Sino-German Agricultural Centre, 2nd Phase

Study:

**Chinese "Digital village" initiatives and the
digitalization of agriculture**

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Disclaimer:

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Executive summary:

This study was carried out by the Sino-German Agricultural Centre (DCZ), a platform jointly financed by the German Federal Ministry of Food and Agriculture (BMEL) and the Chinese Ministry for Agriculture and Rural Affairs (MARA).

The purpose of the study is as follows: to review the current situation of the agriculture sector in China, to analyze the recent government policy initiatives and documents regarding the digital villages, to investigate the various applications of the digital villages in the sub-sectors of agriculture, to lay out the successful key case studies from the different parts of China, to identify the key challenges for the further development of the digital villages in China, and to recommend the potential avenues for Sino-German cooperation in the digital agriculture.

This study has been carried out by reviewing the relevant academic papers, news reports and policy documents and initiatives in English and Chinese.

Key findings from this study:

- Food security, rural poverty and increasing income imbalances between rural and urban areas are the main drivers for the digitalization of agriculture in China.
- Digital villages are designed to achieve food security, poverty alleviation and rural revitalization.
- Digital village development refers to the use of transparency and the integration of digital economy and technology matters to promote the digitalization of the villages.
- The official government policy papers on "Digital village development strategy outline" and "Digital Rural Development Guideline 1.0" are providing a roadmap and case studies for the development of the digital villages in China.
- Chinese tech giants like, *Alibaba*, *Pinduoduo* and *Huawei* are key players in the development of digital villages in China.
- Taobao villages, DuoDuo farms, precision agriculture in the Deqing county, Zhejiang and various village governance apps and many others are successful examples of digital villages in China.
- Lack of standardization, lacking competence and digital skills, insufficient digital infrastructure as well as an increased arbitrary oversight and regulation on involved big tech companies, traditional land allocation policy and scaling-up are major challenges to the development of digital villages in China.
- More grass-root based solutions with increased participation in the decision making, more digital infrastructure investment into underdeveloped regions, more application of the digital agriculture technology to achieve carbon neutrality and relaxation on rural residency Hukou registration system and offering more social services has been recommended as potential remedies for the issues in the development of digital villages.
- Germany and China have a lot to offer to each other for the cooperation and mutual learning and exchanges in the digitalization of the agriculture.

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1. The situation of agriculture and rural areas in China

Given that China has nearly 20% of the world population with only 6% of the fresh water and 7% of the arable land, agriculture and food security, in particular, have always been important issues for the country's development (Veeck et al., 2021). Since the "reform and opening up" policies in the late 1970s, China has been transformed from a rural agrarian society into a modern industrialized economy of the 21st century. During that process, a very large number of rural residents poured into the ever-expanding Chinese cities looking for factory and service sector jobs. As a consequence, the rural population decreased from 82% in 1978 to 38% in 2020 (World bank, 2021). This dramatic change has brought both opportunities and challenges for the Chinese agriculture sector: On one hand, the smaller rural population combined with modern agriculture technology accelerated efficiency, productivity of farming and land consolidation in China. On the other hand, rising income levels increased the demand for food, particularly for meat, leading to a higher pressure on land and with it to soil and water pollution from excessive application of agrichemicals. Meanwhile, farmlands also have been converted to make space for new factories, residential areas of the cities which threatened the sustained production of the agri-food products in China. Urbanization and industrialization also have left many rural areas behind their urban counterparts and rural poverty and decay increasingly become persistent problems in modern China.

Against this backdrop, the Chinese government has initiated the rural revitalization and poverty alleviation campaign with a varying degree of success (Huang & Rozelle, 2018). On February 25, 2021, President Xi declared a complete victory on "eradicating extreme poverty," stating: "According to the current criteria, all 98.99 million rural poor have been taken out of poverty, and 832 poverty-stricken counties, as well as 128,000 villages, have been removed from the poverty list" (BBC, 2021). China's poverty definition – earning less than 4,000 Yuan (620 USD) a year or 1.69 USD per day – is less than the World Bank's threshold of 1.90 USD a day, and well below the 5.50 USD per day that economists recommend for upper-middle-income countries (Kuo, 2021). Thus, despite these achievements, China still has a long way to go in tackling the relative poverty and structural inequalities in the years to come.

China considers digitalization to be increasingly important – not only to improve productivity and efficiency of agriculture, but also to revitalize the impoverished rural regions by bringing new industries as well as services and to reduce the regional economic disparities. The Covid-19 pandemic has accelerated the digitalization of all sectors, including the agriculture sector, which now can use digital technology to improve productivity and to connect farmers, producers and customers under pandemic-related restrictions and subsequent supply chain disruptions.

To achieve the aforementioned goals, the Chinese government has laid out several policy proposals and plans in partnership with the private sector, namely the big tech companies, to transform Chinese agriculture into a more digital and sustainable form. Promoting the digital villages will be a huge part of that effort. This study will analyze the various government policies concerning the digital villages and the role of big tech companies. It will also lay out the major case studies and summarize the major challenges and recommendations for the forthcoming efforts.

2. Digital village initiatives and policies by the Chinese government

The FAO introduced its "1,000 Digital Village Initiative" around the world to help identify and support existing and potential digital villages to improve the agriculture, livelihoods, and nutrition (FAO, 2021). Countries like China, Japan, India and South Korea have their various digital village initiatives and programs, the Chinese example could offer the most comprehensive case studies in such endeavors.

According to the "China digital economy white book, 2021", the digital economy of China has reached 39.2 trillion Yuan which comprised 38.6% of the GDP in 2020 (Wang et al, 2021). The document also stated that the level of digitalization in the service and industrial sector is relatively high with 35.9% and 18.3% respectively. However, the agriculture sector lags behind with only 7.9% (Wang et al, 2021).

The digital village development refers to the integration of digital economy and technology to promote the digitization of the villages in a transparent manner (Wang et al., 2021). According to FAO, the Digital Village can be defined as a flexible, country-specific ecosystem whose design and development must be guided by the principles of feasibility, inclusiveness and sustainability (FAO, 2021).

In 2018, for the first time, the No.1 document – the agriculture policy document annually released by the Chinese State Council to set policy objectives for the year – has mentioned the "Digital village strategy" and how to integrate it into agricultural and rural sectors. The MARA and the Central Cyber Security and Information Committee of China jointly published the "Rural and Agricultural Digitalization Development Plan for 2019-2025" on December 25, 2019 which provided a blueprint for the digitalization of agriculture and the rural areas with significant emphasis on the digital villages (MARA, 2019). According to this plan, by 2025, significant progress shall have been made in the promotion, implementation etc. of digital agriculture and rural areas, which strongly supports the implementation of the digital village strategy. The plan also stated that the agricultural and rural data collection system will be well established, and the air-ground integrated observation network (integration of drone, satellite and other aerial data related to the field with ground data), agricultural and rural basic data resource system, and agricultural and rural cloud platform will be basically completed by then.

In May 2019, the State Council of China also released the "Digital village development strategy outline" which set four stages for the Chinese digital development. Goal of Stage 1, the initial phase, is to increase the coverage of the agricultural information technology. Stage 2, extending into 2025, will focus on reducing the digital divide between cities and rural areas. Goal of Stage 3, which will last until 2035, is to finish the implementation of the digital village program and to update farmers digital skills. Stage 4 will last until 2050. In this stage, digital villages will have been established everywhere in the country and overall rural revitalization will be fully achieved (MARA, 2019).

According to the "2020 Chinese Internet development & statistics report", the number of Internet users in China reached 989 million or 70.4% of the overall population, the rural Internet users reached 309 million or 55.9% of the population (Wang et al., 2021). This shows the high level of overall Internet penetration and the slightly lower penetration in the rural areas. Therefore, China has sufficient infrastructure in place to carry out the agricultural digitalization process.

3. "Digital Rural Development Guideline 1.0"

On July 23, 2021, the Chinese National Reform Commission, the Ministry of Agriculture and Rural Affairs, the Ministry of Technology, the Ministry of Industry and Information, the Office of Central Cyberspace Administration, the State Market Regulation Bureau and the National Rural Revitalization Bureau jointly released the "Digital Rural Development Guideline 1.0". The guideline requires various localities to use this document as a reference and integrate it with real on-site conditions. It provides comprehensive and authoritative suggestions for both the provincial and county levels to promote digital village development as well as to select case studies from various provinces (MARA, 2021).

1) **Overall framework:** According to the guideline, any effort should be integrated with the work and experience of national experimental digital villages. It offers an overall framework for

rural digital village development which includes IT infrastructure, public support platforms, digital application operation management and security system.

2) **Information infrastructure:** The guideline proposes to upgrade the traditional digital infrastructure which includes the Internet infrastructure and IT infrastructure.

3) **Public support platforms:** The guideline suggests that the established public data platforms should serve the three rural affairs (a term used by the Chinese government refering to farmers, villages and agriculture, also known as San-nong in Chinese) for the various administrative levels.

4) **Village digital economy:** This section includes smart agriculture, village e-commerce, new industrial development in villages, agriculture technology innovation and rural digital finance. Regarding smart agriculture, the guideline provides instructions for the establishment of an agricultural database, digitalization of agricultural production, digitalization of processed agri-food products, digital monitoring stations for special products, cloud computing and e-commerce supply chain, early warning and decision support system. For village e-commerce, the document explains how to establish an e-commerce ecosystem which integrates production, logistics and an online payment system and it suggests to train the villagers. For rural digital finance, the document states the importance of financial services, rural credit services and agricultural insurance to address problems like the inaccessibility of credits and the long processes involved.

5) **Digital green village:** This section includes guidelines for green agricultural production, green village life and the digitalization of information on ecological protection.

6) **Village Internet culture:** The guideline suggests that digital villages should provide various cultural products and services like a digital library, art and music to create a positive village culture.

7) **Village digital governance:** This section includes guidelines for the digital party governance, "Internet + government services", online village governance and village emergency management.

8) **Social welfare services:** This section includes guidelines for "Internet + education", "Internet + health care", digital elderly care and improving the digital skills of villagers.

9) **Design model:** According to this guideline, design model of the digital village should be innovative, integrated, effective and sustainable.

10) **Process management:** The document states that the digital village development should focus on an effort towards achieving rural revitalization, and that it should be based on science.

4. The role of Big Tech

In recent years, Chinese tech giants like *Alibaba, JD.com*, *Pinduoduo, Tencent, Baidu, Byte dance, Meituan, Huawei* and *Xiaomi* have emerged as powerhouses of the Chinese IT industry. Their large market shares and market capitalization can only be compared to Silicon Valley heavyweights like *Amazon*, *Google*, *Apple, IBM, Intel* and *Microsoft.* Their market dominance and large acquired data volume make them essential players in the Chinese digital economy. Some companies have tailored their technology and services to the agriculture sector. Among them, *Alibaba*, *Pinduoduo* and *Huawei* are notable in their effort to modernize the Chinese agriculture sector with digital technology.

Alibaba is the owner of the biggest online retail platform *Taobao* (Tmall) in China. It has its own fin-tech, online payment and finance subsidiaries *Zhifubao* (Alipay) and *Ant Financial* as well as its powerful cloud services *Aliyun,* media and entertainment divisions. Alibaba has been instrumental in establishing Taobao villages in which farmers would use Alibaba's digital and logistical network to market their products (this will be discussed in detail in the following chapter about Taobao villages).

Pinduoduo is the third-largest e-commerce platform in China and, with 724 million monthly active users, the largest e-commerce platform for agri-food commodities. Unlike other platforms, on Pinduoduo, buyers can engage in group buying also known as social e-commerce (CNBC, 2020). Compared to Tmall and JD.com, it offers more affordable, albeit slightly less services. Pinduoduo launched its DuoDuo Farms initiative in April 2019 to help farmers in impoverished counties in China to improve their productivity and find new sales channels online (Pinduoduo, 2019). In August 2021, it launched a new 10-billion-Yuan initiative and pledged to finance this sum from its profits to support agricultural modernization and rural revitalization. Although the details of this initiative are not yet completely clear, it is going to use this fund to set up new logistical centers and other channels to help farmers escape from poverty (Pinduoduo, 2021).

Huawei, the Shenzhen-based technology conglomerate which produces and provides everything from telecommunications equipment, smartphones, laptops to cloud services and data management, has been a leader in many cutting-edge technologies. They have been instrumental in setting up 5G and the telecommunication infrastructure all over China including many remote rural regions. Huawei has also rolled out the Agriculture Wotu Cloud Platform, which integrates data on seed, soil, planting, plant growth, processing, warehousing, logistics and sales, so that consumers and other stakeholders can trace and share information regarding specific agricultural products. Although the platform has been successfully used in rice production in the Shangdong province, a wider rollout has yet to come (Rouzi, 2021). However, since 2019, US sanctions have put some strains on the company (Strumpf, 2021) which led Huawei to focus even more on the domestic market and the agriculture sector. It also invested in facial recognition for pigs to monitor their health and well-being (Mecculough, 2021).

Although Chinese big tech companies have been a dominant force in the digitalization of agriculture, the recent government regulations and increased oversight on them could influence their impact on transforming the agriculture sector. As a response to the government calls to be more socially responsible, some of them are already announcing their own "Common Prosperity" initiatives to reduce rural poverty.

5. Sub-sectors and case studies

5.1 E-commerce and Taobao villages

As the largest e-commerce market in the world with 2.2 trillion USD of online sales in 2020, China has been a leading force in e-commerce (FAO, 2021). In 2007, Chinese e-commerce platforms started to sell agricultural products which was accelerated after the global financial crash of 2008. Since 2014, Alibaba, Pinduoduo, JD.com, Suning and other e-commerce platforms have developed concepts and services for rural regions to market their agri-food products which also assisted the government's poverty alleviation and rural revitalization campaigns.

Taobao villages were first launched in 2009. They are rural e-commerce hubs that feature Alibaba's logistics, services and trainings. Their aim is to encourage farmers to sale their farm products online (FAO & ZJU, 2021). According to Alibaba, any village with an active online store that reaches more than 10% of households and generates an annual transaction exceeding 10 million Yuan can be considered as a Taobao village (FAO & ZJU 2021). The program has grown from three villages in 2009 to 5,425 villages in 2020 and covers now 28 provinces and autonomous regions (FAO & ZJU, 2021). Taobao villages have created additional income channels and brought new jobs to the villages with their logistical service centers. They have been widely regarded as a success (Martindale, 2021). Average household income in Taobao villages stood at 35,000 Yuan/year (5,000 USD/year) in 2017 which was three times higher than the average rural household income in China in 2017 and close to the urban household income of 39,396 Yuan/year in the same year (FAO & ZJU, 2021). Taobao villages are also home to collection centers, warehouses and logistical centers where perishable fresh farm

products and local specialties are stored and shipped to the bigger retailers in the cities or to consumers directly through online orders.

Live streaming and social e-commerce where sellers and buyers interact directly has emerged as a new phenomenon for the e-commerce in rural areas.

5.2 Precision agriculture in the Deqing county, Zhejiang

Using modern aerial sensory devices to collect weather, soil, pest and other biological data to make science-based farm management decisions is an importance aspect of the precision agriculture in the digital villages in China.

In 2018, Deqing county which is situated in the Zhejiang province, has initiated the "Digital Village Maps" initiative. Together with scientist and government agencies, the initiative has created a comprehensive land resource map which is made of 18 layers. Remote sensing, aerial photography, onsite measurement, zoning and socio-economic data have been combined to create an integrated map for farmers to make informed decisions on irrigation, use of pesticides and other farm-related issues (MARA, 2021). The map has made the discovery and tackling of the land use problems in these areas much easier and, thus, improved village governance.

5.3 Seed sector and Beidahuang Group, HeiLongJiang

With the establishment of the Nanfan Center for Plant and Animal Breeding, dubbed as "Southern Silicon Valley" in the Hainan province, the Chinese government aims to strengthen the seed and breeding sector. The seed sector has been a top priority for China since the government released the "National Modern Crop Seed Industry Development Plan 2012-2020" (Rouzi, 2021). The seed sector integrates modern biotechnology with digital tools to maximize its effectiveness in the selection, reproduction and developments of new seeds.

The Beidahuang Group, located in the Heilongjiang province and also known as Heilongjiang Agriculture Co Ltd, is working on the development of high-quality seeds for corn, rice, wheat and soybean (MARA, 2021). It uses radio-frequency identification (RFID) technology to keep track of the seed and plant growth as well as to monitor field conditions and implement timely farm management. This has enabled the company to increase the production efficiency of the grains.

5.4 Digital strawberry production in Changfeng county, Anhui

Changfeng county in the Anhui province has long been known for its strawberries. In recent years, the county has experimented with "Internet+" and AI technology on its strawberry farms with remarkable success. "Digital strawberry" uses big data, blockchain, AI and sophisticated logistics supply chain to monitor the field conditions and to manage the harvest, sale, transport and delivery service of the fruit. Since the implementation of digital strawberry production, the use of fertilizers and agrichemicals has declined by 30% and 45% respectively. The labor costs per mu (mu is land area of 666 m^2) declined by 800 Yuan, the per-mu income increased by 3,600 Yuan and the online sales of strawberries surpassed 70,000 tons which made it a pillar industry of the county (MARA, 2021).

5.5 Blockchain and GogoChicken farm in Jiangsu

The GogoChicken program is a Jiangsu-based poultry blockchain project to alleviate poverty. It was jointly established by Zhong'an Technology and the Jingjiang Huayuan poultry cooperative. They use ankle bracelets to monitor each chicken's behavior and movement in their semi-enclosed environment through GPS tracking. This information is then available via Internet. The company aims to build trust among consumers by documenting the origins of their food. As of 2019, 100,000 birds had been tagged with GPS bracelets, and the company plans to tag 23 million birds in the next three

years. Their effort has been documented in a book entitled *Blockchain Chicken Farm* by Xiaowei Wang, which is also profiled in the *New York Times (*Rouzi, 2021*)*.

5.6 Big data pig center in Rongchang district, Chongqing

Rongchang district in Chongqing municipality is one of the core animal husbandry experiment centers at national level. In this center, the health and conditions of each pig are monitored with tags. Health check, slaughter, storage and transport data are recorded and stored in a "one pig one code" system. This system helps producers, buyers and consumers to track each stage of the supply chain, so they can be assured of the quality and safety of the pork. As of July 2021, the center's big-data system successfully entered into 200 farm markets across China and created individual codes for 185,000 pigs (MARA, 2021).

5.7 AI-assisted improved village environment in Wuning County, Jiangsu

In partnership with private companies, Wuning county in the Jiangsu province has invested 20 million Yuan into commercial web and cloud services, big data, 5G and AI to develop a monitoring platform for the village human settlements. Through this platform, rural residents can report incidents in public toilets and sewage system, waste water treatment facilities and problems in the garbage collection and separation, so the relevant sanitation departments would fix the reported problems and create a safe and clean environment for the residents.

5.8 Rural governance and "Integrated online platform" Zhangjiagang, Jiangsu

Government policy documents highlighted the potential of digital villages in transforming the village and rural governance. Zhangjiagang city in the Jiangsu province has developed the "Integrated online platform" for rural residents to use the various government services. People in this area can use the government developed mobile App or its Wechat mini version to receive all kinds of government services like applying for ID cards and business permits, paying taxes, organizing group purchases of agrimachinery equipment or agrichemicals, receiving agricultural extension services etc. which streamlined these official procedures and saved valuable time for farmers (MARA, 2021).

5.9 "Digital village + Health" in Zhenba County, Shaanxi

Telemedicine and digital health care have become popular in recent years, Covid-19 pandemic has accelerated this trend. Zhenba County in the Shaanxi province has made medical care more convenient and accessible for many rural residents through the use of "Internet +" and various other Apps. People in rural areas can now book medical appointments online, receive telemedicine care and store their health data. This improved the health and well-being of the people and made health care more affordable (MARA, 2021).

5.10   Green digital village and black soil protection in Lishu county, Jilin

Lishu county in the Jilin province is located west of the Liaohe river plain which is also known in China as the "golden corn belt" with 260,000 ha of cropland and more than 2 million tons of harvest. Preventing soil degradation in the black soils of this area is very important for the sustainable production of corn as a key feed crop. Therefore, together with academic institutions, the county government has established the "Black soil protection system" which deploys 1,064 monitoring stations and devices to measure the various environmental parameters such as soil salinity, soil water content, soil contamination, weather, forest fire potential and pest presence to provide timely analysis for farm management recommendations and early disaster warning to farmers so they can optimize their crop production as well as prepare for any unforeseen events. This system now covers an area of 4,209 km^2 which helped the protection of the black soil while ensuring food security of the region (MARA, 2021).

6. Major challenges in the development of digital villages

1) Lack of standardization

The vast size of the country, variations in climate and soil conditions along with gaps in socio-economic development levels and infrastructures pose major challenges to the standardization of the digital village tools and concepts in China (Li, 2021). Therefore, many rural areas are developing their own digital villages with the local site conditions and characteristics which makes these efforts more costly in some cases.

2) Traditional land allocation policy and scaling up

Chinese agriculture is made up of small individual, collective as well as large state and private farms (Rouzi, 2021). "China's historical agricultural policy distributed arable land evenly amongst farmers to guarantee employment and a livelihood" (Li, 2021). Most of these farms are small-scale and average farm size stands at 0.43 ha in 2020 in China (Xie, et al., 2020). These small farm holdings and the lack of sufficient rural finance make investments in large-scale agriculture technology not economically viable (Li, 2021). Implementing the digital village initiatives in a large scale would face some challenges, especially for China's smallholder farms – the most common type of farms – where full mechanization and digitalization would come with huge costs and investments (Rouzi, 2021). These additional costs would significantly impact farmers' willingness to join the digital village initiatives. Scaling up the digital villages to a provincial or national scale requires more investment, coordination and support from both the public and private sector (Rouzi, 2021).

3) Competence and digital skills

The rural population in China, as in other countries, has lower levels of education and digital skills and tends to be much older and more prone to digital illiteracy than the urban population. In addition, the rural brain drains, characterized by young and educated people leaving rural areas for the cities in search of better opportunities and living standards make the digital skill discrepancy an enormous obstacle to realizing the full potential of digital villages in China. However, the Chinese government has proposed a new rural revitalization plan to address such problems to keep and attract talents in the rural areas. More training and technical assistance could also alleviate these problems (Rouzi, 2021).

4) Digital infrastructure

Although the Chinese government has invested a great deal of money in digital technologies such as 5G and fiber-based Internet infrastructure with remarkable success, a huge regional disparity still persists between the country's coastal metropolitan areas and more rural and interior regions. For instance, most of the 5G installations in 2020 occurred in the developed coastal regions of China. Because vast swaths of agricultural areas are concentrated in the less developed interior and western regions, building a solid digital infrastructure is of paramount importance for promoting digital villages in these regions (Rouzi, 2021).

5) Increased oversight and regulation of the big tech companies

In January 2021, the Chinese State Administration for Market Regulation opened an antitrust investigation into Ant Financial, a financial subsidiary of the e-commerce giant Alibaba over anti-monopoly and financial regulation issues which resulted in a record 2.8 billion USD fine for the company due to its alleged monopolistic behaviors (CNN, 2021). After that verdict, other companies like JD.com, Tencent, Pinduoduo, Didi and Meituan were subjected to similar investigations (CNBC, 2021) which saw them losing revenues and they were faced with the need to comply with new regulations (CNN, 2021). On January 11, 2021, China released a draft rule for regulating big tech

companies regarding anti-trust and data privacy that is similar to the EU's already enacted *Digital Market Act and Digital Services Act of 2018* (CNBC, 2021). Although some regulations are needed for the protection of consumer data, the arbitrary and sudden nature of these actions with vague legal basis would make Chinese tech companies more vulnerable which could hamper their innovation prowess. The Chinese government's increased arbitrary oversight and regulation of the big tech companies, such as Alibaba, Ant Financial, Tencent and JD.com, on the issues of monopoly, fair market competition, data privacy and data sovereignty will have major and lasting impacts on the future of Chinese big tech, and hence of the development of digital villages (Rouzi, 2021).

7. Recommendations and outlook

Government policy initiatives such as the "Digital Agriculture and Rural Area Development Plan 2019-2025" have set ambitious targets for the next five years, which will encourage both regional officials and tech giants to join this effort. The "Digital village" initiatives in China are mostly top-down efforts by the government with the help of tech companies. Encouraging more grassroot-based solutions could yield similar intended results with reduced costs which would also increase the farmer's participation in the rural affairs and village governance.

Over-relying on Chinese big tech companies could also have negative consequences for farmers and villagers by compromising the privacy of their farm data. The big tech companies might use their data and market dominance to force farmers to accept unfair agreements and arrangements. Therefore, it would be advisable to install strong oversight measures with a transparent legal framework to protect farmer's interests.

It is also important to invest more in the digital infrastructure of the countryside and of the interior and western regions of China to enable the agricultural digitalization of these regions and to reduce regional imbalances.

More social policy reforms, like relaxing the *Hukou* household registry system and improving the social welfare in rural areas would aid in genuinely achieving the rural revitalization and the development of digital villages by keeping and attracting the young talents.

Since China has committed itself to carbon neutrality by 2060 (Meyers, 2020), green and carbon neutral agriculture should also be a part of the digital village initiatives where digital technology would help reduce carbon emissions from farming and make the agricultural production more sustainable.

The success of the digital village efforts will depend on mitigating the conflicting interests and goals of the urbanization and rural development in China.

8. Prospect for Sino-German Cooperation

Germany's advanced agricultural machinery and engineering would be very valuable in establishing the physical infrastructure and production means for digital villages in China. German bio-tech companies could offer a collaboration in the seed and breeding sector with their Chinese counterparts. Moreover, China could learn from the sustainable and environmentally friendly farming and management practices of Germany and integrate it into its own green digital village initiatives. Germany's strict data protection laws and measures could offer some important experiences in insuring data security and data privacy.

On the other hand, Chinese big tech companies could offer Germany 5G and advanced telecommunication equipment which is vital for the digitization of agriculture. Drones, surveillance and sensory devices made in China could be valuable in establishing the precision agriculture monitoring system. Furthermore, Germany could learn from the Chinese experience in e-commerce

including online payment systems and e-finance. Many successful e-commerce, delivery and live-streaming platforms could offer ideas and experiences for German companies and farmers. China can also share its experience in the blockchain technology and the digital integration of agri-logistics.

All in all, both countries have a lot to offer to each other for cooperation, mutual learning and exchanges in digitalization of agriculture.

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