

# Studies on Countermeasures of Agricultural Mechanization in Mountainous Areas in Southern China: A Case Study of Wencheng County

Ruoqi Bai<sup>1\*</sup>, Chengnian Zhang<sup>1</sup>, Kunlong Wu<sup>2</sup>

<sup>1</sup>Wenzhou Vocational College of Science and Technology, Wenzhou, Zhejiang, China

<sup>2</sup>Wencheng Modern Agriculture and Health Industry Research Institute, Wencheng, Zhejiang, China

\*Corresponding Author.

## **Abstract:**

Based on the systematic analysis of agricultural machinery and equipment data in mountainous areas of Wencheng County for nine consecutive years from 2012-2020, the result shows that the total agricultural machinery power is low with only 3.86 kilowatts per hectare and the progress of development is slow, especially the degree of agricultural mechanization in the three links of farming, planting and harvest is low, and the degree of mechanization in the links of plant protection and irrigation is slightly higher. Furthermore, this paper analyzes favorable conditions and the restriction factors of agricultural mechanization in mountainous areas in Southern China, and puts forward some suggestions, such as intensifying organizational coordination, increasing financial support, strengthening the infrastructure construction of agricultural mechanization, innovating service mechanisms of agricultural machinery, applying suitable agricultural machinery and promoting intelligent agriculture for promoting agricultural mechanization in mountainous areas in Southern China.

**Keywords:** Mountainous areas in Southern China, Wencheng County, Agricultural mechanization, Status quo, Countermeasures

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## I. INTRODUCTION

China is country with a mountainous areas accounting for 69.1 percent of the total areas. Southern China with many mountainous cultivated lands includes 15 provinces located in the south of the monsoon zone of eastern China, which is rich in light, temperature and water resources, suitable for the growth of different types of crops. In recent years, the agriculture in the mountainous areas of Southern China has made great development, which has improved

significantly with agricultural resource utilization rate, land output rate and labor productivity, however the degree of agricultural mechanization is far lower than that in the plain area because of its poor agricultural production conditions, uneven mountainous fields, and inconvenient transportation, which has become the main reason restricting the development agricultural production in mountainous area<sup>[1]</sup>. In Wencheng County of Zhejiang Province in China, the mountainous areas accounts for 82.5 percent of the total area, which has typical characteristics of Southern China with beautiful landscape, fresh air and no industrial pollution, but the mechanization of agriculture is still very low<sup>[2,3]</sup>. Based on the statistical data of agricultural machinery and equipment in Wencheng County for 9 consecutive years from 2012 to 2020, this paper analyzes the present situation and problems of agricultural mechanization in mountainous areas in Southern China, and puts forward some countermeasures and suggestions.

## **II. ANALYSIS ON THE SITUATION OF AGRICULTURAL MACHINERY AND EQUIPMENT**

### **2.1 General Power of Agricultural Machinery**

Overall, the level of agricultural mechanization and its development process is very slow in Wencheng County. In 2020, the total power of farm machinery in Wencheng County was 73368 kilowatts with 70950 kilowatts of plant power, and the planting area of crops is 18309 hectares, so the farm power per hectare was 3.86 kilowatts, which was obviously lower than 6.24 kilowatts of a plain area such as Yueqing with 6.24 kilowatts per hectare.

Looking at the statistics from 2012 to 2018, Wencheng County's total power of agricultural machinery does not rise. In 2012, the total power of farm machinery in Wencheng County was 77342 kilowatts, Since then, it had fallen to 66786 kilowatts in 2017, and then which was back up to 71048 kilowatts by 2019 and 73368 kilowatts by 2020. From the change trend of the machinery power type, diesel engine power was declining year by year, which declines from 44066 kilowatts in 2012 to 20315 kilowatts in 2020, but gasoline engine power is rising year by year, which increased from 7884 kilowatts in 2012 to 27396 kilowatts in 2020, however the motor power had barely changed, which was maintained between 25500 and 25600 kilowatts (Fig. 1). The main reason was that in recent years diesel-powered tractors and handheld tractors were eliminated and restricted, and the transportation machinery were gradually replaced by gasoline-powered vehicles, which lead to the overall reduction of diesel engine power agricultural machinery, in addition the gasoline-powered micro-tillage machines and other agricultural machinery increased rapidly.

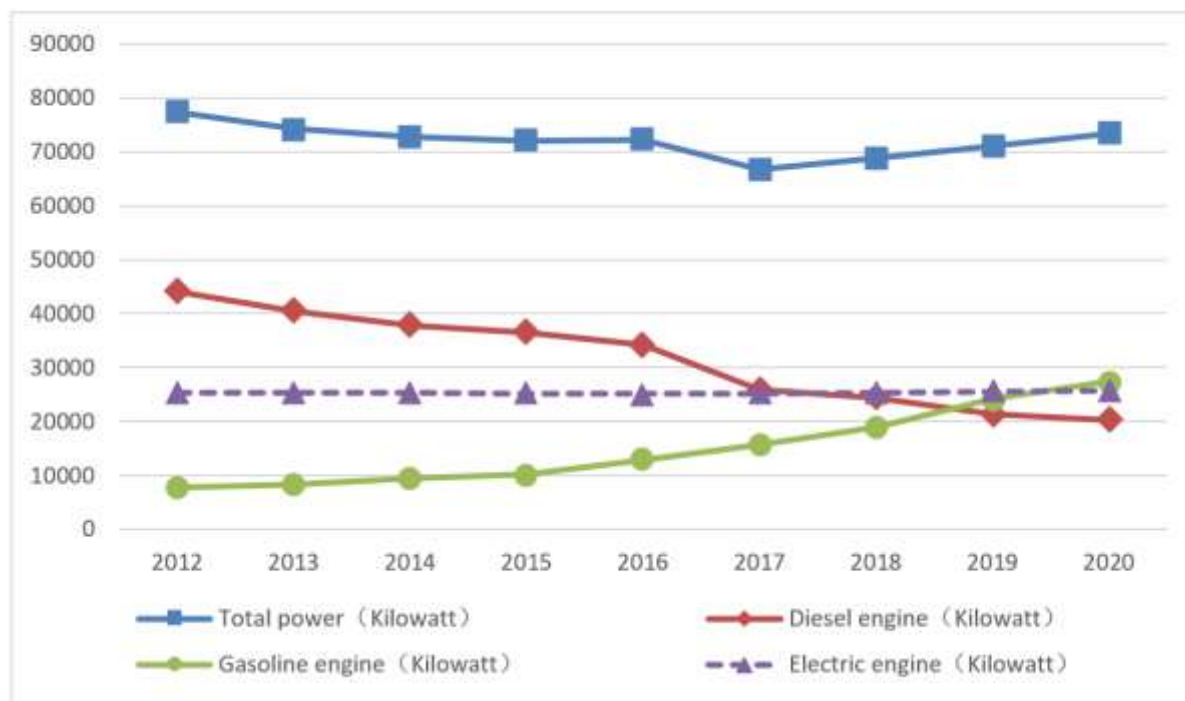


Fig 1: Change of general power of agricultural machinery in Wencheng from 2012 to 2020

## 2.2 Tillage Machinery

In 2020, there are 5431 units of tillage machinery in Wencheng County with 62 large and medium-sized tractors and 35 ploughs, 57 rotary tillers, 9 rakes. At present, many advanced tractor supporting agricultural tools have not been popularized, such as the combined land preparation machine, deep loosening machine, planter, fertilization machine, middle tillage weeding machine, straw returning machine. In recent years, the micro-tillage machine is applied rapidly in Wencheng County with 4258 units in 2019 and 5186 in 2020. From 2012 to 2020, the number of tillage machinery increased year by year, from 934 units in 2012 to 5431 units in 2020. The total number of large, medium and small tractors increased from 0,4,0 sets in 2012 to 39,18,5 sets in 2020, with significant growth in 2019 and 2020. But the handheld tractors decreased year by year, from 369 sets in 2012, down to 40 sets in 2020 (TABLE I).

**TABLE I. Change of tillage machinery in Wencheng mountainous area from 2012 to 2020**

Years	Total power of tillage machinery			Number of tractors			
	Number	diesel	gasoline	small-	medium-	large-	handheld
2012	934	369	0	4	0	0	0
2013	1000	400	0	3	0	0	0
2014	1100	380	0	2	0	0	0
2015	1200	360	0	1	0	0	0
2016	1300	340	0	0	0	0	0
2017	1600	280	0	0	0	0	0
2018	1900	250	0	0	0	0	0
2019	4258	220	0	0	0	0	0
2020	5431	200	0	0	0	0	0

	(set)	engine (kw)	engine (kw)	sized(Under 22.1 kw)	sized(22.1- 73.5 kw)	sized(More than 73.5 kw)	tractor
2012	934	4610	363		4		369
2013	1157	4671	1304		4		340
2014	1485	4862	2352		6		93
2015	1797	5146	3306		6		80
2016	2467	5039	6003		5		57
2017	3305	4992	9390		5		52
2018	4003	5096	12254		9		44
2019	4485	2129	17467	39	12	3	40
2020	5431	2710	20764	39	18	5	40

### 2.3 Planting Machinery

Compared to the plain area, the planting mechanization in Mountainous areas is very poor. At present, it is applied only in the rice with a small number of mechanical planting and has not been promoted in vegetables, bayberry, tea and other characteristic industries. In 2020, there were only 14 rice planting machines, and 13 of them were walking hand transplanter with low efficiency. Because the walking hand transplanter can plant one hectare per day, high-speed transplanter can plant 6 hectares per day, with the suitable planting period of 20 days, only 380 hectares with 4280.3 hectares of rice in Wancheng County can be planted by machines, Therefore, the highest proportion of machine planting is only 8.9 percent. The total number of transplanters in Wencheng County changed between 11 to 14 from 2012 to 2020, and just 8 sets of rice seeding line were added in 2020.

### 2.4 Plant Protection Machinery

There are more plant protection machinery in mountainous areas. In 2020, there were 1143 units in Wencheng County, which was more than 719 units in Yueqing, and there were 795 stretcher sprayers, 319 a backpack powder sprayers and 4 self-propelled sprayers. The plant protection machinery was almost powered by gasoline engines. The plant protection machinery increased year by year, from 969 units in 2012 to 1143 units in 2020, and the total power increased from 2419 kilowatts in 2012 to 2972 kilowatts in 2020 (TABLE. II). However, the type of plant protection machinery had not changed much, and the advanced plant protection machinery, such as high efficiency, uniform amount of spray liquid, good spraying quality spray rod sprayer and air sprayer with long range and high spray force, the agricultural plant protection drone, smoke machine had not been popularized and applied.

**TABLE II. Changes of plant protection machinery in Wencheng mountainous areas from 2012 to 2020**

Years	General power		Spraying or powdering machine		Self-propelled rod sprayer	
	amount	kw	amount	kw	amount	kw
2012	969	2419	960	2395		
2013	990	2480	985	2468		
2014	995	2527	986	2491		
2015	987	2500	979	2478		
2016	1003	2551	995	2529		
2017	1058	2723	1048	2690	4	16
2018	1106	2876	1096	2843	4	16
2019	1140	2963	1111	2858	4	16
2020	1143	2972	1114	2864	4	16

### 2.5 Drainage and Irrigation Machinery

Because of complex irrigation water intake conditions in Wencheng mountainous areas by terraced fields farmland with small and scattered distribution, the need for irrigation machinery is relatively large. In 2020, the irrigation machines were almost water pumps with 5196 pumps in Wencheng more than 2668 in Yueqing, but Wencheng County had only 24 water-saving irrigation machinery, far below 2042 in Yueqing. Currently it has not yet popularized water and fertilizer integration equipment in Wencheng County. The number of irrigation machinery in Wencheng County decreased slightly, with 5395 in 2012 and 5196 in 2020.

### 2.6 Harvesting Machinery

In Wencheng County, there were 1 rice combine harvester in 2012, up to 20 in 2020, the harvest rate of combine harvester was only 18.3 percent, and the rest were harvested manually and electric thresher. There were 3675 electric threshing machines, 1 rape harvester in 2020. At present there are no harvesting machines for vegetables, fruits, tomatoes, potatoes, rape harvest special cutting platform and other auxiliary harvest platform.

### 2.7 Storage and Initial Processing Machinery

In Wencheng County, there were 1 grain dryer in 2012, up to 10 in 2020, which were far lower than 379 in Yueqing. Currently, there were no the fruit and vegetable drying equipment.

There were 26 refrigerated storage equipment, mainly used for storage and preservation of fruits such as bayberry, and its development space was still large. The processing machinery of agricultural products almost were grain processing machinery. In 2020, there were 2308 initial processing machinery for agricultural products, of which 1903 were grain processing machines, mainly rice milling machine and powder processing machine. Other crops just had few initial processing machines. There were 2324 agricultural products processing machinery and 13027 kilowatts in 2012, however which slightly were lower to 2308 units and 12869 kilowatts in 2020.

### **III. THE FAVORABLE CONDITIONS AND RESTRICTIVE FACTORS OF AGRICULTURAL MECHANIZATION**

#### **3.1 The Favorable Conditions**

##### **3.1.1 Policy environment is improving**

In recent years, the agricultural mechanization work has been paid attention to by governments at all levels<sup>[4]</sup>. In 2018, the Guiding Opinions of the State Council of China on Accelerating the Transformation and Upgrading of Agricultural Mechanization and Agricultural Machinery and Equipment Industry put forward, which clears requirements for the goals and tasks of the development of agricultural mechanization in hilly and mountainous areas. In November 2019, Wencheng County issued the "Several Opinions on Wencheng County Benefit Enterprise Policy", to give financial support to agricultural mechanization and facility agriculture construction, for example the purchase of planting fertilization machinery, farming machinery above 40 horsepower, combine harvester under 35 horsepower, food dryer, crawler or rail carrier, plant protection UAV, walking sprayer, waste treatment equipment, beating baler, straw crushing returning machine, tea processing machinery, refrigerated storage to implement a cumulative 50 percent of the total purchase price. Funding subsidies are also given for the newly built facility greenhouses with an area of more than 1000 square meters.

##### **3.1.2 The foundation of agricultural mechanization is solid**

In recent years, Wencheng County has carried out a series of agricultural infrastructure construction projects, such as standard farmland construction, small river basin comprehensive management, land consolidation, standard farmland construction, small river basin comprehensive management, land consolidation and etc., so the agricultural infrastructure has been constantly improved, which creates a good foundation of agricultural mechanization.

Wencheng county has built grain production function area 40900 mu, Mountain Plateau Provincial Modern Agriculture Comprehensive Area 161445 million mu, built 35 Modern Agricultural Park and Leisure Sightseeing Agriculture Demonstration Park, built Eyuan Provincial Alpine Vegetable Characteristic Agriculture Strong Town and Shanxi Provincial Bayberry Characteristic Agriculture Strong Town.

### 3.1.3 Agricultural machinery demand has increased

Agricultural machinery and equipment is the material basis for developing agricultural mechanization. Recently year, agricultural machinery demand has increased rapidly in mountainous areas, especially machinery and equipment for commercialization treatment, storage and preservation, and postpartum processing. Due to the high labor intensity and low efficiency of agriculture, the young and middle-aged labor force in mountainous areas have gone, therefore the lack of agricultural production labor force is a long-term trend. With the development of society, the improvement of farmers' living standards and labor concept have changed to the pursuit of dignified and decent labor. Through agricultural mechanization and the realization of "machine replacement", labor intensity of agricultural production can be greatly reduced, which makes agricultural labor decent and dignified. With the application of agricultural machinery equipped with modern information technologies such as the Internet of Things, artificial intelligence and cloud computing, it also improved the effective supply of suitable agricultural machinery in mountainous areas.

## 3.2 The Restrictive Factors

### 3.2.1 Poor operating conditions of agricultural machinery

In a mountainous areas, the operation of agricultural machinery is unfavorable, with the rugged road and the complex terrain, the cultivated land is scattered with small area, irregular shape, large slope<sup>[5,6]</sup>. In recent years, the traffic environment in Southern China is gradually improving, but with poor plough road, most large and medium-sized agricultural machinery is difficult to pass through and operate, which affects the popularization and use of large or medium-sized advanced agricultural machinery.

### 3.2.2 Less applicable agricultural machinery and tools

In a mountainous areas, many kinds of agricultural machinery were needed with many kinds of crops and complex planting system, however there are little applicable machinery and

tools in the main production links of many crops<sup>[7]</sup>. The enthusiasm of agricultural machinery enterprises in R & D and production is not high because of small market scale of agricultural machinery and tools suitable for mountainous areas and the high after-sales service cost. Some agricultural machinery and tools developed for mountainous area are not widely applied, because the technology is not mature enough, the standard lags behind, the benefit is not good, or it has not enter the catalogue of agricultural machinery purchase subsidy. In vegetables, fruits and other advantage characteristic industries in mountainous areas, the effective supply of agricultural machinery products is insufficient and agricultural mechanization is still very low.

### 3.2.3 Poor efficiency of agricultural machinery

Because of shortage of advanced and applicable agricultural machinery and equipment in mountainous areas, the idle rate of agricultural machinery is high<sup>[8]</sup>. With many no-load trips such as turning and transferring in the operation of agricultural machinery in mountainous area, the cost of fuel consumption is much higher than that in plain. In mountainous areas, there are many types of agricultural industry with small scale and scattered, which is not conducive to the implementation of mechanization and the improvement of agricultural machinery efficiency. At present, the different agricultural production and management units independently manage, the mechanism of agricultural machinery sharing service has not yet been formed, which also affects the utilization rate of agricultural machinery. Investment of agricultural machinery and equipment has the characteristics of large in amount, but the scale of agricultural industry in mountainous area is small, the degree of socialization and specialization of agricultural machinery operation is relatively low, the cost of agricultural machinery operation is relatively high, and the investment return period is long the efficiency of agricultural machinery operation is low, which affects the investment enthusiasm of farmers and agricultural machinery service organizations.

### 3.2.4 Insufficient support from government

Although the government has issued some support policies in recent years, such as agricultural machinery purchase subsidies, the degree of support to agricultural mechanization in mountainous area is not enough, specially overall financial support is insufficient<sup>[9]</sup>. The shortage of agricultural mechanization fund in mountainous areas is severe, although many actions to promote agricultural mechanization require a larger amount funding, such as the transformation of farmland for suitable for mechanization in mountainous area, the introduction and demonstration of new agricultural machinery, the construction and operation service of agricultural machinery service platform, the training and demonstration of agricultural



mechanization technology, etc. At present, the national agricultural machinery purchase subsidy policy is mainly aimed at grain and other large agricultural products, but the small agricultural machinery and tools suitable for the production of high mountain vegetables, red bayberry, honey pear and other major advantages of economic crops in mountainous areas have not been included in the subsidy catalogue or insufficient subsidies.

### 3.2.5 Weak extension service system for agricultural machinery

The extension service of agricultural mechanization technology plays an important role in the popularization of all kinds of advanced and applicable agricultural machinery and new technology. However, the current agricultural machinery extension system is weak, which restricts the process of agricultural mechanization. At present, the agricultural machinery technicians are mainly deployed at the county level and are no full-time agricultural machinery extension technicians at the township level. The agricultural machinery demonstration and extension funds allocated by the state, provincial and municipal finance departments are very few and the local financial is difficulties in mountainous areas, which lead to shortage of funds for agricultural machinery demonstration and extension, and lack of agricultural machinery service platforms and maintenance service outlets. Because of the small scale of agricultural industry in mountainous area and the lack of propaganda, display and demonstration, many farmers in mountainous areas have insufficient understanding for agricultural machinery to reduce agricultural labor intensity and improve production efficiency, which also affect the popularization and application of agricultural machinery.

## **IV. COUNTERMEASURES TO PROMOTE AGRICULTURAL MECHANIZATION IN MOUNTAINOUS AREA**

### 4.1 Intensifying Organizational Coordination

The government should reinforce leadership and support for agricultural mechanization, formulate updated and better policies in combination with the strategy of rural revitalization of Wencheng, and establish a mechanism to ensure the implementation of the policy to support agricultural mechanization development<sup>[10,11]</sup>. It is suggested that the Agricultural and Rural Bureau of Wencheng should take the lead in drawing up the development plan or implementation plan of agricultural mechanization, make clear development key items and development objective of agricultural mechanization. It should increase coordination and cooperation among departments, actively seek the support from the departments of finance, science and technology, development and reform, strengthen cooperation between the

agricultural machinery departments and the departments of grain, economy, seed, soil fertilizer and plant protection, and build an atmosphere and mechanism for working together to promote the development of agricultural mechanization in mountainous areas.

#### 4.2 Increasing Financial Support

We should increase financial funds to support for construction of service organization, new technology demonstration and infrastructure construction of agricultural machinery. Specially supporting mechanization of advantage and characteristic agricultural industries, such as green rice, alpine vegetables, fruits, tea in Wencheng mountainous areas. Exploring the policy support methods of agricultural machinery purchase subsidy in mountainous areas, encouraging the adoption of comprehensive subsidy methods such as purchase subsidy, loan discount interest, lease subsidy for stimulating the enthusiasm of farmers to purchase and use agricultural machines. Making good use of agricultural machinery purchase subsidy policy and strive to list rail transport vehicles, fruit and vegetable cultivation management and other machinery and equipment into the agricultural machinery subsidy catalogue. Actively striving to apply for national, provincial and municipal agricultural mechanization projects, carefully selecting and setting up county-level agricultural mechanization projects and carrying out demonstration of agricultural mechanization technology.

#### 4.3 Strengthening the Infrastructure Construction of Agricultural Mechanization

In combination with the characteristics of agricultural industries in mountainous areas, we should perfect the rural plough roads for improving the conditions of the passage for agricultural machinery<sup>[12]</sup>, promote the construction of agricultural characteristic industrial parks and high standard farmland, form accumulation area of superior industries, such as bayberry, alpine vegetables and tea in Wencheng, promote moderate scale management and standardized planting, and carry on agricultural mechanization on the basis of agricultural industrialization. Combined with the reform of rural property right system, we should promote the concentration of rural land for actualizing industrialization and mechanized production. The construction of farmland infrastructure should be carried out, and the land should be leveled and reformed the small to larger and the slope to level for the field facilitating operation of agricultural machinery. We should also strengthen the infrastructure construction of the agricultural mechanization public service system, including the test site, roads, experimental equipment, training places, testing workshops, demonstration sites, information service platforms, and so on for strengthening public service capacity.

#### 4.4 Innovating Service Mechanisms of Agricultural Machinery

We should innovate the service mechanism of agricultural machinery in mountainous area and strengthen the capacity of public services on agricultural machinery, including agricultural machinery extension, information service, technical training and agricultural machinery maintenance<sup>[13]</sup>. We should strengthen scientific and technological cooperation and exchanges with agricultural colleges and universities and scientific institutions to solve key technical problems in the process of agricultural mechanization. The machinery service organization should improve the ability of agricultural machinery operation service, maintenance, technical training and it is promoted for the socialized service of agricultural machinery such as order operation and trusteeship service. Agricultural mechanization service demonstration base should be established to improve the capacity of agricultural mechanization service, for example, establishing alpine vegetable agricultural mechanization demonstration base in Eryuan Alpine Fruit and Vegetable Provincial Characteristic Agricultural Strong Town, bayberry agricultural mechanization demonstration base in Shanxi Provincial Bayberry Characteristic Agricultural Strong Town in Wencheng.

#### 4.5 Introduction of Suitable Agricultural Machinery and Tools

We should introduce multi-functional, small or medium-sized, portable and durable agricultural machinery and tools adapted to the condition of cultivated land, crop varieties and planting patterns in mountainous areas<sup>[14]</sup>. In grain crops, it should be introduced with the agricultural machinery suitable for green rice production, popularizing rice seeding lines and small or medium-sized rice seedling planting machine in transplanting links, popularizing small or medium-sized rice combine harvester and rice drying machinery in harvest links, and trying to use new agricultural equipment such as drones in plant protection links. It should introduce small or medium-sized agricultural machinery suitable for cultivating, sowing, fertilization, irrigation, harvesting and other agricultural operations of eggplant, melon, leafy vegetables and other major local characteristics vegetable, and develop the machinery and equipment including vegetable after-harvest cleaning, grading, packaging and other storage and preservation, as well as logistics links. In the fruit industry, we should popularize the machinery and equipment, which is suitable for mountain operation, low investment cost, convenient use and management, particularly after-harvest preservation and logistics equipment of bayberry, as well as commercial treatment machinery for alpine pear.

#### 4.6 Promoting Intelligent Agriculture

Agricultural intelligence is the trend of modern agriculture, which can promote the integration of agricultural mechanization and information relying on the Internet of Things, cloud computing and the application of modern communication technology in agricultural production in mountainous areas<sup>[15,16]</sup>. We should promote the application of small or medium-sized intelligent agricultural machinery and tools in mountainous areas, demonstrate intelligent equipment with automatic control of light, temperature and water, integrated irrigation of water, fertilizer and pesticide, remote monitoring system based on information technology of Internet of Things, cloud computing, mobile interconnection. We should promote automatic processing and production line of agricultural products and intelligent logistics facilities of agricultural products. We should support the construction of Internet agricultural visualization platform. According to the characteristics of mountain agricultural products, we should develop online and offline e-commerce system with docking supply and demand online, physical distribution offline, and set up modern agricultural big data application system, by which the relation between supply and demand can be predicted and guide planting and sales of agricultural products.

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