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Problems of Application of Internet of Things in Agricultural Informationization and Recommendations for Shandong Province

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Abstract This paper firstly elaborated the research status of agricultural Internet of Things (IoT) and basic concepts of IoT technology. Then, it analyzed main problems in the application of IoT technology in the agricultural informationization. Finally, it came up with recommendations in strategic planning, policies, technologies, funds and mechanisms, to provide policy references for the connotative development of agriculture in Shandong Province.

Key words Internet of Things (IoT), Agriculture, Informationization, Standardization

1 Agricultural Informationization and Internet of Things (IoT) technology

1.1 Agricultural informationization Agricultural informationization refers to the process that information and knowledge gradually become the basic resources and impetus for agricultural production activities. Information and technology consulting services are increasingly becoming a basic industry of the entire agricultural structure, and have a greater contribution to growth of information and intellectual activities in agriculture. Thus, the meaning of agricultural informationization includes two aspects: (i) popularization and application of computer technology in the agricultural field; (ii) extension and application of microelectronic technology, communication technology, optoelectronic technology and remote sensing technology. In other words, agricultural informationization is a historical process that has brought about the agricultural and the benefit of the whole society through cultivating and developing new productive forces represented by intelligent tools^[1].

1.2 IoT technology IoT refers to the "Internet of things". It is a network connecting any things for information exchange and communication through the radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners and other information sensing devices according to agreed protocols, to realize intelligent identification, positioning, tracking, monitoring and management^[2]. The Agricultural Internet of Things (IoT) provides a new technology support platform for establishing modern agriculture, developing the rural economy, increasing the income of farmers, improving grassroots agricultural technology extension and service system, raising the integrated agricultural production capacity, promoting comprehensive rural re-

form, strengthening rural administrative service efficiency, and promoting new socialist countryside construction through information collection of crop growth, farmer living, agricultural production and circulation with the aid of IoT technology, combination of the basic elements of agricultural production with cultivation and management, animal husbandry, fertilization, plant protection and farmer education through intelligent agricultural information technology, and improvement of agricultural production, management, transaction, and logistics^[3]. The application of agricultural IoT technology mainly includes: (i) agricultural greenhouse IoT information system; (ii) IoT based agricultural product logistics information system; (iii) smart agricultural information management system; (iv) IoT-induced smart agricultural irrigation system^[4–6].

2 Main problems of the application of IoT in agricultural informationization

2.1 Agricultural IoT not established a clear development mode yet For a long time, China's economic development has relied largely on industry and agriculture has always remained at the status of contribution. In the development of China's agricultural IoT, there appeared problems such as low degree of industrialization, low marketization of agricultural products circulation, low level of agricultural modernization, imperfect rural finance and imperfect popularization of agricultural science and technology. At present, China's IoT technology has just started, thus it is still necessary to continue to make exploration and research. Especially, the agricultural IoT is still at the exploratory stage of development, the development mode is not clear, and there is still no perfect IoT architecture system. As a traditional production project of China, agriculture concerns people's livelihood and living conditions. The application of IOT technology in agricultural production will effectively solve the problems arising in traditional agriculture such as low efficiency of agricultural production, high agricultural production costs, weak traceability and monitoring of production

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safety of agricultural products. For now, however, there is still no clear development mode of agricultural IoT.

2.2 Agricultural IoT commercial mode not reasonable enough

To become bigger and stronger, a business and application must be based on a good commercial mode. At present, the commercial mode of agricultural IoT mainly includes three types: (i) demonstration project operated by enterprises, paid by the operation enterprises; (ii) demonstration project promoted and paid by agricultural competent authorities; (iii) some large farms buy IoT for themselves. The above three modes of agricultural IoT have failed to fundamentally solve the problems of high cost of application of agricultural IoT and insufficient active participation in the industrial chain. Therefore, it is still necessary to further explore and study how to encourage all parties involved in the industrial chain to effectively integrate the resources of all social sectors, strengthen the construction of agricultural IoT technology, financing platform, and broaden the financing channels and build a more reasonable and effective commercial operation mode, so as to provide excellent environment for extension and application of agricultural IoT technology.

2.3 No standardization system for IoT technology In China, the IoT industry still remains at the starting stage. Even in the global range, there is still no unified standardized system, which has become a bottleneck restricting the application of technology development and product scale. From the perspective of industrial technology, the IoT mainly lacks two standards: one is the standardization of the data model, and the other is the standardization of the interface. Only the standardization at IoT technology level can promote the large-scale production and use of IoT products. Therefore, the establishment of IoT standardization system will become the primary condition for the development of IoT industry.

As a systematic project, agricultural IoT is a comprehensive information service system integrating sensors, information processing, control, wireless communication and network technologies. Its construction and application need to use a large number of sensors to monitor the transmission of data. However, because there is still no unified national technical standard at three technical levels including information acquisition, sensor and data platform applications, and human-computer interaction interfaces, gradual establishment of a unified standard system for IoT is a key factor for solving the problem of promotion and application of agricultural IoT technology.

2.4 Insufficient basic investment and low utilization of agricultural funds

The utilization rate of agricultural funds is low. (i) The division of departments is so serious that the powers of the government at all levels involved in the agricultural sector cross each other and it fails to realize the overall management and deployment of funds. The overall efficiency of the management team in dealing with agriculture-related issues is not high, responsibilities are not clear, and the response is slow. (ii) The financial departments in all districts did not realize the reasonable allocation of office expenses and staff costs, of which only 30%–40% of the

funds were used for agriculture-related and agricultural production projects thus the fund actually invested in the benefit departments at all levels becomes very small. (iii) Due to the lack of expertise in agricultural investment and financial planning, a fair, impartial and scientific funding approval mechanism fails to be established, the agricultural investment is blind and arbitrary. (iv) The utilization of agricultural funds is not reasonable and effective, and the supervision system is not adequate. The above four factors have seriously affected the utilization efficiency of supporting agriculture funds, hindered the popularization and application of agricultural IoT technology and have become an important bottleneck restricting the application and promotion of agricultural IoT technology.

2.5 Weak scientific and technological innovation, and the key IoT technology to be broken through

In the development and application of IoT technology, the sensing layer is used for information acquisition and collection, and the transmission network layer is used for transmission and exchange of information. At present, the key technologies involved in these two layers need to be improved badly. Taking precision agricultural intelligent monitoring as an example, the key problems to be solved urgently in the innovation and application of agricultural science and technology are as follows. (i) Studies about low power consumption and low-cost technologies on sensor products and various sensors for real-time non-destructive measurement of nutrients in the soil or plants. (ii) Studies about the reliability of facility control equipment and on-site utilization of solar and biomass energy, research data and system fault tolerance techniques. (iii) Studies about issues of remote high bandwidth transmission of wireless data, standardization of data acquisition standards for the IoT and data exchange and control interfaces, and so on. Therefore, rapid IoT development will rely on technological innovation, it is required to break through key technology barriers and speed up the development of agricultural IoT technologies.

2.6 Intelligent software for agricultural application of IoT seriously lagging behind

Agricultural IoT technology is mainly applied in the collection, processing, analysis and intelligent control of a large amount of data, especially in growth modes and control of different planting environments of crops, different cultivation modes and different crop varieties. The application and extension of IoT technology in the above aspects need support of various types of intelligent software, so as to realize efficient utilization of IoT. Under the function of integrated intelligent software, extension and application of IoT technology can effectively promote the direct conversion and maximum efficiency of scientific and technological achievements, thus it plays an important role in promoting the standardization, scale and brand development of agricultural production.

2.7 Integrated application of information and cost issue The agricultural IoT widely collects variety of information, the information elements and sources are relatively complex. In the process of information collection, it is necessary to have the mutual cooperation and support of epidemic control, health, commerce, agricul-

ture, animal husbandry and other departments. Only through this, may it be able to realize information collection and integration of agricultural product planting bases, agricultural product processing, warehousing, and marketing. IoT technology has insufficient resources in agricultural field application and is limited by many factors such as complex topography and natural environment, resulting in high cost of sensors and related equipment. Generally, the price of agricultural products is lower and the cost of equipment and components is higher, making it impractical to apply devices such as electronic tags on a single product. Therefore, the above problems seriously hinder the popularization and application of IoT technology in agricultural production.

In summary, on the one hand, IoT technology has broad application prospects in the agricultural field, China has also made some achievements in IoT technology research; on the other hand, because IoT is still a new thing, there are still many difficulties to realize large-scale application of IoT technology in the agricultural field. Thus, the extension of agricultural IoT must gradually solve the above seven problems.

3 Recommendations for the application of IoT in agricultural informationization

3.1 Strategic planning At present, the IoT technology and its application still remain at the research and exploration stage both at home and abroad. Under such background, Shandong Province needs to formulate a strategic plan for the development of the agricultural IoT in line with the actual situation. Analyzing from the field of agricultural IoT technology application in Shandong Province, it is necessary to make long-term strategic planning in priority to the development of the IoT for utilization of agricultural resources, the IoT for agricultural production and the IoT that prioritizes the development of agro-ecological environment monitoring and agricultural product safety regulation. Starting from the actual situation in Shandong Province, it is required to make thorough survey and study on whether to firstly establish demonstrative application in some areas or promote in the whole province^[7].

3.2 Policies (i) Policy support. As the primary industry in China, agriculture, on the one hand, is an important foundation for ensuring a sustained, stable and rapid development of the national economy. On the other hand, agriculture remains in the weak position in the process of national economic and social development. For a long time, due to the inadequate support for agriculture in the process of public expenditure in China, the construction of agricultural information is not sufficient. Although China has increased its support for the development of agricultural informationization in recent years, it has also achieved some success. However, from an overall perspective, the foundation of China's agricultural industry is still relatively weak. The performance of agricultural informationization is particularly obvious. Under this background, it is imperative to conscientiously implement the state policy of "industry promoting agriculture and urban areas supporting rural areas" to maximize the benefits of limited finan-

cial support for agriculture. To accelerate the process of agricultural informationization and raise the level of agricultural informationization is a top priority.

(ii) Increasing government investment, promulgating more agriculture-benefiting policies, to promote the steady development of agricultural industry. Now, only by relying on a variety of high-tech application and promotion, can promote the development of modern agriculture, in which the application of Internet technology and information technology is an important factor. As the emerging high-tech industry in modern agriculture, agricultural IoT technology has both advantages and disadvantages. Main advantages include high efficiency, wide range of benefits and strong public welfare.

(iii) In order to gradually establish a mode of agricultural production and management with specialization, standardization, large scale and socialization, it is recommended to accelerate the development of specialized farmer cooperatives, vigorously develop leading enterprises, make innovation in well-known brands and extend the industrial chain. Government should guide leading enterprises and provide subsidies and tax deduction or exemption for enterprises that apply agricultural IoT technology. Great efforts should be made to support and propagate the brands independently developed by the enterprises^[8-10].

3.3 Technologies At present, due to the immature technology of the IoT products, low performance of the sensor products and the high cost, it is required to have break-in of demands, product functions and performance in the process of popularization and implementation of the IoT technology. Through promptly feeding back the defects of products, manufacturers can improve and optimize products and solutions, so as to constantly raise the technological level and product quality^[11-12]. In the technologies, it is recommended to implement the following three works. (i) Accelerating the construction of technical support system and the development of national standards for sensor information collection. (ii) Technical support. It is recommended to try to expand the demonstration projects in facility agriculture, farm crops, field stations and factory-based breeding. (ii) Scientific and technological innovation. It is recommended to provide low-cost, high-efficiency hardware support platform and make agricultural IoT technology innovation on this platform.

3.4 Funds (i) Increasing investment and consolidating the foundation of rural information industry. It is necessary to make use of government financial expenditures and increase special funds to ensure that special funds are used for special purposes. It is recommended to support the project through the project-driven development of key technologies in agricultural IoT to speed up the standardization of agricultural IoT technology and products. (ii) The government finance should mainly support facility agriculture and pay attention to pilot demonstration of agricultural IoT. Many years of experience of practical activities of agricultural IoT companies indicated that with the government's financial support, on the one hand, government finance needs to continue to support and

nurture facility agriculture, strengthen support for facility agriculture, and further intensify the construction of agricultural information infrastructure to enhance rural information construction; on the other hand, it is necessary to support the pilot demonstration of construction-related agriculture and agricultural IoT. (iii) It is recommended to provide great support for agricultural IoT and its key technologies with the aid of agricultural finance. On the one hand, it is recommended to continue to improve the financing channels in rural areas and gradually raise the credit capital, actively guide the private capital to flow into agricultural field and provide diversified financial support for the development of agricultural IoT. On the other hand, it is recommended to increase the credit development in rural areas and implement preferential policies for agricultural credit, provide strong financial support for the development of agricultural IoT. (iv) It is recommended to encourage agricultural IoT companies to set up production bases in Shandong Province through inviting outside investment. Especially, it is recommended to introduce leading enterprises with the production capacity of complete agricultural IoT products, to promote agricultural IoT technologies of Shandong Province. Besides, it is recommended to strengthen the cultivation of market demands of agricultural IoT, invite agricultural IoT enterprises in proper time to establish the production base, so as to promote the development and extension of agricultural IoT technologies of Shandong Province.

3.5 Mechanism (i) It is recommended to establish a high-level research team and set up expert team and technical personnel for innovation and improvement. (ii) It is recommended to constantly strengthen cooperation and exchange with higher education institutions and institutes, formulate a scientific and rational agricultural IoT technical personnel cultivation and training program, and develop a compound type talent team with IoT and agricultural professional backgrounds. (iii) The government should continue to encourage and guide the cooperation between schools and enterprises, provide technical personnel training through internship and training bases, improve the ability of talent to solve practical problems and rapidly upgrade the quantity and quality of agricultural IoT technical personnel. (iv) It is recommended to strengthen the technical training of farmers and carry out comprehensive business training for basic skills, information technology and management of farmers. It is recommended to gradually build a multi-level, high-level technical personnel team, so as to enhance the development of agricultural IoT, to provide technical personnel support.

4 Conclusions

In summary, to realize application and popularization of agricultural IoT technology, it is necessary to make long-term strategic planning in priority to the development of the IoT for utilization of agricultural resources, the IoT for agricultural production and the IoT that prioritizes the development of agro-ecological environment

monitoring and agricultural product safety regulation. (i) In policies, it is recommended to strengthen the policy support for agricultural IoT, increase the government input, formulate more agriculture-benefiting policies, to promote steady development of the agricultural IoT industry. (ii) In technologies, it is recommended to accelerate the construction of a technical support system and formulate national standards for the collection of sensor information, strengthen the support for agricultural IoT technologies, and strengthen the scientific and technological innovation. (iii) In funds, it is recommended to increase the input, consolidate the foundation of rural information industry; government should support the facility agriculture through government finance, and also consider the pilot demonstration of agricultural IoT; energetically support agricultural IoT with the aid of agricultural finance, and it is recommended to encourage agricultural IoT enterprises to establish production bases in Shandong Province. (iv) In mechanism, it is recommended to set up a team of experts and technical personnel. The government should encourage and guide the cooperation between schools and enterprises so as to increase technical training for farmers.

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