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To cite this article: Wen Luo et al 2020 IOP Conf. Ser.: Earth Environ. Sci. 568 012042

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Application Analysis of Intelligent Irrigation System Based on Internet of Things Technology

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Abstract. In recent years, Zhejiang Province has actively propelled the application of the intelligent irrigation technology based on the Internet of things, which has strongly promoted the transformation and upgrading of the agricultural industry and greatly enhanced the level of modern agriculture in Zhejiang Province. According to the investigation of the application of the intelligent irrigation technology based on the Internet of things in Zhejiang Province, this article summarizes and analyzes the existing problems in the popularization and application of this technology. Furthermore, it puts forward corresponding suggestions for improvement in hopes that it would play a positive role in the popularization and application of intelligent irrigation technology based on the Internet of things.

1. General Application Analysis of the Intelligent Irrigation Technology on IOT (abbr. IOT) in Zhejiang Province

1.1 Analysis of Irrigation Water Use in Zhejiang Province.

Located in the south of the Yangtze River, Zhejiang is mainly mountainous and hilly. As the saying goes, "Seventy percent of the land are mountains, ten percent are water, the rest twenty percent are Farmland." The existing cultivated land area of the whole province is 31.20 million mu, and the effective irrigated area is 21.373 million mu, among which the paddy field is 17.32 million mu, and the per capita cultivated land is about 0.58 mu. The annual average water resources of the province are 93.724 billion cubic meters, while the annual average water resources are 20.28 billion cubic meters, the per capita water resources of 2004 cubic meters, which is lower than the national average level and belongs to the moderate water shortage area.

According to the data collected in Zhejiang Province Water Resources Bullet over the years(Table1), the water consumption of agricultural irrigation in Zhejiang Province accounts for a large proportion, ranking first among all kinds of water use in the province (about 39.08% in 2018). The average water consumption per mu for farmland irrigation hovered between 330-350 cubic meters, lower than 300 cubic meters in some other provinces and regions in China. In 2018, the effective utilization coefficient of irrigation water was 0.597, higher than the average 0.542 of the national effective utilization coefficient of irrigation water, which is far from the utilization coefficient of 0.7 to 0.8 in developed countries. Therefore, agriculture still has great water-saving potential.

Name Year	2011	2012	2013	2014	2015	2016	2017	2018
Total water consumption (100 million m ³)	222.4	222.31	224.75	220.24	186.06	181.15	179.5	173.81
Water consumption for farmland irrigation (100 million m ³)	77.4	75.78	75.79	73.11	71.76	70.93	71.31	67.92
Proportion of farmland irrigation water consumption%	34.80%	34.09%	33.72%	33.20%	38.57%	39.16%	39.73%	39.08%
Average water consumption per mu for farmland irrigation (m ³)	347	335	346	346	355	347	351	337

Table1 Statistics on Water Use in Zhejiang Province Over the Years

1.2 Analysis of Traditional High-efficiency Water-saving Irrigation in Zhejiang Province

In recent years, Zhejiang Province has actively promoted the popularization and application of highefficiency water-saving irrigation technology by focusing on Million mu of Spray-micro Irrigation Project, key Construction Counties of Ministry of Finance Small-scale Irrigation and Water Conservancy Project, and Large-scale Water-saving Demonstration Project, forming various highefficiency water-saving irrigation modes, such as spray drip irrigation, low-pressure irrigation, micro irrigation and so on. All kinds of high-efficiency water-saving irrigation type rapidly popularized in the whole province, in which economical drip irrigation from Yuyao,PE pressure pipe irrigation from Jiashan and Super low-head micro irrigation from Tongxiang are as representatives.Table2 has made the list of the basic situation of various high-efficiency water-saving irrigation projects in Zhejiang province by 2014.

Municipal	Water-saving	Sprinkler	Micro-Irrigation	Pipeline
Administrative	Irrigation	Irrigation	Project(Ten	Irrigation
Region	Project(Ten	Project(Ten	thousand mu)	Project(Ten
	thousand mu)	thousand mu)		thousand mu)
Hangzhou	143.60	8.95	2.84	12.95
Ningbo	262.50	21.23	13.92	9.21
Wenzhou	145.22	6.03	3.78	1.77
Jiaxing	249.23	2.16	6.38	57.56
Huzhou	156.29	3.12	2.46	1.46
Shaoxing	121.50	5.42	4.05	4.65
Jinhua	176.03	3.98	2.03	3.09
Quzhou	138.82	2.99	5.52	1.37
Zhoushan	11.13	0.83	0.57	0.56
Taizhou	144.74	3.23	5.40	5.52
Lishui	62.44	5.35	1.94	0.86
Total	1611.50	63.29	51.89	99.00

Table2 Basic information of various high-efficiency water-saving irrigation projects in Zhejiang

 Province in 2014

By comparing the types and structures of water-saving irrigation projects in Zhejiang province(Figure1), water-saving irrigation projects are still dominated by anti-seepage of canal, accounting for 86.7% of the province's water-saving irrigation area. While the proportion of high-efficiency water-saving irrigation (including water conveyance pipe, sprinkler and micro irrigation engineering) area is only about 13.3%, in which the pipeline is given priority to and the spray of

micro-irrigation engineering area, as an important infrastructure of modern agriculture, accounts for only about 7.1% of the whole province irrigation area ratio. It's improved than previous years, but the overall proportion is not high.



channel = pipeline = spray irrigation = micro-irrigation

Figure1 Composition diagram of traditional water-saving irrigation Projects in Zhejiang Province

In terms of popularizing advanced water-saving irrigation technology, spray micro-irrigation technology is the main form of irrigation in modern facility agriculture, which has obvious advantages of saving water, labor and land, increasing production, etc. However, the cost of traditional spraying and micro-irrigation is relatively high. According to the conventional design, the cost of spraying micro-irrigation project is about 1200 -- 1600 yuan/mu, and some even reach up to 2000 -- 3000 yuan/mu, which is beyond the economic bearing capacity of ordinary farmers and affects the promotion and application of spraying micro-irrigation technology. After a long period of exploration and research, application of new materials, development of new equipment, technology innovation actively,water conservancy workers in Ningbo Yuyao, Zhejiang province, put forward the "mobile unit miniaturization and pumping stations, plastic pipe, water mains HeWangHua, micro belt, belt, the thin wall" mode of economical spray of micro-irrigation, which lowered per acre investment to only 600--800 yuan/mu and greatly reduced the project cost, promoted the gush of micro-irrigation technology promotion and application in the whole province. Tongxiang Water Resources Bureau has successfully developed extra-low water head spray micro-irrigation technology, which meets the needs of agricultural planting development spray micro-irrigation technology in plain irrigation area and has achieved good results.

1.3 Application Analysis of Intelligent Irrigation Technology on The IOT in Zhejiang Province.

High-efficiency water-saving is the foundation of modern precision agriculture, whose achievement can't do without the agricultural infrastructure and equipment information, namely, the intelligent irrigation system of IOT based on high-efficiency water-saving irrigation project, which can easily achieve Integrated irrigation with water and fertilizer, irrigation automation and other functions intelligent through the pipeline irrigation, spray micro irrigation configuration system(Figure2). Therefore, Zhejiang province is now accelerating the development of high-efficiency water-saving irrigation agriculture and improving the basic system of agricultural irrigation, so as to gradually bring Zhejiang agriculture into the digital and information era and keep pace with the agricultural development in the new century.



Figure2 Intelligent Irrigation System of IOT

At present, the intelligent irrigation technology of The IOT in Zhejiang Province, mainly applied in modern agricultural parks, is widely applied and developed. The application of intelligent irrigation technology of The IOT in Zhejiang Province has the following main characteristics:

(1) Irrigation water sources: it's from channel diversion, mountain spring diversion, mountain pond diversion, rainwater collection and storage, etc. Irrigation methods are mainly pressurized irrigation, fixed head, which can achieve the integration of water and fertilizer.

(2) Pipe engineering: PE pipes are used for dry and branch pipes, which are buried underground with long service life.

(3) Emitter: It mainly includes suspended micro-sprinkler head, buried drip irrigation pipe, microjet belt, etc.

(4) Control engineering: equipment like ball valve, butterfly valve and so on, convenient for separate operation and control.

(5) Others: Intelligent micro-irrigation project is equipped with intelligent irrigation system, including information transmission system, information processing system, expert system and other software systems, as well as all kinds of sensors, computing host, solenoid valve, relay and other hardware control equipment.

In recent years, Zhejiang smart water conservancy has been continuously promoted. Intelligent irrigation technology, wireless transmission technology, video monitoring technology and automatic control system of the IOT have been gradually applied to high-efficiency water-saving projects, and the area of application and promotion has been continuously expanded. By the end of 2019, Zhejiang province had built 1,028 modern agricultural parks, covering 1.01 million mu of intelligent irrigation area with IOT, among which 13 national modern agricultural demonstration zones have been successfully established.

Since 2015, Zhejiang Province has carried out the overall construction of "Four Million Projects" with high efficiency and water saving: ① "Spraying micro-irrigation for one-million-mu sloping farmland Project"; ② "Intelligent standard Micro-irrigation for one-million-mu agricultural Park Project"; ③ "Economical sprinkler irrigation for one-million-mu of forest garden land Project ";④ "Rice area pipeline irrigation for one-million-mu project". Among them, the second Project mainly refers to: In the modern agricultural parks or vegetable basket supply base, it constructs and updates high-efficiency water-saving irrigation projects which are suitable for vegetables, fruits, tea, edible

fungi, Chinese medicinal materials and flowers industry.while in plain areas and hilly basin areas, it adopts standard micro-irrigation construction to improve crop yield and quality and the intelligent micro-irrigation project at the same time to achieve precision irrigation and form a precision agriculture technology system through automatic collection and treatment of soil moisture, temperature, humidity and other information. The construction content includes: ①reservoir, pond dam (excluding newly built mountain pond), water source projects like small diversion works; ②Standard or intelligent spray micro-irrigation system, including the power system and fertilization and filtration facilities of the first hub, pipe network, emitter and intelligent control system;③Field supporting facilities. Large-scale modern agricultural parks develop intelligent micro-irrigation projects with the help of computers to collect and deal with soil moisture, soil texture, temperature and humidity, and implement water-fertilizer coupled precision irrigation according to the growth mechanism of different crops to form a precision agriculture technology system. From 2015 to 2019, Zhejiang Province had completed an intelligent standard micro-irrigation project of 1.056 million mu of agricultural park through the key promotion of intelligent irrigation technology application of IOT.

According to Table1 Statistics on Water Use in Zhejiang Province Over the Years, we can see the variation of total water consumption and irrigation water use in recent years. From 2011 to 2018, the province's total water use fell from 22.224 billion m3 to 17.381 billion m3 and the decrease rate reached 21.79%, of which the irrigation water use reduced from 7.74 billion m3 to 6.792 billion m3 and the decrease rate was 12.25%. Thus it can be seen water-saving effect is significant.

2. Problems Existing in the Popularization and Application of Intelligent Irrigation Technology of IOT

In recent years, the rapid increasing of high-efficiency water-saving irrigation area, especially the application and promotion of intelligent irrigation technology of IOT, has realized the accuracy (precision irrigation and precision fertilization, etc.), high efficiency, saving, water saving, energy saving, land saving, fertilizer saving), environmental protection, manageability, which effectively supported the development of efficient agriculture in Zhejiang province, promoted the transformation and upgrading of agricultural industry, significantly improved the level of modern agriculture in Zhejiang province, as well. However, it still has some deficiencies, mainly as follows:

2.1 Lack of Cooperation between Government Departments

Zhejiang province is dominated by mountains and hills, and the cultivated land is scattered. The main crops are mostly concentrated in the hills and mountains, and the water-saving effect of traditional irrigation technology is not obvious. Practice has proved that high-efficiency water-saving irrigation technology is the best way to save water, conserve water, soil and fertilizer, increase production. At the same time, it is also one of the important ways to solve the problem of water-saving irrigation in hilly and mountainous areas. However, due to the higher cost, longer investment return period, unobvious economic efficiency, enterprise and farmers both lack enthusiasm for application of the technique, which limits the promotion and leads the responsibility to the government that no department can manage it well at last. At present, Ministry of Water Resources, Ministry of Land and Resources, Ministry of Agriculture, Ministry of Forestry and other departments are making efforts on efficient water-saving irrigation projects, but there is lack of integrated planning and unified construction standards and there is no resultant force formed which seriously restricts the development of the province's efficient water-saving.

2.2 Private Enterprises Lack both Confidence in Investment and enthusiasm on Application

Although in the progress of steady promotion smart agriculture in Zhejiang province has got certain achievements and gradually played a positive role, however, in general, the production control mode of agricultural intelligent irrigation technology is still in its infancy. Part of the base and the pilot enterprise effect works well, but most of the base are government demonstration project, which is 2020 2nd Global Conference on Ecological Environment and Civil EngineeringIOP PublishingIOP Conf. Series: Earth and Environmental Science 568 (2020) 012042doi:10.1088/1755-1315/568/1/012042

partly financed by the government to install equipment for the farmers.Private enterprises lack confidence in investment which leads to lack of enthusiasm and willingness on application. Therefor,we need to think and make efforts on how to create agricultural Internet business model to make agricultural enterprises, enterprises of IOT, the broad masses of farmers all-win.

2.3 Shortage of Talents and Insufficient Technical Force at the Primary Level.

Administrative staff in service in agricultural park are of low technical level. Due to lack of systematic professional training, they are unfamiliar with system performance and characteristics, unskilled on operation and maintenance of equipment. The difficulties of irrigation equipment maintenance seize up system and difficult to achieve the desired effect. According to the projects investigated by the project research team, some agricultural parks that were originally equipped with relatively advanced intelligent irrigation systems of the IOT were not put into use again after the system passed the acceptance due to the lack of relevant technical management personnel in the later maintenance and operation process. The intelligent system was on the verge of obsolescence and could only be operated manually.

2.4 Separation of Industry and Research Brings about that Technical Innovation and Production and Application are not Closely Linked

At present, great progress has been made in technological innovation of facility agriculture and precision agriculture, but it is still not closely related to actual production and application. There are some deviations in the practical application of new products and new technologies developed based on ideal conditions by scientific research institutions. Some enterprises are faced with the problems of ineffective integration and poor compatibility of different equipment produced by different manufacturers in practical application.

In terms of information sensing, the sensitivity of sensing equipment used for intelligent irrigation is greatly affected by the environment. Its service life is short with high price. In intelligent irrigation, water and fertilizer integrated decision-making, comprehensive intelligent management level still needs to be improved.

3. Suggestions on Intelligent Technology Promotion and Application of IOT

3.1 Analysis on the Application Prospect of Intelligent Irrigation Technology on IOT

As an absolute big user of water, Agricultural irrigation in Zhejiang province takes the first place among all kinds of water consumption in the province (39.08%). At present, the effective utilization coefficient of irrigation water in Zhejiang province is 0.579, which still has great room for improvement compared with 0.7-0.8 in developed countries, and the water-saving potential is still great.

Zhejiang province has an effective irrigated area of 21.373 million mu, of which only about 3.142 million mu, accounting for only 14.7% of the effective irrigated area, has realized high-efficiency water-saving. Due to the problems of unreasonable irrigation specifications, backward irrigation technology and extensive irrigation management, the utilization of irrigation water conservancy in Zhejiang province is inefficiency. Intelligent irrigation technology based on the IOT can greatly reduce water loss and waste in irrigation process, which is conducive to the development of ecological and water-saving modern agriculture to a certain extent.

As one of the regions with the most developed IOT technology in China, Zhejiang Province has its inevitable technological advantages in developing the intelligent irrigation technology of IOT. Meanwhile, the agricultural economy of Zhejiang Province is high value-added economy with scale-management effect. The promotion and application of the intelligent irrigation technology of IOT for many years also lays a good economic foundation for the later large-scale promotion and application.

To sum up, in the future, intelligent irrigation technology of the IOT has a good prospect of popularization and application in Zhejiang Province, and will surely contribute to the sustainable development of agricultural economy and the economy of the IOT.

However, it must be clearly recognized that although the intelligent irrigation technology of the IOT has its technological advantages, its construction cost is not enough to highlight its significant benefits in terms of water saving, labor saving and emission reduction compared with small-scale agricultural production. Meanwhile, the application of the intelligent irrigation technology of the IOT requires complete communication network hardware facilities. For most mountainous areas in Zhejiang Province, it still cannot be widely used in the short term.

In addition, the inherent consciousness and the lack of the knowledge level are the obstacles of the technology popularization and application. Therefore, for a period of time in the future, the intelligent irrigation technology of the IOT will still be in the demonstration stage. The application users are mainly agricultural parks built by local governments and large farmers with certain scale and economic strength, and the application objects should also be mainly flowers and seedlings, Chinese medicinal materials, fruit trees and other crops with high economic value.

3.2 Countermeasures and Suggestions for the Popularization and Application of Intelligent Irrigation Technology on IOT

3.2.1 Increasing Capital Input and Unblocking the Channel of Agricultural Enterprise. Funding is the major obstacle to the development of "smart agriculture" and "smart irrigation" technologies. In terms of agricultural informatization, government financial support is far from enough. The informatization special funds, whether it be a hardware improvement, or software development and maintenance, personnel training, both lack of financial support. In the process of building "smart city" in the future, the government should increase the capital input of "smart agriculture", combine information technology with specific agricultural industry and the construction of implementation projects. Only after striving for more financial support can the agricultural enterprises have enough confidence to carry out their work. At the same time, the government should provide policy support to guide leading agricultural enterprises to actively participate in the development of "smart agriculture". Relying on government-led advantages, it should build an exchange platform for intelligent irrigation technology of IOT, push relevant technical information to the leaders of agricultural enterprises, and carry out relevant meeting training for front-line technical personnel, so as to improve the practical application level of grassroots front-line.

3.2.2 Innovating Development Strategies and Promoting Enterprise Transformation and Upgrading. According to the survey results, agricultural enterprises with a high degree of intensification, strict requirements on precise planting of crops, and indexes meeting export standards are more willing to introduce IOT equipment and precise irrigation and fertilization technology to monitor the production process, while those with lower degree of intensification, lower economic benefits, and mainly oriented to the local market are reluctant to increase their investment in this aspect considering the cost problem. Therefore, from the enterprise point of view, on the one hand, whether the IOT technology can bring benefits or not, in the situation of transformation and upgrading of agricultural development mode, they should follow the modern agricultural development trend and advocate "to promote new urbanization and agricultural modernization" under the new situation. On the other hand, enterprises should develop "smart agriculture" and popularize intelligent irrigation technology according to their own positioning and development direction. In recent years, labor costs are rising, land resources are becoming increasingly scarce, and trace-ability system for agricultural products' quality and safety is gradually improving. Enterprises should see the advantages and long-term benefits of "smart agriculture" and "intelligent irrigation -- precise fertilization" and then establish a long-term mechanism, make full use of IOT technology to save cost and increase efficiency, eliminate backward production capacity. In addition, enterprises that intend to introduce and develop IOT devices and technologies should feed back their demands to scientific research institutions and professional companies based on the actual situation, so as to avoid problems such as lack of functions or poor compatibility in the later operation and maintenance process.

3.2.3 Promulgating Supporting policies and Encouraging Enterprises to Participate in the Integration of Production, Education, Research and Application. It is suggested that the government introduce the policy of tax reduction and exemption, encourage enterprises to cooperate with outstanding scientific research forces of scientific research institutions within and outside the province, and increase the integration of production, study, research and application of intelligent irrigation technology of the IOT, so as to realize a good situation of personnel exchange, technology sharing, resource sharing and results sharing. At the same time, through scientific research projects and other means, technology experts from scientific research colleges and universities actively involved in the research and application of intelligent irrigation technology of IOT. At last, it will form an integrated development model of industry-university-research-application led by the government, with enterprises and scientific research participating in.

3.2.4 Increasing Mobile Applications and Promoting "Intelligent Irrigation Technology of IOT" Innovatively. China has overtaken the United States to become the world's largest number of smart mobile devices such as mobile phones. Smart mobile devices like mobile phone have a high penetration rate, among which the 5G technology is relatively advanced. To make full use of the advantages, it's suggested to vigorously develop the irrigation system of mobile applications and realize the real and reliable IOT of agriculture through intelligent mobile equipment such as mobile application.

3.2.5 Intensifying Training and Improve the Technical Application Level of Grassroots Front-line Talents. It's suggested to make full use of the modern agriculture industrial park, various platforms like high-efficiency agriculture demonstration zone, develop and demonstrate and intelligent irrigation technology of IOT, build communication and learning platform for the people of different level to improve the basic line technician's application level of intelligent irrigation technology of IOT.

3.2.6 Planning Scientifically and Implementing Step-by-step and Propelling Fastly. IOT in agriculture is a system engineering. It is suggested that the relevant government departments should do toptier designing scientifically and rationally which can be carried out step-by-step and impelled rapidly. At the same time, the local departments like the local water conservancy and agriculture department should set up medium and long-term development planning and annual implementation planning of intelligent irrigation technology of IOT according to the specific situation and gradually implement the project and content, constantly promote rural water conservancy modernization.

Acknowledgement

It's a significant and forgettable experience for me to spend such a long time on writing, modifying and polishing the thesis. My project has been approved by Science and Technology Project of Zhejiang Provincial Water Resources Department in 2018 (RC1821). I would like to express my gratitude to all those who helped me during the writing of this thesis.

My deepest gratitude goes first and foremost to Vice President of Zhejiang Tongji Vocational College of Science and Technology Zili, Shen, the corresponding author, whose research direction is water conservation and water resource utilization, for his constant encouragement and guidance. He has walked me through all the stages of the writing of this thesis. Without his consistent and illumi nating instruction, this thesis could not have reached its present form.

Second, I would like to express my heartfelt gratitude to Yuan, Xu, who helped me a lot in translation.

Last, my thanks would go to my beloved family for their loving considerations and great confidence in me all through these years. I also owe my sincere gratitude to my friends who gave me help and time in listening to me and helping me work out my problems during the difficult course of the thesis.

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