Food and Agriculture Organization of the United Nations

Chinese information technology experience

on digitalization of rural areas and poverty alleviation

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South-South cooperation project: Response and recovery of the impacto of COVID-19 pandemic on rural livelihoods and food systems in the countries of the Community of Latin American and the Caribbean States (CELAC)

Food and Agriculture Organization of the United Nations
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Key concepts

Digitization: Digitization usually refers to converting traditional information into data that can be processed by a computer. For example, converting symbols in paper documents into files on a computer disk, converting paper photos into image files, or converting a parameter in the natural environment into a digital signal that can be processed by a computer. Digitization is the prerequisite for humans to perceive and improve the physical world through digital technology, focusing on a static description of data.

Digitalization: When the digital data in the above-mentioned digitization has a positive impact on elements in the digital domain or the real world, according to certain rules or models, we call it digitalization. For example: an order information affects inventory and profit information, or a temperature change signal triggers the turning on or off of the air conditioner through digital tools, and ultimately affects the indoor temperature. Digitalization is a dynamic concept relative to digitization.

Digital transformation: If there are many digital models, they could extend to all aspects of an organization and change the entire organization's business model. They can even accelerate its connection with collaborative partners in society and change related business models. The implementation of these models is called digital transformation.

Field technologies: Field technologies in the digital domain refer to how information flows affect the production environment in the field, or how the production environment generates information flows. Since this involves an interaction between the information world and the production site, it is usually more difficult and costly to implement than the flow and interaction of information streams in their own world and their impact on society and people.

Geographical Information System (GIS): A GIS is an agriculture-oriented data management platform or technology designed to facilitate data storage and access in the agriculture sector when the amount of data is large enough, taking into account the spatial characteristics of agricultural data. The emergence of open-source GIS platforms has also reduced its implementation costs.

Digital twin: In order to build a digital platform for agriculture, it is important to develop a method to quickly obtain valuable information from large databases. The extraction of relevant data based on these large databases and specific models, and then displaying the results graphically with multiple dimensions, is a technical challenge. Digital twin technology provides a good solution, although its cost is still relatively high.

Generalizability: New digital technologies are constantly emerging, while some technologies are being phased out. Information technologies with strong cohesion tend to remain, such as smartphones, digital cameras, smart cars, drones, and robots. The cohesiveness of these technologies is manifested in, for example, the increasing number of sensors on cell phones and the machine vision technology that enables camera applications to penetrate various application areas. This cohesiveness makes these technologies highly generalizable and continues to attract private investment, creating wealth myths while generating scale effects to reduce their cost of use.

Standardization: The issue of universality is also closely related to standardization. In addition to the use of GIS and digital twins as mentioned above, there is also a standardization issue, especially since we are focused on the whole region of Latin America and the Caribbean. Standardization is an important task when dealing with different pilot solutions or projects, and it also supports generalizability, which plays an important role in bridging the digital divide, while reducing system and training costs.

Introduction

1. - Background

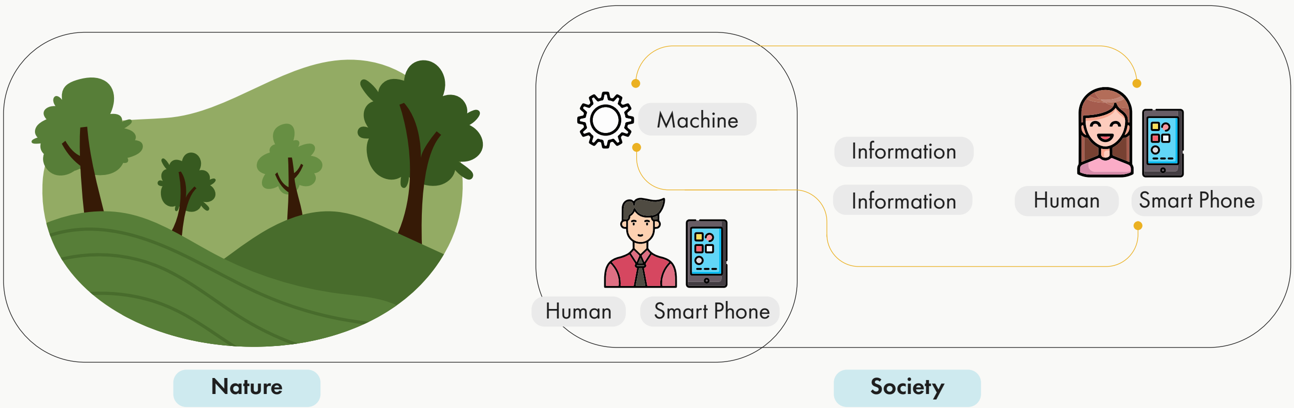
Agriculture is a human production activity based on natural resources (Figure 1), while industrialization and information technology are human processes that enhance productivity and output, with strong social attributes. The increase in productivity and production has created a demand for trade, while trade efficiency is itself a new value.

Modern information technology is a type of abstract symbol processing technology which uses electrons as the carrier and transmits information at the speed of light. Information can flow rapidly between human beings and industrial tools, thus having an impact on them and the human living environment.

The advantage of digital technology lies in the efficiency of its flow and its substitution of traditional transformations under certain conditions. Digital technology allows human beings to communicate across time and space and allows for precise modelling and control of things.

The main challenge in digital agriculture is how to implement digital technology quickly and efficiently in an agricultural environment with strong natural attributes, so that it can connect society and nature and generate added value.

Figure 1: Relationship between agriculture and information



Source: Own elaboration.

2. - Necessity and urgency

Although digitalization is now a hot trend globally, agriculture as a primary industry lags the secondary and tertiary industries in this wave. In recent years, e-commerce has been growing rapidly, and the entire tertiary industry is now aiming at developing new markets, which means extending the reach of business to the place of origin of products, including factories and farms. In other words, the tertiary industry is trying to penetrate agriculture and industry.

In terms of the secondary industry, its goal is Industry 4.0, or the Industrial Internet of Things (IoT), which is essentially a digital interconnection of everything, including the origins and markets of agricultural raw materials. This is the age of digitalization, and if the agricultural industry fails to grow with the wave, it will be at an even greater disadvantage in the division of labour among the three major industries.

Of course, the digitalization of agriculture does not mean that there will be a clash between agriculture, industry and service, but rather that through their development these three industries will work together and avoid widening the digital divide in the agricultural sector.

The coordinated development of these three industries will create an inclusive digital society and improve the efficiency of e-commerce activities.

3. - Challenges

Modern information technologies, such as Big Data, IoT, cloud computing and artificial intelligence (AI), need to penetrate rural areas to narrow the digital divide. However, the digitalization of agriculture is relatively difficult to implement compared to industrial digitalization because information has to interact with the natural environment.

In this process, it is necessary to focus on addressing the following three main issues:

- **Digital skills**
- **Affordability**
- **Accessibility (including not only the physical Internet connection, but also language, text and the security of network connection)**

4. - Positive factors

In order to overcome the above challenges, the necessary measures include:

- **Governmental support**
- **New technology**
- **Private investment**

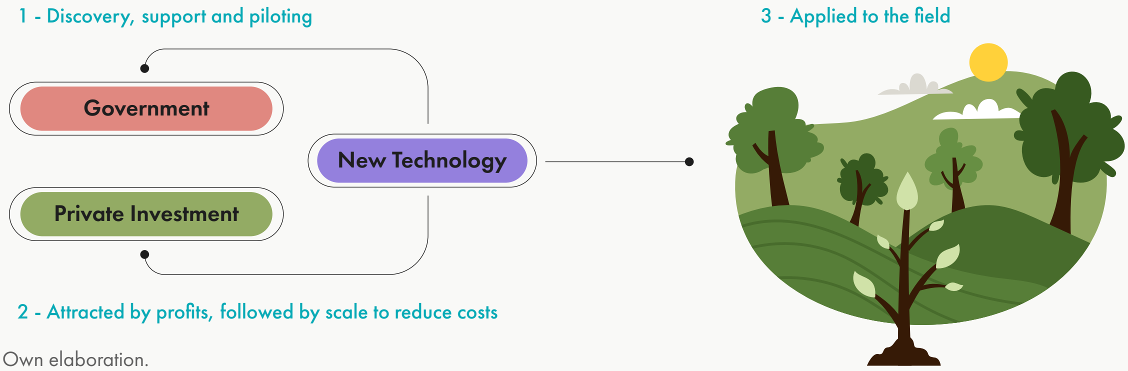
In the discussion and analysis of the following case, we will only discuss the main positive factors and will not mention the influence of other minor elements due to time constraints. In addition, some external factors may become the main driving force of an event. For example, e-commerce in China started with the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003, and after recently experiencing the impact of the COVID-19 pandemic we are now looking to accelerate the process of digitization in agriculture.

5. - About family farmers

In the value chain of the agricultural industry, family farmers are in a relatively weak position. Efficient information flow using digital tools can not only improve production efficiency at the farm level, but also support the standardization of production and the adding of value to agricultural products, and efficiently organize family farmers to increase production and supply.

Elements in the development cycle

Figure 2: Development model



Source: Own elaboration.

As shown in Figure 2, government participation, the adoption of new technologies and private investment are important elements in the healthy development of agricultural digitization and maintaining a high level of interaction among these three elements will facilitate the effective advancement of the process.

Promoting agricultural digitization requires the intervention of new technologies, but the diffusion of new technologies often faces challenges in terms of affordability and digital skills, and this is where the importance of public and private investment comes to the fore.

The government identifies and nurtures the development of new technologies when they are unprofitable or less profitable and demonstrates their development potential. For its part, private investment selects valuable new technologies in the market for investment and increases production through market expansion to reduce costs.

The implementation of digital technologies requires a complete development process in which various elements are involved: transportation, communication facilities, education and laws, among others. The government plays the most important role in the initial creation of this process, since its commitment is based on a long-term return rather than on short-term results. The examples below, which cover different time periods, show the active role of the government in the digitization process.

1. - The role of government

1.1 - Internet access in China

In the early stages of the development of information technology and the Internet in China, new technologies and government foresight played an important role.

China established its first connection to the Internet in 1994 after the rise and rapid development of the Internet between 1990 and 1992. The rapid development of the Internet during this period was thanks to the launch of Intel 80386 in 1985 and the rise of the open source community GNU[1] in 1990, which cleared the software and hardware barriers to the affordability of Internet access.

The Chinese Government accurately identified the key moment to promote technological development and, after approving the National Computing and Networking Facility of China (NCFC) project financed by the World Bank in 1989 to promote Internet access, access was finally obtained in 1994.

[1]GNU (GNU's Not Unix) is a community organization of the Open Source System (OSS) project, founded in 1984, and is currently the largest free software consortium in the Unix field.

1.2 - Digital skills, education, and digital inclusion

1.2.1 - Primary education

On 16 February 1984, the Government of China proposed that "the popularization of computers should start with children". From then on, digital skills training began in primary and secondary schools where conditions permit. The reason why China proposed such an education strategy in 1984 is that the large-scale development of global informatization began with the popularization of microcomputers in 1982.

On 10 June 1977, the Apple II officially launched in the United States of America. Then, in 1982, International Business Machines Corporation (IBM) publicly released information on personal computer technology, enabling the global promotion of microcomputers. In August 1983, China's first Personal Computer (PC) compatible computer was exhibited at the Beijing Exhibition Hall, marking the beginning of the popularization and promotion of microcomputers in China.

1.2.2 - Higher education

China's higher education programme in computer science began in 1956. That year, China released its first scientific and technological development plan, the Long term Plan for the Development of Science and Technology 1956-1967. The government included computers in the long-term plan for scientific development, which was the origin of computer education in Chinese universities.

1.2.3 - Indigenous education

China has always attached great importance to the education of Indigenous Peoples. In addition to ordinary colleges and universities, there are also specialized universities for Indigenous Peoples. For example, as shown in Figure 3, there are six universities directly under the State Ethnic Affairs Commission of the People's Republic of China.

Figure 3: Universities for Indigenous Peoples belonging to the National Ethnic Affairs Commission

1. Minzu University of China
2. South-Central Minzu University
3. SouthWest Minzu University
4. NorthWest Minzu University
5. North Minzu University
6. DaLian Minzu University

Source: Own elaboration.

The Affiliated High School of Minzu University of China for is also a national high school for ethnic minorities in China. In addition, there are many other indigenous universities, as shown in Figure 4.

Figure 4: Public universities for Indigenous Peoples

1. Xizang Minzu University
2. Giuzhou Minzu University
3. South-Central Minzu University
4. Guangxi Minzu University
5. Yunnan Minzu University
6. Qinghai Minzu University
7. Sichuan Minzu College
8. Hebei Normal University for Nationalities
9. Hohhot Minzu College

Source: Own elaboration.

In addition to the above, universities located in ethnic minority areas also have targeted policies for indigenous students, including scholarships, admission rewards, and language preparatory courses. These regional universities as shown in Figure 5.

Figure 5: Regional universities for Indigenous People

1. Inner Mongolia University
2. Xinjiang University
3. Tibet University
4. Kashi University

Source: Own elaboration.

1.2.4 - Computer technology for Indigenous Peoples' languages

China is a multi-ethnic country with dozens of Indigenous Peoples' languages in addition to the widely used Chinese language, some of which are only spoken but not written. Before the Internet was connected to China, the informatization work of ethnic minority languages had also been carried out.

Uyghur language

Xinjiang University has been engaged in the research and development of multilingual information technology such as Uyghur, Kazakh, and Kirgiz since 1984, and has developed Uyghur and multilingual mixed processing and typesetting systems. In terms of intelligence, it has established a recognition model for Uyghur speech signal features and proposed an Hidden Markov Method (HMM) model with state dwell segment length distribution and its parameter estimation.

Tibetan language

In 1984, with the support of relevant national departments, NorthWest Minzu University established a company to develop multi-functional series of combination software with independent intellectual property rights, using the Tibetan language window platform as the core technology.

It has also developed the first Tibetan software package based on mainstream intelligent mobile phone operating systems both at the domestic and international level, solving the technical problem of Tibetan mobile phones being unable to achieve multiple operating systems and models coverage.

Yi language

SouthWest Minzu University invented the input method for Yi language on computers and promoted the establishment of national and international standards for Yi language information processing. In June 1984, the development of Yi language processing was carried out on a PIED PIPER microcomputer. It also established a Yi character library, which can be accessed using BASIC or FORTRAN languages.

Unwritten indigenous language

For non-literate Indigenous Peoples, the Chinese Government helped them establish dictionaries and websites to protect their languages and culture.

Series dictionary of Peoples' languages without character sets

In the 1990s, China began editing and publishing the Chinese Ethnic Minority Language Dictionary Series, promoting the compilation of small language dictionaries. Dictionaries play a very important role in the comparative study of the history of Sino Tibetan language families.

Website for Indigenous Peoples' languages without character sets

Through the establishment of websites, the Chinese Government has achieved the goals of preserving indigenous language materials, disseminating indigenous knowledge and highlighting the culture of Indigenous Peoples. From the perspective of cultural inheritance, the information contained in the network is irreplaceable by any other means of cultural inheritance, and represents a new tendency in the use of science and technology to play a dynamic role in cultural preservation and dissemination.

1.3. - Infrastructure development

1.3.1 - Logistics and Internet access

In terms of physical logistics, the Chinese Ministry of Transport formulated the "Five Verticals and Seven Horizontals" National Highway Main Line System Plan in 1993 and put it into practice, laying a solid foundation for logistics and population mobility. In 2007, China completed this planned goal 13 years ahead of schedule.

In 1993, the government launched the Three Golden Projects, namely the Golden Bridge Project, the Golden Card Project and the Golden Gateway Project, with the goal of building China's "quasi-speed information highway", realizing interconnectivity among various government departments.

The above-mentioned policies and investments have played a role in promoting and guiding the initial formation of China's logistics, information and payment flows.

On 1 April 1998, the Chinese Government revised its regulations on foreign investment in China's mobile and fixed-line telephone networks with the aim of ensuring the rapid development of the information industry.

1.3.2 - The introduction of competition

In 1994, in the same year as China obtained a ccess to the Internet, the country began to restructure State-owned Internet service providers, break monopolies, and introduce competition mechanisms. As a competitor of China Telecom, China Unicom, which was established in 1994, has led to significant changes in the telecommunications structure. In April 2000, China Mobile was spun off from China Telecom, creating a more competitive market structure. In addition, in May 2002, China Telecom was further divided into two departments.

The Chinese Government also issued the "Regulations on Foreign Investment in Telecommunications Enterprises" at the end of 2001, relaxing foreign investment in the domestic telecommunications industry, thereby laying the foundation for reducing networking costs.

However, for ordinary people in China, even if they lived in the city, the cost of accessing the Internet remained high during this period. So, what caused the number of Internet users in China to grow to nearly 60 million in 2002 after just a few years?

2. - Private investment in e-commerce

2.1 - Introduction

It is becoming increasingly evident that e-commerce has become a novel and effective method to help small-scale farmers gain market access. Due to the lack of pricing pressure from intermediaries and marketing restrictions, e-commerce enables small-scale farmers to sell most of their products at higher prices than in the past. The use of agricultural e-commerce is driving the process of small-scale farmers integrating into the market.

2.2 - New technology: Web 2.0

Web 2.0, which appeared around 1996, introduced customer interaction and galvanized users and investors compared to Web 1.0, which simply supported information dissemination. The three major Internet giants in China – Baidu, Alibaba, and Tencent (BAT) – were created in 1998, 1999, and 2000, respectively.

Many internationally famous companies, such as Google, were also established during this period. Subsequently, these companies launched Web 2.0 in the market, providing end users with more user generated content and usability, and laying the foundation for the promotion of e-commerce in the later stage.

2.3 - Affordability: private investment in Internet cafés

At that time, private investment in China began to enter the Internet café industry. These businesses built and operated Internet cafés in a shared mode, allowing more young people to access the Internet more conveniently and cheaply. Therefore, Internet cafés made important contributions to the initial development of the Internet in China.

In May 1996, China's first Internet café opened in Shanghai. The number of Internet users in China increased to nearly 60 million in 2002, second only to the United States of America in the global ranking. At the end of June 2008, the number of Internet users in China reached 253 million, significantly surpassing the United States of America for the first time, and meant that China jumped to first place globally in terms of number of users. Among them, 46.4 percent of users are female, and the gender balance of users is gradually improving.

2.4 - External stimulation: the launch of e-commerce

In fact, China's e-commerce development began because of various external emergencies. In 2003, due to the impact of SARS, Alibaba launched the Taobao platform and third-party payment digital tools. At this stage, the completion of e-commerce processes relied on relatively simple information, payment, and product flows.

The flow of information relies on websites or self-built chat tools, while the payment flow relies on computers to complete payments.

Taobao allows merchants to open stores on their own platforms for free and use third-party logistics companies to establish logistics flow. This method has low investment but poor controllability and relies on external factors.

JD, on the other hand, has established its own logistics system, which is independent of external factors and allows for self-control of delivery time. Vertical integration makes its distribution and after-sales service more efficient and absorbs upstream and downstream profits.

2.5 - New technology: the smartphone

Although the number of Chinese Internet users reached a high level in 2008, the market needs more user groups. In addition, desktop computers are not suitable for the full integration of people and the Internet. From the perspective of e-commerce, the PC-based Internet cannot fully attract consumers who do not have access to a PC.

Only by freeing consumers from the shackles of wires and PCs will they be able to complete transactions more freely. Importantly, the availability of consumer data will be greatly enhanced if the consumer has a personal identification (ID) in the consumption process. Smartphones (not traditional cell phones) largely fulfil these needs.

The advantages of smartphones:

- Cost lower than PC, affordability
- The surge in user numbers has increased network coverage
- Portable: smartphones have the characteristics of "anytime, anywhere" and "always online"
- Private attributes, where the phone number is the personal ID, improve the availability of consumption data

The popularization of mobile phones has made a huge contribution to improving Internet access in Chinese rural areas, with the number of rural Internet users increasing from 84.6 million in 2008 to 222 million in 2018.

In the period 2009 to 2015, China experienced an acceleration in the development of smartphones. The rapid rise in the popularity of smartphones has also affected users' online behaviour, with online entertainment functions, self-media, and instant messaging tools occupying a large amount of traffic. In fact, a large number of traditional Internet users have shifted from PC platforms to mobile platforms. Therefore, this is an important stage for the expansion of the number of Chinese Internet users, playing an important role in the popularization of the Internet.

2.6 - New technology: social media

In 2011, Tencent officially launched WeChat, which has since become a national social network application. Today, the total number of WeChat users has reached 421 million, and WeChat payment has become a popular digital tool for electronic payments.

Another interesting phenomenon is that, between 2014 and 2015, Taobao and JD.com seemed to have almost dominated the entire e-commerce market in China, with little opportunity for other companies to compete.

However, in 2015, from the perspective of social media as meeting a fundamental human need, PinDuoDuo started with social networks and successfully entered the market, receiving customer orders and becoming one of the three major e-commerce companies in China. In Chinese, 'Pin' means gathering, while 'DuoDuo' means many.

By 2020, PinDuoDuo's agricultural product transactions totalled USD 39.14 billion, with over 16 million agricultural producers directly connected. This means that its business model cannot only receive a large number of similar product orders on the consumer end, but it also brings together 16 million producers to meet this demand. In this regard, it provides a successful model for small family farms.

2.7 - Free movement of e-commerce elements – O2O

Since the advent of smartphones and mobile payments, the flow of people and payments has been almost free, which has led to the emergence of a new e-commerce model. In this new model, it is no longer just people searching for things on the Internet, but services can also draw people to complete transactions in physical stores, which is called online-to-offline (O2O).

The application of the O2O e-commerce model in mobile Internet is also a promising and valuable research direction. It integrates and improves localized offline services with services on mobile terminals. Today, various O2O models such as delivering meals and fresh food to home have begun to emerge. By displaying products and services offline and completing payments online, the O2O model not only attracts customers online, but also records user behaviour, thus providing more useful information for companies about their consumers.

The section below focuses on material flows in e-commerce. The traditional product flow refers to goods logistics, but here it may also refer to shared bicycles and cars, or one-time on-site services. It can also be reverse or relative, where customer flow occurs while the product itself does not move. The flow of information and mobile digital payment is an important feature of e-commerce transactions, and the ultimate goal of business is to combine goods or services with people through the matching of information flows.

Connecting with markets and improving farm productivity

1. - Background

In the 1.0 era of traditional agriculture and the 2.0 era of mechanized agriculture, mechanization is the beginning of automation. Mechanization can improve agricultural labour productivity, land output rate, and resource utilization rate. The basis for the development of digital agriculture is the aforementioned agricultural mechanization and the adoption of modern agricultural technology.

In the automated Agriculture 3.0 era, automation is more dependent on data, but its control loop is relatively simple. As for Agriculture 4.0, it is the deep integration of AI, the Internet of Things, Big Data, cloud computing, 5G and other information technology with agriculture, and this process involves the incorporation of high technology across the agriculture industry.

However, there are still many challenges to be faced in implementing Agriculture 4.0, which is commonly used in facility agriculture, and it will likely coexist with Agriculture 3.0 for a long period of time.

2. - Challenges to be overcome in the digital process on the farm-side

In e-commerce, it is common to use one or two-dimensional bar codes, Radio Frequency Identification (RFID), etc. to identify items, but on the production side, sensors have evolved from simple smartphones to diverse sensors. In addition, on the production side, the information flow is more of an interaction or even a struggle with the forces of nature as it is influenced by external factors such as climate and thus is exposed to environmental impacts.

However, the volume of data and the diversity of spatiality, real-time, and internal logic on the production side is very different from that of e-commerce, since it requires more computing power, storage, specialized software, models, and diverse expertise than in e-commerce.

The Internet mainly connects people, while digital agriculture connects people, machines, systems and the whole value chain, so the number of connections is far more than the consumer Internet, which means the system is more complex, the initial investment cost is higher and the return is slower.

3. - Government infrastructure investment

Offering personalized services on public platforms and allowing individuals to access them in a modular way can lead to the development of pervasive and low-cost technology with low-skill needs.

For example, the previous section mentioned transportation, logistics and other infrastructure. On the production side, water, electricity, computing power, gas, as well as climate and soil information, as well as other basic information, can be categorized as infrastructure. Therefore, improving access to this infrastructure can reduce the costs on the production side and facilitate the development of digital agriculture.

The Chinese Government has developed different projects in this area, such as Eastern data-Western computing, South-to-North Water Diversion, transmitting electricity from west to east, and transporting gas from west to east, among others.

3.1 - Eastern data-Western computing

The rural areas of western China are rich in renewable energy such as hydropower, wind power, and solar energy, coupled with cool weather, which means a reduction in heat dissipation cost in data centres.

If fact, the Eastern data-Western computing project not only promotes the development of data centres in China's western rural area, but also promotes the construction of network facilities in rural areas.

In this regard, the energy savings brought by the project may become an entry point to attract facilities investment in rural areas.

3.2 - South-to-North Water Diversion Project

The south of China is rich in water resources, while the north is relatively short of water. In 2012, the east and middle routes of China's South-to-North Water Diversion Project have been officially put into production. As of May 2022, the cumulative water transfer volume of the project reached 53 billion m³.

One of the reasons to mention the project here is that the digital twin technology was piloted on this project. This technology is discussed in greater detail later.

3.3 - Information service platform

3.3.1 - High spatial resolution satellite

China has also successfully launched a number of high-resolution satellites in recent years. On 2 June 2018, the Gf-6 satellite was successfully launched, marking the first time that a high-resolution remote sensing satellite has been used in the country that can effectively distinguish crop types. This will significantly improve agricultural land monitoring capabilities and accurately support the development of digital agriculture. The Gf-6 will operate in a network with the in-orbit Gf-1 satellite, with an expected lifespan of eight years.

3.3.2 - Beidou navigation satellite system

BeiDou Navigation Satellite System (BDS) is a global satellite navigation system developed by China and the third mature satellite navigation system after Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS). in June 2020, China implemented its BeiDou-3 navigation and communication satellite system. The BDS provides all-time, all-weather and high accuracy positioning, navigation, short message, and timing services to global users. The short message function of BeiDou is very useful for rural areas and fishing vessels.

4. - Key technology

The following section lists some key technologies extracted from the farm side. These technologies include data collection by sensors, drones and humans, data storage and analysis, control models and data visualizing. For convenience, the technologies are divided into the follow four sections.

4.1 - Data collection

Regarding data collection in an agriculture system, this is important not only for traceability, but also for on-site production control.

Traceability generally has relevant standards for different products. For example, for cherries from Chile to enter other countries' markets, growers must implement Good Agricultural Practices (GAP), which includes maintaining orchard sanitation and implementing Total Pest Management or other pest control measures. Packers must also have well-established Standard Operating Procedures (SOPs), covering all processes related to cherry fruit grading, handling and packaging.

Another example is the breeding of cattle in Western Australia, which requires the use of an approved National Livestock Identification System (NLIS) electronic device for identification. NLIS devices can be mounted on the ear, or a bolus injected into the rumen of cattle.

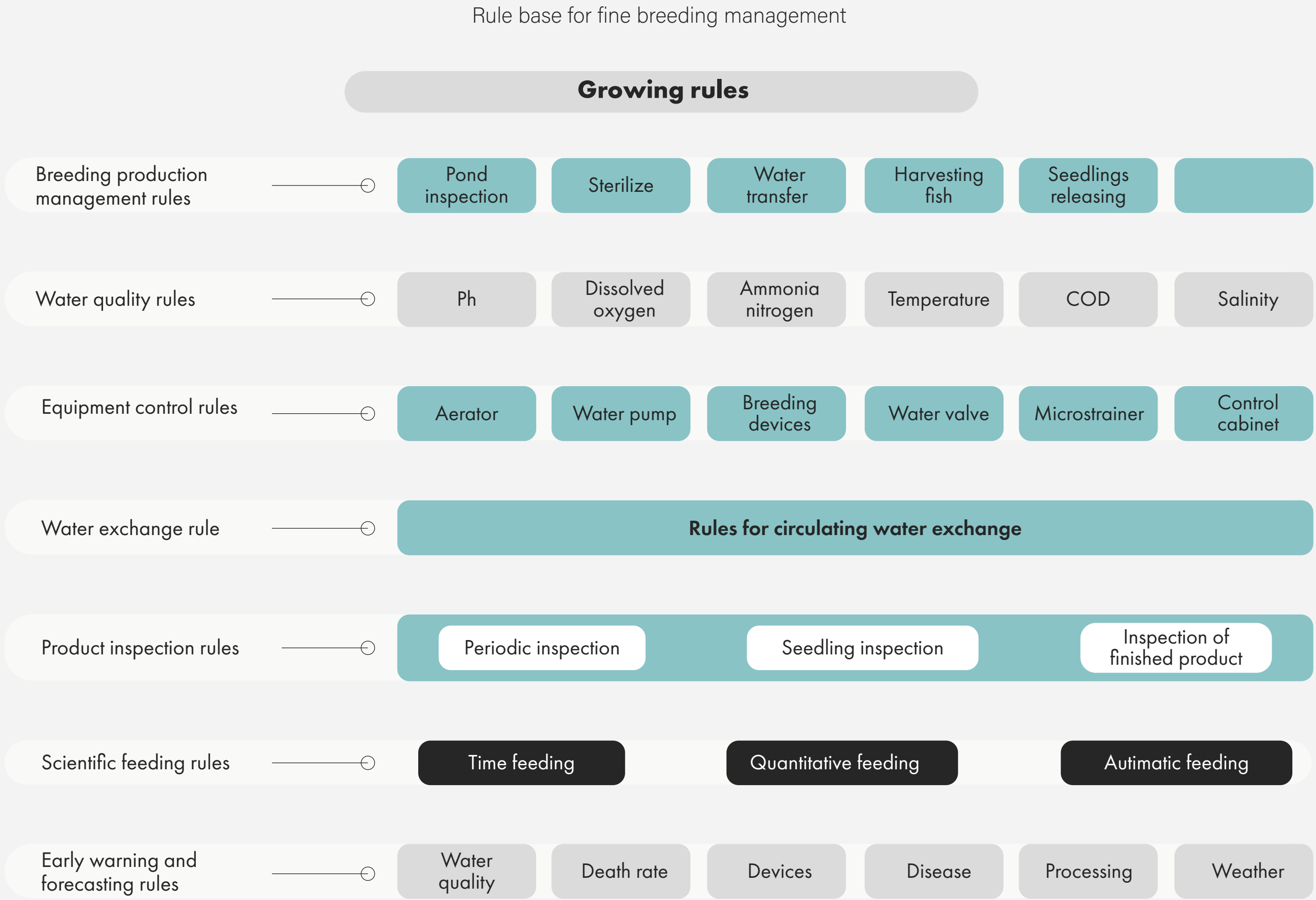
4.2 - Control model and facility agriculture

Control models are widely used in facility agriculture, which emphasizes the control of environmental factors and the use of off-season methods to increase yield, such as humans using LED-based greenhouses to grow vegetables in Antarctica.

Common cases of facility agriculture include intensive aquaculture, circulating water treatment, tail water treatment, and greenhouse plant growth. The control models used in facility agriculture can be automatic unit control models. However, if the user has sufficient production knowledge, the realization of these models does not seem to be the main challenge. Instead, the main challenge comes from affordability and the digital skills of users. Unlike affordability in the e-commerce field, maintenance costs and operating costs are large part of total cost.

Figure 6 shows an example of an intelligent aquaculture feeding model with different models for different growing rules.

Figure 6: Example of an intelligent aquaculture feeding model



Source: Own elaboration.

The energy issues in facility agriculture operations can be mitigated by solar, wind, and bioenergy, which is in line with the previously mentioned principle of integrating computing into the physical world.

In Digital Agriculture 4.0, facility agriculture is a more successful model because facilities are more like the devices with their previously noted adsorption properties. Since facility agriculture involves large investments in equipment, users share the investment costs of the digital equipment.

The counterpart of facility agriculture is outdoor crop growth, which is currently mostly at the level of mechanization and automation and is difficult to digitize. Mature technology relies heavily on drones, satellites, navigation, and sensors attached to agricultural machinery to further enhance the intelligence and digitalization of production.

4.3 - Data storage and visualization

In terms of how data is stored and displayed, this mainly involves ensuring data security and ownership in the face of digital transformation, as well as how to allow users to quickly access valuable information from large amounts of data.

Due to the spatial nature of agriculture data, GIS is a very good data storage and display platform for this purpose. If the data needs to be open to the public or a third party, and there are requirements such as tamper-proofing, blockchain is currently a better choice. However, for internal data, considering performance and other issues, it is not necessarily necessary to be part of the chain.

It is worth noting that some big companies, such as IBM, are making efforts on the blockchain platform, and the blockchain-based traceability platform is one of IBM's products.

Putting aside security and some technical issues, if we use a platform like Google Earth as a unified interface, then data from all pilot or digital projects can be pushed to this platform. This would be a good idea as we can use it to visually collect all pilot projects together at the global level. The GIS platform is very suitable for data and applications in the field of agriculture.

In fact, the "One Province, One Map" project is currently being implemented in China, which seeks to integrate smart cities and villages projects into a single platform.

Another data visualization technology is digital twin, which aims to enable users to quickly find valuable information from a large amount of data and even interact directly with this data. If GIS is a surface, then the digital twin is a point.

Digital twin technology solves the issue of usability to some extent, which is related to the challenge of improving digital skills that was mentioned above.

Examples of agricultural applications

Finally, two digital agriculture application cases are presented involving the integration of primary, secondary and tertiary industries in China.

1. - Fishery industry

The first case is about a fishery cooperative. The project is located in Wenling Shitang, Zhejiang, China, with an area of 28.47 km^2 and a coastline of 58.6 km, which has an annual fish catch of about 150 000 tonnes.

Initially, the cooperative's main income came from fishing, but it has since developed a secondary shipbuilding industry and a tertiary tourism industry, which is more conducive to ecological conservation.

In terms of shipbuilding, this mainly focuses on the building of fishing vessels. The team is mainly responsible for researching and developing intelligent, automated fishing equipment, as well as navigation, communication and emergency equipment on board.

As for tourism development, this means that tourists can go fishing on the boat and the cooperative provides catering services.

2. - Aquaculture

The second case involves ZhongYang Group, an aquaculture group in Jiangsu, China, which is focued on fish farming, fish feed processing, food processing, hotels, and tourism. The group has more than 800 km^2 under aquaculture production.

The group's main product is puffer fish, which is an aquatic product with high nutritional value. The group is also engaged in breeding and protecting rare fish in the Yangtze River. It also breeds crocodiles and giant salamanders in its own breeding centre.

The group has its own food processing plant and cold storage facility to increase the added value of its products through food processing. Also, guests at the group's luxury five-star hotels often share the hotel's food and accommodations on social media.

Recommendations for Latin America and the Caribbean

In the process of digitalization of agriculture, this report distinguishes between e-commerce, which is more related to the social aspects, and field digitalization technologies, which are related to the production aspects, and identifies the challenges and main contradictions in their implementation. Examples include expanding the number of connected users, while enhancing the interaction and flexibility of information, human, logistics and payment flows.

The report also emphasizes the concepts of platformization and scale management, in which the government, private investment and small-scale farmers play different roles:

The government is mainly responsible for policy support and investing in large-scale or basic platforms (including education) with broad benefits, while private investment focuses on medium-sized platforms with a certain degree of profitability. For their part, small-scale farmers and technicians use the new technology to address specific production needs. Through pilot projects, new technologies are continuously developed and evolved into platforms that can attract government or private capital investment.

In this way, we can continuously shift costs from the farm field to government or private investment projects can be operated at scale, which in turn reduces project costs on the farm side.

For example, in China the success of smartphones, cameras and drones, among other devices, are all prime examples of this process.

One of the goals we are working towards is – through continuous platformization – to make computing ubiquitous in the agriculture sector and to realize its intangible benefits.

References

Ali M.E, Cheema M.A, Hashem T., Ulhaq A., Babar M.A. 2023. *Enabling Spatial Digital Twins: Technologies, Challenges, and Future Research Directions.* https://arxiv.org/pdf/2306.06600

China Satellite Navigation Office. 2021. *10 Application Scenarios of BDS in Africa.* http://m.beidou.gov.cn/xt/gfxz/202111/P020211105587887134672.pdf

De Clercq, M., Vats, A. y Biel, A. 2018. Agriculture 4.0 – *The Future Of Farming Technology. World Government Summit.* https://www.bollettinoadapt.it/wp-content/uploads/2019/12/OliverWyman-Report_English-LOW.pdf

Li, D.R. 2022. *China's High-Resolution Earth Observation System (CHEOS): Advances and perspectives. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, V-3: 583–590.* Nice. https://isprs-annals.copernicus.org/articles/V-3-2022/583/2022/isprs-annals-V-3-2022-583-2022.pdf

ECLAC (Economic Commission for Latin America and the Caribbean). 2022. *A digital path for sustainable development in Latin America and the Caribbean.* Santiago https://hdl.handle.net/11362/48461

FAO (Food and Agriculture Organization of the United Nations). 2013. *ICT uses for inclusive agricultural value chain.* Roma https://www.fao.org/sustainable-food-value-chains/library/details/en/c/267215/

FAO (Food and Agriculture Organization of the United Nations) and Zhejiang University. 2021. *Rural e-commerce development experience from China.* Roma http://www.fao.org/3/cb4960en/cb4960en.pdf

FAO. 2022. *Training manual – Good agricultural practices (GAP) guidelines. Volumes 1 and 2.* Nay Pyi Taw https://doi.org/10.4060/cc3338en

GS1 in Europe Fruit & Vegetable Implementation Group. 2021. *Fresh Fruit and Vegetable Traceability Guideline.* https://ref.gs1.org/guidelines/fruit-veg/

Hasan, H.R., Salah, K., Jayaraman, R., Omar, M., Yaqoob, I., Pesic, S., Taylor, T. & Boscovic, D. 2020. *A blockchain-based approach for the creation of digital twins. IEEE Access, vol. 8:* 34113-34126 https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9001017

Krishnan A., Mulvihill T., Hayden B., Droke M. 2018. *Blockchain for the Food Industry: The Essential Primer.* https://www.dorsey.com/-/media/files/newsresources/events/2018/09/food-risk-summit-2018blockchain-materials.pdf?rev=deec7b3c6e1042c19792c82c823ec1ef&hash=%20B7FB2137B76540FA04B205683D395863

Khurape, A. & Kirve, S. 2019. *Industry 4.0 in agriculture: Focus on IoT aspects. JETIR Journal, V-6: 382–389.*
https://www.jetir.org/papers/JETIRBO06073.pdf

Liping M., Kaiqing Z., Xiaohui J. 2015. R*esearch on Square Hmong Language Characters Fonts Based on OpenType Technology[J]. Journal of Chinese Information Processing.*
https://www.cnki.net/kns/defaultresult/index

OECD (Organisation for Economic Co-operation and Development). 2003. *Review of the Development and Reform of the Telecommunications Sector in China.* Paris
https://doi.org/10.1787/233204728762

PrimusLabs.com. 2008. *Packinghouse with Haccp audit scoring guidelines.*
https://www.primuslabs.com/docs/guidelines/packinghousewithhaccpauditscoringguidelinesv08.06rev4.pdf

World Bank. 2011. *ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions.* Washington, DC
https://hdl.handle.net/10986/12613

Yokogawa Electric Corporation. 2021. *The Differences Between Digitization, Digitalization, and Digital Transformation in Manufacturing.*
https://www.yokogawa.com/sa-es/library/resources/white-papers/the-differences-between-digitization-digitalization-and-digital-transformation-in-manufacturing/

CD4965EN/1/05.25