng Tribute Tea", making it a combination of Liuji culture, natural green raw materials, traditional processing techniques, and modern high-tech.

## 3. Analysis of the degree of agricultural mechanization

In 2022, the comprehensive mechanization level of main crops in Wencheng County was 61.8%, far lower than that of Rui'an City (88.0%) and Yueqing City (83.8%), which are mainly plains. Comparing the power of planting area per unit in different regions of Wenzhou city, there is not much difference between mountainous and plain areas. In 2022, the city's crop planting area was 1611439 acres, with 1168841 kilowatts of planting machinery power, an average of 0.73 kilowatts per acre. The planting area of crops in Wencheng County is 101396 hectares, with planting machinery power of 75939 kilowatts, which is 0.75 kilowatts of agricultural machinery power per acre of crops with slightly higher than the city's average level of Wenzhou (Table 1). However, the comprehensive mechanization level of crop cultivation and harvest in mountainous areas of Wenzhou is much lower than that in plain areas. In 2022, the comprehensive mechanization level of the cultivation and harvesting of major crops in Taishun and Wencheng counties was 61.8%, which is far lower than the 88.8% of Ruian and 83.8% of Yueqing. There are two reasons for this: firstly, currently, most crops in mountainous areas are planted in a single season, with diverse planting modes and varieties, and various types of agricultural machinery need to be equipped, resulting in a high idle rate of agricultural machinery; on the other hand, the agricultural production conditions in mountainous areas are poor, and the labor required for planting crops per unit area is high, especially in the transportation, irrigation, and cultivation processes, which use much more labor than in plains.

Table 1 Comparison of total power of agricultural machinery (2022)

Type	Region	Comprehensive mechanization level (%)	Total Power(kw)	Planting area(ha)	Total Power/Planting area(kw/ha)
Pure mountainous area	Wencheng County	61.8	75939	6759.9	11.23
Mainly	Yongjia	71.7	159282	14511.1	10.98

mountainous area	County				
	Pingyang County	82.9	203166	17187.9	11.82
	Cangnan County	76.9	135740	12860.7	10.55
Mainly Plain	Ruian City	61.8	242122	18384.6	13.16
	Yueqing City	83.8	179284	19665.3	9,12

### 3.1 Analysis on the degree of mechanization of rice industry

Research shows that the mechanization of rice cultivation in mountainous areas of Wenzhou City has been increasing year by year, but it is significantly lower than that in plain areas [5]. In 2022, the comprehensive mechanization level of rice cultivation and harvest in Wencheng County was 70.2%, which is lower than the average level in Wenzhou City (87.4%) and the three semi mountainous districts, the counties of Yongjia, Pingyang, and Cangnan. However, the level in Rui'an City was as high as 94.8% and the level in Leqing City was also as high as 84.1%, which are mainly composed of plains. At present, the mechanization level of rice cultivation in the Wencheng mountainous area is 99.6%, which is no different from that in the plain area. However, in the plain area, large and medium-sized tractors are mainly used for cultivation, while micro tillage machines account for a large proportion of cultivation in the mountainous area. There is a significant difference between the plain and mountainous areas during the seeding process of rice. In 2022, Wenzhou has 2251 rice transplanters, while Wencheng County has only 23. In 2022, the rice transplanting rate in Wencheng County was only 14.8%, significantly lower than the average level of 62.38% in Wenzhou, and even lower than the plains dominated cities of Rui'an (77.3%) and Leqing (73.6%). The total number of rice transplanters in Wencheng County from 2012 to 2022 varied between 11 and 24, with a small increase. Before 2019, there was no rice planting assembly line in Wencheng County, and in 2022, there were 9 sets of rice planting assembly lines. In links of harvest, the mechanization degree of rice harvest in Wencheng mountainous area is relatively low. In 2022, Wencheng County's rice machine harvest level was 86.4%, which was lower than that of Yueqing City (95.4%) and Yueqing City (98.8%)(Table 2). The most rice of the mountain areas are harvested manually, and the electric threshing machine threshes, while the plains are mainly harvested by combine harvester, by which the harvesting, threshing and straw crushing operations are completed at one time.

Table 2 Comparison of mechanization level of rice cultivation and harvest in Different Regions (2022)

Type	Region	Planting area(ha)	comprehensive mechanization level (%)	Machine farming (%)	Machine sowing (%)	Machine harvesting (%)
Pure mountainous area	Wenchen g County	4918.7	70.2	99.6	14.8	86.4
Mainly mountainous area	Yongjia County	10040.9	84.1	100	53.0	93.9
	Pingyang County	12871.8	90.8	100	69.5	99.9
	Cangnan County	10123.1	91.0	98.6	74.2	96.4
Mainly Plain	Ruian City	15873.3	91.8	100	77.3	95.4
	Yueqing City	15700.0	84.1	100	73.6	98.8

### 3.2 Analysis on the degree of mechanization of tea industry

Currently, the degree of mechanization in tea production in Wencheng County is relatively high. The tea planting process, pruning, pest control, and bulk tea picking are mostly mechanized, and mechanical equipment such as automated tea processing lines is promoted[6]. However, the mechanization of agricultural operations such as intertillage weeding, fertilization, and sprinkler irrigation is still relatively low, and it is necessary to promote some small and medium-sized tea garden intertillage weeding, fertilization, and tea tree defrosting and antifreeze mechanical equipment that adapt to the geographical environment of hilly and mountainous areas, as well as applicable tea tree pruning, bulk tea picking, tea fresh leaf grading, and mountain tea garden rail transportation equipment. Statistics show that the mechanization level of the tea industry in Wencheng County is relatively high. In 2022, the county's tea garden area was 1322.1 ha, with an area of 233.3 ha for machine picking and 1233.3 ha for machine cutting, accounting for 17.6% and 93.3% respectively. At present, Wencheng County has 192 tea pruning machines, 16 tea picking machines, 65 tea kneading and twisting machines, 602 flat tea frying machines, 61 multi-functional tea striping machines, and 28 tea wrapping machines; And it has 14 automated tea processing lines. According to the change of tea machinery in Wencheng County from 2012 to 2021, the number of machinery units increased from 728 in 2012 to 1075 in 2021, and the total power increased from 1093 KW in 2012 to 2375 KW in 2021; Tea machinery such as flat tea frying machines, pruning machines, picking machines, and kneading machines have all shown a growth trend. Since 2018, there have been 14 automatic production lines for famous and high-quality tea, with an annual processing capacity of 320 tons (Table 3).

Table 3 Changes in tea machinery in Wencheng County from 2013 to 2022

(sets)

Year	Total of tea machine	Pruning machine	Picking machine	Rolling machine	Multifunctional striping machine	Flat tea frying machine	Wrapping machine	Tea automatic assembly line	Others
2013	728	155	10	38	50	377	25		73
2014	758	152	10	39	51	406	25		75
2015	789	157	10	39	51	433	25		74
2016	793	158	10	40	51	434	25		75
2017	818	158	10	45	51	454	25		75
2018	843	158	11	45	51	466	25		75
2019	933	187	16	55	52	495	27	14	87
2020	949	189	16	56	54	495	28	14	97
2021	1002	192	16	65	55	535	23	14	97
2022	1075	192	16	65	61	602	28	14	97

### 3.3 Analysis of the degree of mechanization in the fruit and vegetable industry

At present, the degree of mechanization of the vegetable and fruit industries in the mountainous areas of Wenzhou is very low. In recent years, the mechanization level of vegetable farming in mountainous areas has been increasing year by year, mainly due to the rapid promotion and application of micro tillage machines. In 2016, the total number of micro tillage machines in Wencheng County was less than 1000, and in 2019, the total number of micro tillage machines had reached 4258. In 2022, the total number had increased to 6395, which basically solve the mechanization problem of tillage. However, the degree of mechanization in the planting and harvesting is very low. Currently, there is no promotion of sowing and transplanting machinery, and the degree of mechanization in fruit and vegetable garden management is also relatively low. In 2022, the Wenzhou municipal has 312 fruit tree pruners, while Wencheng County has only 6. The

degree of mechanization in the and processing of the fruit and vegetable industry in Wencheng Mountain Area is also very low. According to statistics, in 2022, there were 33 fruit and vegetable dryers in Wencheng, while there were no in Wencheng; there were 290 sets of post-harvest refrigeration and preservation equipment for agricultural products in Wenzhou, while there were 28 sets with a low proportion in Wencheng. There is a large demand and development space for storage and preservation of fruits and vegetables such as vegetables and red bayberries in the mountainous areas.

At present, there are few facility agricultural equipment mainly used for vegetable production in the Wencheng mountainous area. In 2022, there were a total of 23.48065 million square meters of farmland facilities in Wenzhou city, while Wencheng County only had 954500 square meters. Currently, there are no advanced facilities such as mesh covered steel frame sheds, intelligent greenhouses in Wencheng mountainous areas. Facility agriculture improves the agricultural production environment and improves the quality of agricultural products. There is a certain development space in mountainous areas. With the development of facility agriculture, the demand for various small or micro agricultural machinery and equipment that adapt to the narrow environment of greenhouse facilities for production operations is also increasing [7].

## **4. Main bottlenecks and their solutions**

### **4.1 Geographic bottlenecks and their solutions**

Wencheng is located in a mountainous area with complex terrain, small cultivated land area, irregular shape, large slope between most plots, narrow field roads, resulting in difficulties in accessing, and operating for agricultural machinery. For solving the geographical bottlenecks mentioned above, it is recommended to increase transformation of farmland to be suitable for mechanization and the construction of farming road in the field, and increase the concentration of rural land [8][9]. Based on the actual situation in Wencheng, the innovative measure should be made to explore various transfer models such as villagers' independent land transfer, collective unified transfer, and rural land transfer for reservoir area immigrants. This will ensure the orderly transfer of land management rights, and concentrate the previously scattered farmland among farmers, which effectively improves land utilization efficiency. It should be promoted for the construction of agricultural characteristic industrial parks and high standard farmland for forming accumulation area of advantageous and characteristic industries such as bayberry, alpine vegetables, and tea. We should promote the moderate scale production and industrial management for realizing mechanization on the basis of agricultural industrialization.

### **4.2 Policy bottlenecks and their solutions**

In response to the current situation of not enough policy support, and insufficient financial investment in agricultural mechanization in Wencheng mountainous areas. We should strengthen the leadership and guidance of the county's agricultural mechanization work, strengthen the analysis and understanding of the policy system for promoting agricultural mechanization. We should fully utilize the existing policies and formulate some new better policies based on the actual situation of Wencheng for creating a good policy environment for agricultural mechanization. Various departments should increase coordination, clarify goals, update concepts, form a working force for solving problems in the promotion of agricultural mechanization and ensuring the implementation of agricultural mechanization support policies. It should increase financial support for agricultural mechanization and raise funds for agricultural mechanization construction through multiple channels. In addition to increasing subsidies for the purchase of agricultural machinery in the main production links of bulk agricultural products such as grains and tea, we will also study and formulate subsidy policies for small agricultural machinery suitable for advantageous and characteristic crops such as alpine vegetables, bayberry, and pear, and formulate subsidy policies

for local agricultural machinery enterprises and national large agricultural machinery manufacturers to jointly develop new agricultural machinery suitable for the mountainous areas.

### 4.3 Industrial bottlenecks and their solutions

The agricultural industries in mountainous areas are small and scattered, with small plots of land and very little arable land per household. The different agricultural operators mainly operate independently with low commercialization, therefore the socialization and specialization of agricultural machinery operations are low, and the mechanism of sharing together for agricultural machinery services has not yet been formed. However, the scope of use of agricultural machinery in mountainous areas is narrow, with high idle rates, high operating costs, high losses, and poor promotion efficiency. It is recommended to innovate the mechanism of large-scale production of agriculture, and to collaborate with agricultural professional cooperatives, agricultural machinery cooperatives, professional large households, and other organizations within the region to form Rural Economic Organization Federation. Through the alliance of agricultural cooperative organizations, various types of agricultural service resources are gathered to carry out cooperation in technology, production, sales, financing, insurance, etc., which forms a large-scale cooperation and service pattern in the agricultural industry, solves key common problems in agricultural production and agricultural machinery services, and achieves the close connection between small farmers and modern agriculture. Relying on the advantageous and characteristic agricultural products having high clustering degree, excellent quality, as well as the first-class ecological environment in mountainous areas, by selecting excellent varieties and promoting the application of agricultural machinery, a value system of agricultural products with "product value+ecological value+brand value" is formed, and the advantageous and characteristic industries in mountainous areas are developed which greatly improves the efficiency of agricultural production and agricultural machinery operation.

### 4.4 Equipment bottlenecks and their solutions

At present, there is a serious shortage of agricultural machinery products suitable for the terrain, crop types, and planting system in the Wencheng mountainous area [10]. Moreover, the research and development of intelligent new agricultural machinery suitable for mountainous areas is difficult, with high after-sales service costs, small market size, and no research and development subsidy policies. The main production links of advantageous and characteristic industries in mountainous agriculture are in a state of "no ideal machine" or "good machine availability". In addition, the economic level of farmers in mountainous areas is relatively low, making it difficult for them to invest in purchasing machinery. As a result, farmers and agricultural machinery service organizations have low enthusiasm for purchasing machinery. It is recommended to increase the application of multifunctional, small and medium-sized, lightweight, and durable new agricultural machinery and strengthen cooperation with agricultural machinery production enterprises and agricultural universities, relying on digital technologies such as robots and artificial intelligence, as well as modern communication technologies, to develop new intelligent agricultural machinery suitable for advantageous industries in mountainous areas for promoting a leap in the quality of agricultural machinery [11] [12]. We should promote the application of intelligent agricultural machinery in the cultivation, harvesting, and field management of advantageous and industries such as rice, vegetables, fruits, and tea, with a focus on solving the problem of no ideal machine in the transplanting and drying processes of green rice in mountainous areas, solving the problem of no machine availability in the sowing, transplanting, harvesting, and field management processes of alpine vegetables, solving the problem of lacking mechanical facilities and equipment in the transportation, picking, and preservation processes of alpine fruits such as bayberry, and solving the problem of mechanized picking in high-quality tea industry.

#### 4.5 Technical bottlenecks and their solutions

At present, the agricultural production technology and agricultural mechanization in the Wencheng mountainous area are poor. A comprehensive agricultural machinery service system has not yet been formed, and the policy mechanism for agricultural machinery services across administrative regions is still blank, which restricts the development of agricultural mechanization. The investment in agricultural machinery demonstration and promotion funds is low. In addition, local financial difficulties in mountainous areas make the annual investment unable to meet the funding needs of agricultural machinery demonstration and promotion. In the mountainous areas, the popularization rate of new agricultural varieties and technologies is low, agricultural machinery and techniques are not integrated, and the overall agricultural efficiency is not high, which also affects the development of agricultural mechanization in mountainous areas. It is suggested to improve the agricultural machinery extension institutions, equipped with full-time county, township (town) agricultural machinery extension personnel and agricultural machinery personnel are not randomly selected to engage in non professional work. We should train farmers for enhancing the ability of them to master new agricultural machinery technologies and methods, as well as the integration skills of agricultural machinery and agronomy. We should increase the research and application of agricultural technology and machinery, select excellent varieties and planting models, promote suitable agricultural machinery, study the water and fertilizer demand characteristics and high yield and quality cultivation techniques, promote the integration of agricultural machinery and agricultural technology, improve the efficiency and adaptability of agricultural machinery and the yield and quality of agricultural products.

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