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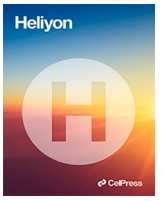

Research article

# What drives the development of digital rural life in China?

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ABSTRACT

*Background and objective:* Empowering rural life through digital technology reflects the collective aspirations of millions of farmers striving for a better quality of life. Ensuring that the benefits of digital advancements reach every corner of the population is a crucial and inevitable choice. To expedite the establishment of an inclusive digital life for all citizens, the Chinese government has exerted substantial efforts by positioning the development of digital villages as a national strategy. Through comprehensive initiatives in digital village construction, facilitating the extension of "Internet+" services such as education, healthcare, transportation, and entertainment to rural areas. 24-hour digital village libraries, smart health stations, intelligent homes, facial recognition payments, unmanned supermarkets, and a variety of digitized, networked, and intelligent lifestyle applications are increasingly prevalent in Chinese rural regions. The digital gap between urban and rural areas in China is gradually diminishing, and the ongoing evolution of rural digital lifestyles paints a picturesque picture of an enhanced rural life. This study endeavors to provide a meticulous analysis of the digital landscape in Chinese villages, seeking to unravel the intricacies behind the swift development of rural digital life.

*Methods:* Using the top 100 counties in China's 2020 Rural Life Digitization Index ranking as case studies, this research collected the necessary data through industry research reports and official statistical sources. To begin with, based on the Technology-Organization-Environment (TOE) analysis framework, variables such as digital infrastructure, government policy support, funds are put into utilization, digital economy level, and farmer digital literacy were identified. The fuzzy set qualitative comparative analysis (fsQCA) method was then employed to recognize the influencing factors of rural digital life and combinations of condition variables. Subsequently, utilizing the system dynamics methodology, the relationships between factors were analyzed, simulating changes in rural digital life development to gain a deeper understanding of the key elements affecting rural digital life. Sensitivity analysis was conducted to further reveal the extent of influence of these key elements on rural digital life.

*Results:* The fuzzy set qualitative comparative analysis reveals that the evolution of rural digital life in China is a complex outcome influenced by the simultaneous interplay of multiple factors. It demonstrates a pattern of diverse combinations and parallel pathways encompassing various variables. Among these configurations, six paths stand out with the highest coverage. These six paths can be further classified into three modes of rural digital life development in China: environment-empowered type, organization-pushed type, and compound-driven type. Further dissection of causal combinations through a system dynamics model unveils that the progression of rural digital life is intricately linked to key factors such as information infrastructure, policy intensity, and digital learning and development. Over time, there is a discernible upward

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trajectory in the level of rural digital life, characterized by an accelerating pace of improvement. The influence of policy intensity on rural digital life surpasses that of information infrastructure and digital learning and development, indicating that policy intensity exerts the most significant impact overall.

*Conclusion:* The evolution of rural digital life in China is a complex, long-term process propelled by a combination of multiple factors. China's experience demonstrates that achieving high-level development in rural digital life demands attention not only to the synergistic interplay of various factors but also a strategic focus on leveraging specific key elements. This entails skillfully integrating diverse factors and identifying pivotal areas to maximize the impact of relevant conditions to the greatest extent possible.

## 1. Introduction

Driven by the wave of global informatization, digital technology has penetrated into rural areas, changing the living habits of rural residents by facilitating the high-speed dissemination of information, enhancing the comfort and convenience of rural life and thus promoting the development of modern rural civilization. The digitalization of rural life is the process of creating new scenarios in the countryside by using new technologies and resources, and it is the inevitable way for the countryside to comply with the wave of information and promote the development of rural modernization. In this path, villages must seek ways to improve the level of rural digital life, as well as the key core elements to realize high-quality rural digital life. Rural digital living, a contemporary rural way of life based on digital technology, is replete with technological services [1] such as digital consumption [2], healthcare [3], education [4], and tourism [5]. It stands out for its convenience, affordability, and efficiency. Rural digital living is viewed as an efficient strategy to help farmers achieve their high-level living needs, live comfortably in their hometowns, and advance overall rural progress. In May 2019, the Chinese government put forward the Strategic Outline for the Development of Digital Villages, aiming to promote digital life in villages. By promoting mobile payment applications, expanding novel and diversified application scenarios such as online shopping, social transfers, public utility payments and community group purchases, it promotes a high degree of integration between digital scenarios and people's lives [6], so that farmers can live a modern and civilized life on the spot; by accelerating the equalization of basic public services in urban and rural areas, promoting the extension of public services to the countryside and the coverage of social undertakings there [7], and eliminating the imbalance and insufficiency of the development of public services in villages By accelerating the equalization of basic public services in urban and rural areas, promoting the extension of public services to the countryside and the coverage of social undertakings in the countryside, the unbalanced and inadequate development of public services in the countryside will be eliminated, the quality of life of farmers will be improved, and the needs of farmers for a high-level life will be met [8].

However, the uncertainty brought by digital technology and the complex and changing external environment make the efficacy of digitization of rural life controversial. The impact on traditional rural culture and habits, the destruction of the traditional rural ecosystem [9], the resulting "technology addiction" [10], the disruption of the balance between digital and real life [11], the lack of digital literacy, the difficulty of sharing a high-level digital life [12], the leakage of personal privacy [13], digital identity anxiety, the rise of cybercrime [14], and the widening of the digital divide are all testing the ability of rural villages to use digital technology to improve their standard of living reasonably. The ability of villages to reasonably utilize digital technology to improve their living standards is being tested. The development of the countryside is related to national strategic deployment and development and stability, and as an indispensable and important part of a country, the digital living standard of the countryside is closely related to the modernization level of the country. How to address the potential risks associated with the digitization of rural life so as to achieve a high level of development of rural digital life has been closely watched by a wide range of national governments. While Anna and Massimo [15]underline that policy measures are essential for accelerating the resolution of digital inequality concerns, Rosenbaum et al. [16] contend that policy planning can enhance the popularization and utilization of the Internet in rural areas. The government should actively encourage the growth of digital rural living and generate new value for farmers, according to Sabina and Hana [17]. Through rapid reorganization of resources and policy guidance, Governments are promoting the widespread use of digital technology in rural areas. In the U.S., for example, the Office of Rural Development of the Federal Department of Agriculture issued a series of policy measures for rural construction as early as 2000, focusing on the digital construction of rural communication facilities, e-healthcare networks, and tele-education networks; the European Union also initiated the European Union Smart Villages Initiative in 2017, which comprehensively promotes the construction of smart villages through the organization of digital platforms [18], the Office of Broadband Capacity, and other projects; Armenia, on the other hand, adopted the Digital Transformation Agenda 2030 and the Digitalization Strategy 2021–2025 in 2017 and 2021, respectively, aiming to accelerate the construction of broadband and telecommunications infrastructure. construction; Armenia, on the other hand, adopted the Digital Transformation Agenda 2030 and the Digitalization Strategy 2021–2025 in 2017 and 2021, respectively, aiming to accelerate the construction of broadband and telecommunication infrastructures and strengthen the foundation of rural digitization [19]; Ghana released its Rural Development Policy in 2019, which proposes to regulate the rural economy by using ICTs in order to improve rural residents' living standards and quality of services [20]; Finland is quite mature in ICT technology infrastructure development, with its mobile network covering the vast majority of households, providing a solid foundation for rural digital life [21]. These international cases not only demonstrate the diversity of the digital development of rural life, but also reflect the joint efforts and determination of governments in this area. Against the backdrop of several countries actively taking steps to promote the digitization of rural life, a number of important questions arise.

What are the elements that influence the digitalization of rural life? And how do these factors interact with each other to produce high levels of rural digital life? What are the most critical of them?

The government is a significant player in the quick rearrangement of resources and the development of digital rural living, and rural digitization entails the movement of resource elements to rural areas. In fact, the digitalization of rural life is a process of multi-factor linkage, the nature of which is a process of continuous development and improvement, and in the process of its development, it is necessary to continuously promote and adjust the relevant factors in order to seek a high level path of digitalization of rural life. Collating relevant literature, we find that scholars have conducted more studies on the factors affecting the development of rural life digitalization. From the perspective of technical facilities, digital infrastructure and derived application scenarios, etc., to achieve information and intelligence in many fields such as farmers' life and services, and enable the digitalization of rural life [22]. From the perspective of organizational carrier, the planning and implementation of policies and institutions provide authoritative mobilization for promoting the digitalization of rural life [23], and the input and use of financial funds provide material resources for the digitalization development of rural life. From the perspective of environmental support, a good digital economy foundation promotes the flow of data elements to the countryside, and realizes the optimal allocation of capital, technology and talents [24]. Cultivating farmers' digital literacy is helpful to their cognition and evaluation of digital life, and to build a localized and personalized digital social network [25]. Scholars' research mainly focuses on the independent effects of single factors of technology, organization and environment, but less on the systemic perspective to explore the multi-factor linkage to drive rural digital life, and the actual effect of the magnitude of changes in different factors on the level of development of rural digital life is still unknown, not to mention that no general law has been revealed on this basis. Therefore, how to grasp the combination of conditions and key power sources for the development of rural digital life, and how to improve the level of rural digital life, is crucial to realizing the expectations of farmers for a better life.

Based on this, in the practice scenario of typical cases of rural digital life in China, this paper combines qualitative comparative analysis and simulation methods to analyze how the three dimensions of technology, organization and environment jointly drive rural digital life from a systematic perspective, and finds out the key factors to seek ways to improve the standard of rural digital life. Hence, this study, based on the Technology-Organization-Environment (TOE) analysis framework, Considering digital infrastructure, government policy support, funds are put into utilization, digital economy level, and farmer digital literacy as conditional variables, taking the top 100 counties in China's 2020 Rural Life Digital Index as cases, the fuzzy set qualitative comparative analysis method was employed to investigate the combinations of conditional variables influencing rural digital life. Following the identification of these combinations, system dynamics analysis is applied to scrutinize the interrelationships among factors, simulating the dynamic evolution process of rural digital life systems to gain a deeper understanding of the key elements influencing rural digital life (Fig. 1). This comprehensive analysis helps unveil the configurations of conditions, key variables, and path selection for the enhancement of rural digital life levels in China, aspects often overlooked in previous studies. As one of the world's most populous countries with a significant rural population, China has achieved effective development in rural digital life, making its study representative.

## 2. Overview of the development of digital life in rural China

Digital rural living is evolving into a new development trend as a result of the digital economy's quick expansion. Digital rural living is already quite well-liked in developed nations like the United States and Europe. For instance, American farmers use internet marketplaces to trade goods, learn about market conditions and pricing fluctuations, and increase the effectiveness of their sales. To save labor costs in agricultural production and increase the effectiveness and quality of production, high-speed broadband and digital gadgets are frequently installed in rural areas in Europe. China is one of the most agriculturally productive nations in the world, and with the growing use of digital technology in rural regions, rural life in China has also entered the digital era.

The use of technologies like the Internet of Things, cloud computing, and big data in rural areas is expanding rapidly as a result of the ongoing growth of information technology and internet technology. Traditional rural economics and socialization structures have

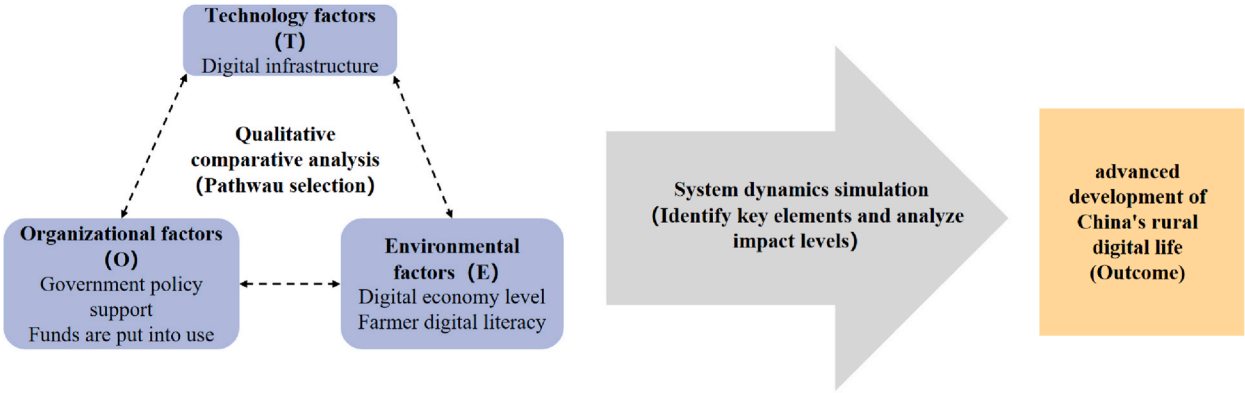


**Fig. 1.** Research frame of China's rural digital life development.

changed as a result of the creation of new rural cooperatives, village-level e-commerce, and other organizational forms. Digital living has become an unavoidable trend in rural development due to the acceleration of urbanization and the closing of the urban-rural divide, which has raised the demand for digital services and convenience among rural people. The "digital rural" policy put forth by the Chinese government aims to encourage the use of digital technology in rural areas as well as the growth of digital consumption, education, culture, health, and tourism.

This policy has made it possible to conduct a variety of digital projects in China's rural areas, and the results have been encouraging. China's rural information infrastructure had a 58.8 % penetration rate as of June 2022, and there were more than 293 million rural netizens [26]. In terms of digital consumption, 148 counties in China have received support from the comprehensive demonstration project of e-commerce entering rural areas in 2022, helping to build more than 2600 county-level e-commerce public service centers and logistics distribution facilities [27]. Additionally, digital healthcare is slowly gaining popularity. By the end of 2020, Ali Health has collaborated with over 3000 institutions across 40 Chinese provinces, municipalities, and autonomous areas [28]. China, At the same time, is advancing significantly in fostering digital public services, and by 2022, it had built 467,000 beneficial information societies and provided various services to a total of 980 million people [29].

The vast and profound impacts of rural digitization on farmers' lives result in a palpable, touchable, and perceptible digital lifestyle. Using the example of digital consumption, farmers can more easily access market information to optimize production plans, increase the quality and quantity of agricultural products to satisfy consumer demand, and sell their products directly to consumers through online platforms. Regarding digital healthcare, the construction of smart health stations makes it possible for rural areas to benefit from top-notch medical resources while also easing the issue of insufficient rural healthcare resources. The national smart education public service platform, which offers free, high-quality educational resources for rural areas and improves educational opportunities for rural children, was launched in the field of digital education. It has since made available 22,000 online courses for vocational education and 34,000 resources for basic education [27]. Traditional rural tourism is merged with current technology in digital tourism to produce an exciting and varied travel experience. Local resources and information are integrated through digital tourism platforms like "China Rural Tourism Network" and "Love Farmer Network." Farmers may quickly and easily access a variety of information and services when it comes to digital living services. They are able to make online payments and take advantage of a smarter living environment thanks to digital living service platforms. A number of economic advantages are also brought by the digitization of rural life. New industries and new business models brought about by "Internet +", such as rural e-commerce, agricultural crowdfunding, and live-streaming agriculture, are injecting fresh impetus into the development of agriculture and rural areas. According to statistics, China's rural online retail sales would total 2.17 trillion in 2022, with 1.2 trillion of those sales being for agricultural products. Additionally growing, the digital medical market is anticipated to reach $100 billion by 2025. Digital education is advantageous in that it lowers schooling expenses, improves the rural labor structure, and increases human capital investment, all of which help rural areas flourish economically and socially. Digital tourism gives citizens of rural areas the opportunity to use new business models, such serving tourists and launching online shops, considerably expanding job prospects and advancing the growth of rural tourism. Digital living services improve service quality, increase customer stickiness, and encourage usage. The deployment of network cables facilitates the access of high-quality consumer goods to farmers' households, while also enabling the integration of superior public resources like medical care and education into rural communities, thereby enhancing convenience and well-being for farmers.

Varied parts of China have quite varied digital lifestyle characteristics and development trends. These development patterns serve as examples:

First of all, e-commerce is what motivates this paradigm. Cao County in Shandong Province is the model's exemplar locale. As a traditional agricultural area and impoverished region, Cao County took advantage of the digital wave to grow the e-commerce sector, creating a "super-large Taobao village cluster" and looking into the possibility of creating a replicable "Cao County model." The government's aggressive promotion, the swift integration of resources, and the iterative upgrading of products are all essential to Cao County's success in Shandong. First, the government actively encouraged the development of elite architecture. As a pioneer, Cao County E-commerce Service Center was created and is in charge of countywide e-commerce strategy and implementation. It has released policy documents that encourage the growth of e-commerce, further strengthening the system of policy support for rural e-commerce. Utilizing platform resources to create local platforms is the second step. Farmers can now display and sell their agricultural products on e-commerce platforms like "Cao County Specialty Network" and "Cao County Rural E-commerce Service Center," which have been developed. By the end of 2020, there were 250,000 registered users of Cao County's e-commerce platforms, and there were more than 100,000 online products and more than 1 billion transactions per year. Third, enhancing the value of the product and encouraging iterative upgrading. Creating brands, fostering culture, and connecting rural tourism to advance branding and e-commerce growth in Cao County. Additionally, a dedicated organization with full-time employees has been set up to create a "green channel" for e-commerce businesses to submit patent and trademark applications. Under this model, Caoxian has seen success. E-commerce in Caoxian is expected to raise farmers' income by over 100 million by the year 2020. Caoxian's online sales in the first half of 2021 were more than 19.2 billion, and 151 Taobao villages and 17 Taobao towns were built. Taobao communities in Caoxian have attained complete town coverage.

Secondly, intelligent tourism-focused. Due to the flourishing tourism business, Wuyishan City in the province of Fujian has developed from an underdeveloped mountainous region to a well-known tourist destination around the world. It's a normal town that depends on tourism. With the government's strong encouragement, the city has advanced smart tourism and followed the market growth trend, giving rural digital living a new lease on life. On the one hand, the government has enlarged development area and laid the groundwork. In addition to digital museums, digital cultural centers, digital libraries, and digitized rural tourist sites, the government has invested in smart tourism projects. At the same time, a platform for digital tourism services has been developed to offer tourists practical services including information requests, online booking, and scenic region navigation. On the other hand, the city has

developed novel models by imitating the market. Wuyishan's metaverse digital ecosystem, constructed by leveraging the metaverse, is a virtual digital environment with tourism resources. There are countless opportunities for the advancement of digital living thanks to the creative fusion of technology, digitization, enjoyment, and living-oriented tourism. The channels for the expansion of farmers' income have been widened by these methods. The creation of the tourism platform has increased digital tourism earnings to $8.6 billion.

Thirdly, the development approach is also focused on intelligent governance. The "Digital Village Map" digital governance platform has assisted Deqing County in promoting the improvement of rural living conditions. A digital governance platform called "Digital Village Map" was created by the Deqing County government and Zhejiang University. In order to achieve the digitization, visualization, and intelligent management of rural resources, it makes use of cutting-edge information technology to thoroughly, accurately, and in three dimensions scan and monitor the resources of Deqing County. First, it appropriately distributes resources to satisfy inhabitants' needs. The "Digital Village Map" aids government comprehension of rural citizens' living circumstances and enables exact administration of rural living. The government effectively comprehends the demands and standard of living of rural residents through data analysis and statistics, and accordingly develops pertinent policies and initiatives. Additionally, it facilitates information flow and boosts productivity. Farmers may better manage agricultural production thanks to data exchange and visualization, which helps them avoid numerous issues caused by asymmetric knowledge and boosts productivity. Third, it develops cutting-edge carriers and takes advantage of intelligent services. A digital village project team has been established in Deqing County to investigate the creation of complete service stations for the digital village and support the development of new digital living services. Farmers now have access to mobile devices that allow them to shop online, learn in their spare time, and take use of intelligent living services like home security and care provided by intelligent locks and other gadgets, making life more convenient and intelligent. Statistics show that the "Digital Village Map" is used more than 90 % of the time in Deqing County. By using digital methods, it successfully reduces resource waste and environmental pollution while fostering the growth of regional developing businesses like banking, tourism, and e-commerce, and enhancing farmers' income and wealth.

The game-driven development model is the fourth aspect. Fuding City in Fujian Province supports the fusion of video games and farmers' life through the "Digital Fuding" project. On the one side, a variety of games are created to meet the demands of farmers. The Fuding city administration promotes regional gaming studios to collaborate with farmers, release digital games featuring farmers, and assist them in unwinding, relieving tension, and enhancing their knowledge and abilities in agriculture. For instance, a game named "Farm Simulator" allows farmers to learn about crop planting, fertilizing, and harvesting by simulating real farm life. A game called "Farmer Monopoly" that models the actual agricultural market also teaches farmers how to run the agricultural sector and sharpens their business skills. On the other side, it expands the growth chain and includes rural tea tourism. Digital games with a young and digitized setting bring new experiences to tea culture, making it hipper, younger, and more immersive. This boosts the allure of tourist destinations, raises the bar for tea tourism's management and service, and better satisfies visitor demands. Additionally, it encourages regional economic growth and increases local villagers' employment chances.

Despite the diversity of China's rural digital living development models, they are all geared toward smart, practical, and scenario-based development. In order to further the development of digital living both domestically and internationally, it can be extremely important and valuable to examine the various development models of China's rural digital living and to draw on the successful experiences and knowledge of those communities.

## 3. Material and methods

### *3.1. Research method*

The initial step in this study's use of the qualitative comparative analysis (QCA) approach is to investigate how to raise the degree of digitization in rural areas. In order to move above the limitations of qualitative and quantitative methodologies and explain outcomes through a set-theoretical arrangement of conditions, Ragin [30]first developed the method [31]. The qualitative comparative analysis method combines the thought of set with the thought of Boolean algebra, takes the case as the research orientation, and allows to explore the specific results brought by the combination of multiple factors by comparing the results of different cases under different combination of conditional variables [32].The Fuzzy Set Qualitative Comparative Analysis (fsQCA) approach is used in this study, and the fsqca3.0 program is used to analyze the data. The decision to use a fuzzy set was made because the majority of data on the dependent and independent variables can be quantified, the fuzzy set method can more accurately classify outcomes and conditions because they are typically in-between existing and non-existent, making it difficult to determine their presence, and it can better avoid data loss during the conversion process [33].

According to the selected variables, the conditional configurations analysis is carried out, and then the system dynamics method (SD) is used to deeply study the relationship between the factors and understand the key factors affecting the rural digital life. System Dynamics, which was developed from the industrial dynamics theory put forth by Forrester [34]in 1958, focuses on analyzing the behavior of intricate socializing systems. Based on the theoretical underpinnings of feedback control theory, information theory, systems theory, and decision-making process theory [35], utilizing the causal feedback relationships inherent in the system, computer-based simulation and modeling are employed to recreate the dynamic evolution process of the system [36]. The primary objective is to identify the root causes of issues originating from within the system. Through recognizing the key factors, this approach facilitates an exploration of the impact on the level of rural digital life under diverse conditions and the varied states of different factors by analyzing their interrelationships.

### 3.2. Data collection

#### 3.2.1. Variable selection

The first step in a qualitative comparative analysis is to identify the dependent and independent variables. The digitization index of rural living, a crucial indicator for determining the degree of digitization of rural living in China, serves as the dependent variable in this study. This paper conducts an analysis of the conditional variables impacting rural digital life using the Technology-Organization-Environment (TOE) theoretical framework. Introduced by Tornatizky and Fleischer in 1990 [37], the TOE framework comprises three dimensions: technology, organization, and environment. Technical factors primarily focus on characteristics related to information technology; organizational factors delve into the features of the organization itself, encompassing finances, tasks, leadership support, etc.; environmental factors mainly refer to the external context in which the organization operates, covering socio-economic, societal, cultural, demographic aspects, and more [38]. Prior research has demonstrated that the TOE theory demonstrates high flexibility and applicability in explaining behaviors related to the application of information technology innovations. Building on this foundation, the TOE theoretical framework is integrated into the configurations analysis, applying it to rural digital life to elucidate the factors influencing the level of rural digital life and regional variations. Drawing extensively from existing research, this paper synthesizes and summarizes factors influencing rural digital life, extracting five conditional variables from the technological, organizational, and environmental dimensions.

The influence of technological factors on the rural digital life level is notably prominent in the realm of Digital Infrastructure (DI). A well-established digital infrastructure serves as the cornerstone for rural residents to embrace digital life fully [39]. Digital infrastructure operates as a catalyst, accelerator, and optimizer for rural development, driving high-quality advancements in agriculture and rural areas [40]. The construction of digital infrastructure plays a pivotal role in enhancing the level of rural digital life. In scenarios where essential support from digital infrastructure is lacking, the cost of implementing new technologies will escalate, resulting in a reduction in the effectiveness of technology application and, to some extent, impacting the overall level of rural digital life.

The organizational factors encompass two conditional variables: Government policy support (GPS) and Funds are put into utilization (PIU). Policy documents are the materialized carriers of government conduct and consciousness [41], and the number of policy texts directly represents how much attention leaders are paying to issues related to the growth of digitization in rural areas. The adoption of national policies establishes specific implementation objectives, directs the growth of digitization in rural areas, and enables government organizations to concentrate on crucial issues and resolve the most urgent problems faced by farmers, allowing farmers to easily take advantage of the convenience of digitization. Government investment in the development of digital living is an important support for policy implementation [42]. The superstructure is determined by the economic base, and digital technology cannot be incorporated into rural digital living without adequate material backing. To advance aggressively with the development of rural digital living, sufficient financial resources are required. Government investment can be viewed as the foundation of development. The development of rural digital life is greatly impacted by the financial resources that are skewed toward rural living.

Environmental factors encompass two conditional variables: Digital Economy Level (DEL) and Farmer Digital Literacy (FDL). In order to disrupt the traditional socialization and relational structure of rural areas, reshape their spatial pattern, and add a virtual network of relationships on top of the pre-existing human relationships network, the digital economy relies on the low-cost and highly mobile information and channel advantages of the internet. This increases the living space available to farmers. The digital economy encourages the incorporation of data elements into the rural production process, permits farmers to use digital goods and services, and gives rural areas a digital boost overall [43].In addition to directly fostering the growth of digital rural living, a higher level of the digital economy also produces positive spillover effects from more comprehensive digital facilities and resources, further fostering the growth of digital rural living and raising its level of development. Farmer digital literacy is pivotal in recognizing the significance of digital information, judiciously using digital tools, accessing and utilizing digital resources, and possessing awareness, attitudes, abilities, and ethical principles for effective communication and sharing resources in agricultural production and life contexts [44]. Farmers who are very digitally literate can use their mobile devices to practice using the internet, enhancing the digital life environment. Farmers with high levels of digital literacy can easily take use of the conveniences that come with living in the digital age and can maintain data security awareness during network contact and engage in innovative activities more successfully.

#### 3.2.2. Case selection

The "County Digital Rural Index (2020) Research Report" (hereafter referred to as the "Report") in China is the data source used to create this article. The report, which evaluated the level of digital rural development of all county-level administrative entities in China, was jointly released by the Alibaba Research Institute and the New Rural Development Research Institute of Peking University. It methodically demonstrates the overall pattern, significant flaws, and future development potential of China's rural digital development at this time. The "Report" has the backing of numerous government funds and the participation of numerous high-tech digital leading businesses. It contains features that are factual, authoritative, and backed by science. It can depict the features and level of development of digital rural areas in China's counties objectively and precisely. The "Report" is divided into sections that discuss the digitization of rural governance, rural living, and rural economics. This article bases its study on the "Report," using the top 100 counties in the ranking of the rural living digitization index in 2020.

#### 3.2.3. Case processing

According to Hua and Tim F [45], the chosen case's coding should adhere to structured and defined coding rules. The elements that affect rural digital living have been established in earlier studies, giving a foundation for case coding. The research data sources of this

paper are as follows: (1) Research Report of County Digital Rural Index (2020). This paper uses the rural digital Living Index to measure the development level of rural digital living, and the rural Digital infrastructure index to measure the digital infrastructure. The Rural Digital economy Index measures the level of rural digital economy, and the reported data is a comparable indicator to ensure the scientific, comprehensive and authoritative data. (2) The Funds are put into utilization in the condition variables are from the fiscal expenditure of agriculture, forestry and water conservancy in China County Statistical Yearbook 2020. The Government policy support data comes from the 2020 documents on digital rural life released by local governments in China. The Farmer digital literacy data is derived from the illiteracy rate of each county in the Seventh Census (County Volume). All the statistics published by the government are used in this paper, which ensures the reliability of the data and makes the analysis results more reasonable. Because fsQCA requires a truth table with values in the range of 0 and 1, this article calibrates the data using three-value fuzzy sets (0.05, 0.5, and 0.95). All surgeries are listed in detail in Table 1

## 4. Results

### 4.1. QCA operation and results

Prior to undertaking a sufficiency analysis, it is vital to evaluate each individual variable's necessity and ascertain whether each requirement is required for raising rural digital living standards. When choosing 0.9 as the consistency level, the results of the requirement analysis (see Table 2) show that none of the five conditions are required.

Sufficiency analysis determines whether the set of results includes the combination of the aforementioned conditions [46]. The sufficiency analysis's findings, which are based on intermediary solutions, are shown in Table 3. The findings reveal six distinct paths that account for 68.6 % of the top 100 counties in terms of the development of digital living, demonstrating the great explanatory power of these six paths for the development of digital living in these counties. The solution's overall consistency level is 0.77, which is higher than the generally accepted cutoff point of 0.75. This suggests that a set-theoretic relationship can be established using these findings. The combination of various factors gives rise to these six generation paths, which also represent three types of advanced development in rural digital life.

(1) Environment-empowered type

In the context of Path 1, it signifies that in rural areas characterized by a high level of digital economic development, when both attention allocation and financial input are concurrently lacking, adjusting more digital resources can lead to spillover effects, ultimately resulting in an elevated level of rural digital life. This path validates approximately 26 % of cases exhibiting a high level of rural digital life, with around 1 % of cases exclusively explained by this pathway. Qinghe County in Hebei Province serves as an illustrative example of this path, where the digital economy serves as a foundation, fostering the growth of the construction, commerce, and tourism sectors. This rapid development has facilitated widespread adoption of rural e-commerce and mobile payments, contributing

**Table 1**
Definitions and operation of the outcome and conditions.

| Definition | Data source | Operation (detailed value range) |
|---|---|---|
| **Outcome:** the development level of rural digital | County Digital Rural Index (2020) research report rural digital living index | 0.05 = Significantly below the county average level(<86.32)<br>0.5 = Not significantly below or above the county average level(86.32–113.31)<br>0.95 = Significantly above the county average level (>113.31) |
| **Technology Conditions:** Digital infrastructure (DI) | County Digital Rural Index (2020) Research Report Rural Digital Infrastructure Index | 0.05 = Significantly below the county average level(79.45)<br>0.5 = Not significantly below or above the county average level(79.45–115.68)<br>0.95 = Significantly above the county average level(115.68) |
| **Organization Conditions:** Government policy support (GPS) | A government website document on rural digital living | 0 = There is no planning and guidance for rural digital living<br>1 = There is a planning and guidance on rural digital living |
| **Organization Conditions:** Funds are put into utilization (PIU) | Expenditures on agriculture, forestry and water resources at all counties in 2020 | 0.05 = Significantly below the county average level (27598.55)<br>0.5 = Not significantly below or above the county average level(27598.55–165430.60)<br>0.95 = Significantly above the county average level (165430.60) |
| **Environment Conditions:** Digital economy level (DEL) | County Digital Rural Index (2020) Rural digital economy index in the research report | 0.05 = Significantly below the county average level(43.12)<br>0.5 = Not significantly below or above the county average level(43.12–111.12)<br>0.95 = Significantly above the county average level(111.12) |
| **Environment Conditions:** Farmer digital literacy (FDL) | Illiteracy rate by county in 2020 | 0.05 = Significantly above the county average level(0.07)<br>0.5 = Not significantly below or above the county average level(0.07–0.01)<br>0.95 = Significantly below the county average level(0.01) |

**Table 2**
Necessity condition analysis.

| Consistency Coverage | Consistency | Coverage |
|---|---|---|
| DI Digital infrastructure | 0.717 | 0.675 |
| GPS Government policy support | 0.516 | 0.482 |
| PIU Funds are put into utilization | 0.616 | 0.642 |
| DEL Digital economy level | 0.719 | 0.700 |
| FDL Farmer digital literacy | 0.716 | 0.630 |

**Table 3**
Adequacy analysis.

| | ~GPS*DEL*~PIU (Path 1) | DEL*DI*~PIU (Path 2) | DEL*PIU*FDL (Path 3) | ~GPS*~DI*PIU*~FDL (Path 4) | GPS*DI*PIU*~FDL (Path 5) | GPS*~DI*PIU*FDL (Path 6) |
|---|---|---|---|---|---|---|
| **Digital infrastructure (DI)** | | ● | | ⊗ | ● | ⊗ |
| **Government policy support (GPS)** | ⊗ | | | ⊗ | ● | ● |
| **Funds are put into utilization (PIU)** | ⊗ | ⊗ | • | ● | ● | ● |
| **Digital economy level (DEL)** | ● | ● | • | | | |
| **Farmer digital literacy (FDL)** | | | • | ⊗ | ⊗ | ● |
| **Consistency:** | 0.866 | 0.848 | 0.828 | 0.814 | 0.814 | 0.839 |
| **Raw coverage:** | 0.264 | 0.432 | 0.399 | 0.164 | 0.226 | 0.189 |
| **Unique coverage:** | 0.014 | 0.04 | 0.034 | 0.036 | 0.057 | 0.026 |
| **Solution coverage:** | 0.686 | | | | | |
| **Solution consistency:** | 0.774 | | | | | |

Note:• is the edge condition; ● is the core condition; ⊗ is the missing edge condition; ⊗ is the missing core condition.

to increased income levels and improved quality of life for farmers.

(2) Organization-pushed type

In the context of Path 4, it suggests that in financially well-supported rural areas, even when technological empowerment, government policy support, and farmer autonomy are all lacking, a high level of rural digital life can still be attained by relying on sufficient external resources input. This path can account for approximately 43 % of cases with a high level of rural digital life, with around 4 % of cases exclusively explained by this pathway. Fuding City serves as a noteworthy example of this path, where smart community development is accomplished through financial investment, allowing the local population to fully embrace the benefits brought about by digital technology.

(3) Compound-driven type

Corresponding paths 2, 3, 5, and 6. Path 2 indicates that in rural areas with high levels of digital economic development and a well-established digital infrastructure, a high level of rural digital life can still be achieved even in the absence of sufficient resource input. Wuyi County in Zhejiang Province serves as an exemplary case, where the digitized application scenario of "I have something to do" addresses local issues through digital empowerment, enhancing citizen satisfaction and happiness [47]. Path 3 suggests that when farmers play an autonomous role, enjoy the benefits brought by the digital economy, and invest funds in rural digital life or construction, a high level of rural digital life can also be realized. This path is illustrated by Puning City in Guangdong Province, which, through the implementation of digital Puning planning, guides technology, funds, and talent inflow into rural areas, nurtures farmers' digital literacy, and achieves digital life development. Path 5 indicates that in rural areas with well-established digital infrastructure and high organizational attention, a high level of rural digital life can still be attained even in the presence of developmental shortcomings. This path is applicable to Nanchang County in Jiangxi Province, which relies on broadband networks and mobile devices to conduct farmer e-commerce live training activities, enriching farmers' life scenarios and bringing new development opportunities to the rural area, ensuring sustainable development [48]. Path 6 demonstrates that in rural areas where organizations highly prioritize and farmers fully exercise autonomy, a high level of rural digital life can still be achieved even if digital infrastructure is not yet perfected. This path corresponds to Longquan City in Zhejiang Province, benefiting from robust financial and policy support, providing

a solid material foundation for the development of rural digital life.

The QCA analysis underscores the pivotal role of a comprehensive set of factors, including well-established digital infrastructure, robust government policy support, sufficient funds utilization, the rapid development of the digital economy, and enhanced farmer digital literacy, in propelling the development of rural digital life. However, the precise magnitude of the impact of changes in these diverse factors on the level of digital life remains uncertain. Consequently, it is imperative to adopt a system dynamics perspective, involving the construction of relevant models and the implementation of simulation exercises to thoroughly explore the interrelationships among these factors. This approach aims to achieve a holistic understanding of the key elements influencing rural digital life, offering scientific guidance for the advancement of digital life in rural areas.

### 4.2. System dynamics simulation results

System dynamics analysis demonstrates how different system components influence the system's outcome under various states of change. The elements that influence the growth of rural digital life can be broken down into various subsystems through the design of a system dynamics model, including digital infrastructure, government policy support, funding use, development of the digital economy, and farmers' digital literacy. Each subsystem incorporates a variety of elements, such as digital infrastructure, which includes, among other things, infrastructure for information, communication, and the Internet of Things. The interaction of each aspect creates a complicated dynamic system. By establishing the initial values and change rules of each element, the model may simulate the effects of various factor changes on the overall system. Therefore, based on the identification of the primary variables by QCA, the secondary effect factors of each factor were further refined through the analysis of pertinent literature and instances, as shown in Table 4, and utilized Vensim PLE software drawn the matching causal diagram of rural digital life in the linkage of technology-organization-environment. as shown in Fig. 2.

The causal diagram shows the secret model components and can show both positive and negative feedback loops, allowing for a greater comprehension of the system's feedback and control mechanisms [59]. Analyzing the causal connections between variables is crucial to better comprehend the causal loop diagram. For instance, there is a positive association between policy effectiveness and policy intensity, indicating that increasing policy effectiveness will be facilitated by increasing policy intensity. There is a significant positive feedback loop in the causal diagram in Fig. 2:

The development level of rural digital living→+Management of utilization of funds→+Digital economy added value→+Source of capital investment→+Amount of capital input→+Internet of Things infrastructure→+Total output of digital economy→+Policy instrument→+Digital socialization and collaboration→+The development level of rural digital living; This feedback loop illustrates that as rural areas' financial management improves along with their digital living standards, this successfully encourages the rapid expansion of the digital economy. As a result, the creation of IoT infrastructure will receive funding from a wider range of sources, larger investments, and more resources, which will boost the overall output of the digital economy. Farmers' digital socialization and cooperative behavior are regulated and streamlined in areas with high economic production, which promotes further advancement of rural digital living.

The causal diagram illustrates mutual relationships and feedback processes among various elements but lacks the ability to differentiate between variables of different natures. A system flowchart serves the purpose of distinguishing the nature of internal variables, managing, and controlling the system. It employs intuitive symbols to express logical relationships among system elements. Building upon the causal diagram (Fig. 2), a system flowchart for the development of rural digital life was created using the system dynamics software Vensim PLE, as depicted in Fig. 3 below. This model is a first-order system dynamics model, comprising 19 variables, including one state variable for the development level of rural digital living, 2 rate variables, and 16 auxiliary variables.

Analysis reveals that there are regional disparities in the elements influencing the level of rural digital living development, and it is challenging to gather all the necessary data quickly during actual operation. As a result, this article employs the system dynamics

**Table 4**
Factors affecting the improvement of digital living standard in rural areas.

| First-order influencing factor | Secondary influencing factor | Reference |
|---|---|---|
| **Technology Conditions:** | Information infrastructure | ITU(2019) [49] |
| Digital infrastructure (DI) | Communication infrastructure | ITU(2019)(2019) |
| | Internet of Things infrastructure | Rai et al.(2023) [50] |
| | Data security infrastructure | Bhavnan et al.(2021) [51] |
| **Organization Conditions:** | Policy objective | Yuichiro and Fuhito(2020) [52] |
| Government policy support (GPS) | Policy instrument | Cejudo and Michel(2021) [53] |
| | Policy intensity | Hugh and Ian(2016) [54] |
| | Policy validity | Mark(2003) [55] |
| **Organization Conditions:** | Source of capital investment | Brent C(2008) [56] |
| Funds are put into utilization (PIU) | Amount of capital input | Brent C(2008) |
| | Management of utilization of funds | Brent C(2008) |
| **Environment Conditions:** | Total output of digital economy | BEA(2022) [57] |
| Digital economy level (DEL) | Digital economy added value | BEA(2022) |
| **Environment Conditions:** | Digital learning and development | JISC(2014) [58] |
| Farmer digital literacy (FDL) | Digital socialization and collaboration | JISC(2014) |
| | Digital utilization and creativity | JISC(2014) |

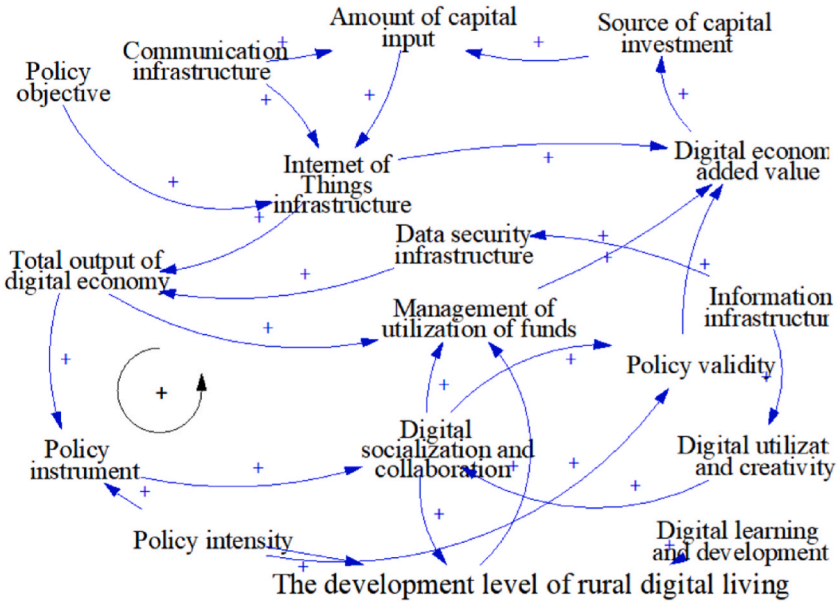


**Fig. 2.** Casual loop diagram.

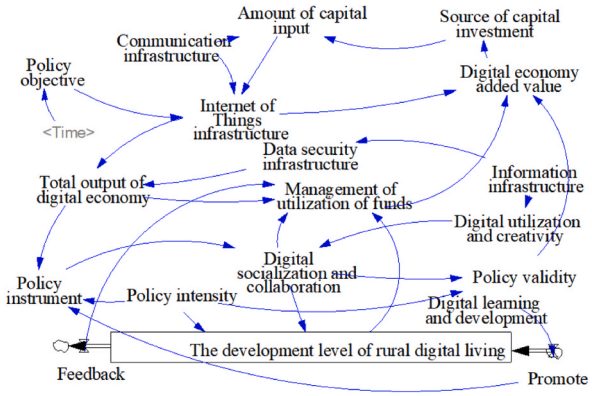


**Fig. 3.** System flow chart.

method, concentrating on how the state of system components changes rather than adhering to fixed values. Multiple factors in Fig. 3 have been frequently tested and adjusted, and the pertinent parameters have been first specified. These tests and corrections have been combined with the research of pertinent scholars [60]. Finally, emulation and simulation are used to produce outcomes that are consistent with the ideal condition. This study restricts the rural digital living development cycle to 24 months with a 1-month time step. The model has 19 equations in total, and Table 5 lists the settings for the equations and parameters.

The Pensive PLE program was used to examine the model's validity. Initial Time, Final Time, Time Step, and Units for Time were all set to 0 and 1, respectively. The Eular integration type was chosen. The built model is viable for further investigation, as indicated by the "Model Is OK" result after the Check Model function was run.

*4.2.1. Model simulation analysis results*

Under the given parameters, the system is analyzed. The dynamic changes of "Management of utilization of funds", "Digital socialization and collaboration", "Digital economy added value" and "The development level of rural digital living" are shown in Figs. 4–7 below.

1) A strong linear growth pattern in the management of fund utilization during the project's early stages suggests that adequate funding allocation and utilization were accomplished at the outset (Fig. 4). At this point, a significant quantity of financial support is needed for many jobs, making financial investment crucial. However, there was a sharp fall in the management of fund usage over the following three months. The numerous duties may have stabilized as the project entered its middle stage, which led to a

**Table 5**
Variable relation equation.

| Number | Type | Variables | Variable Relation Equation |
|---|---|---|---|
| **1** | Digital infrastructure (DI) | *Information infrastructure* | *0.5* |
| **2** | | *Communication infrastructure* | *0.8* |
| **3** | | *Internet of Things infrastructure* | *Policy objective*Communication infrastructure + Amount of capital input* |
| **4** | | *Data security infrastructure* | *Information infrastructure*5* |
| **5** | Government policy support (GPS) | *Policy objective* | *1.1*Time* |
| **6** | | *Policy instrument* | *(Total output of digital economy + Promote + Policy intensity)*0.08* |
| **7** | | *Policy intensity* | *10* |
| **8** | | *Policy validity* | *Digital socialization and collaboration*Time*0.2*IF THEN ELSE(Policy intensity=10,10,IF THEN ELSE(Policy intensity>10,12,8))* |
| **9** | Funds are put into utilization (PIU) | *Source of capital investment* | *Digital economy added value*0.05* |
| **10** | | *Amount of capital input* | *SMOOTHI(Source of capital investment, 2, 1) + Communication infrastructure* |
| **11** | | *Management of utilization of funds* | *DELAY1I((Digital socialization and collaboration*Total output of digital economy)/(Feedback + The development level of rural digital living)*2,1,0)* |
| **12** | Digital economy level (DEL) | *Total output of digital economy* | *Internet of Things infrastructure*Data security infrastructure* |
| **13** | | *Digital economy added value* | *Internet of Things infrastructure*Management of utilization of funds*0.2*Policy validity* |
| **14** | Farmer digital literacy (FDL) | *Digital learning and development* | *6* |
| **15** | | *Digital utilization and creativity* | *Information infrastructure*2* |
| **16** | | *Digital socialization and collaboration* | *Digital utilization and creativity*Policy instrument* |
| **17** | | *Promote* | *Digital learning and development*1.5* |
| **18** | | *Feedback* | *0.8* |
| **19** | | *The development level of rural digital living* | *Promote*Feedback*Digital socialization and collaboration*IF THEN ELSE(Policy intensity=10,10,IF THEN ELSE(Policy intensity>10,20,5)), set the initial value to 100* |

corresponding drop in funding need and weakening financial management. The management of fund utilization slowly decreased over the course of the project's development and then gradually increased starting in the fourth month. This indicates that strengthening the administration and utilization of funds is required to ensure better development of the project when the demand for cash rises once more in the project's later stages.

2) Digital socialization and collaboration take time to develop. In this model, there is a trend toward moderate but consistent rise in digital socialization and collaboration (Fig. 5). Strong technological support and thorough strategic planning are required for the development of digital socializing and collaboration in order to foster the essential communication and data resource flow between the government and citizens. Modern technologies that improve user experience and productivity include cloud computing, AI, and the Internet of Things. Planning strategically using logic and science makes it easier to build digital collaboration and socialization. The development of digital socializing and collaboration necessitates the long-term investment and work of both the government and the general public.
3) The added value of the digital economy did not change much in the first 10 months. After the 10th month, the extra value did, however, quickly increase (Fig. 6). It means that the digital economy is still in its infancy of growth and needs time to build up and stabilize. The local growth of digital living may benefit from regions with higher added value in the digital economy. This is due to

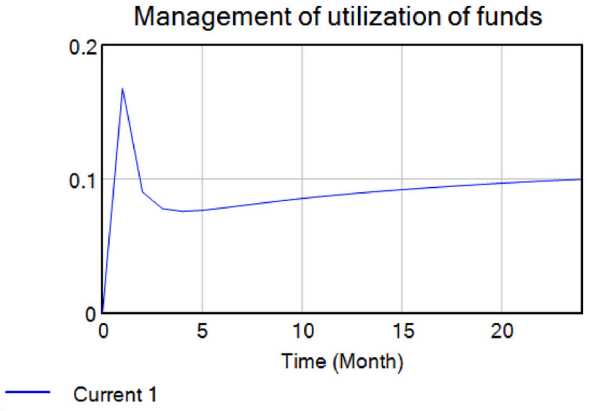


**Fig. 4.** Management of utilization of funds simulation change chart.

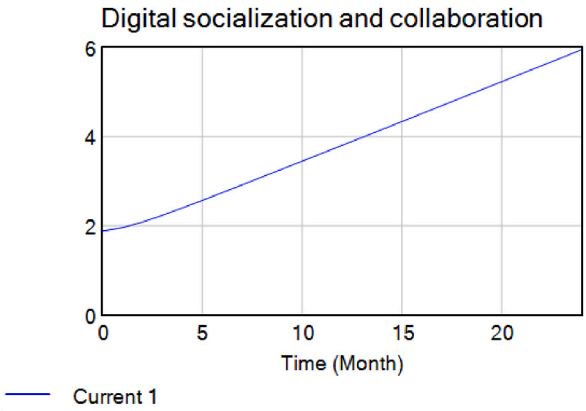


**Fig. 5.** Digital socialization and collaboration simulation change chart.

the reality that a solid economic foundation may secure a lot of resources, which can spur the growth of linked industries, encourage the improvement of social and economic levels, and enhance the standard of living for people.

4) Rural digital living has demonstrated an increased trend in development level, and development speed is accelerating (Fig. 7). The combination of several factors results in the growth of rural digital living. Important impacting elements include government policy support, economic status, investment and usage of funds and farmers' level of digital literacy. The quick advancement of the degree of rural digital living development can only be accomplished through the interaction of multiple variables and long-term growth.

*4.2.2. Model sensitivity analysis results*

Sensitivity analysis is the process of altering the values of critical parameters, contrasting the variations in simulation outcomes, and examining the effects of critical variables on the operation of the system and the strength of those effects [61]. By examining the change of variable parameters, we can judge the strength of the influence of related factors on the system. In this paper, a single variable is analyzed one by one, but in view of the length of the paper, only the three variables that have the greatest impact on the rural digital life degree are analyzed in this paper. The technical dimension is "Information infrastructure"; The organizational dimension is "Policy intensity" and the environmental dimension is "Digital learning and development". By changing the values of three variables, the sensitivity of the model was analyzed, and the influence of each variable on the development level of rural digital life was observed.

*4.2.2.1. Sensitivity analysis of "information infrastructure" in technical dimension.* Building an information infrastructure is a requirement for taking advantage of digital living. The degree of impact of "information infrastructure" on the "development level of rural digital living" under various circumstances is seen, as shown in Fig. 8, after the values of "information infrastructure" completeness are adjusted to 0.2, 0.4, and 0.6, respectively.

As the simulation period lengthens, Fig. 8 shows that there is a substantial degree of impact from the growth of information infrastructure on the level of rural digital living. Rural digital living develops slowly when the degree of information infrastructure is inadequate, but it rapidly speeds up speed once it reaches a certain height. This is so that people may access information, communicate, and engage in various digital activities more conveniently. Information infrastructure construction offers more dependable network

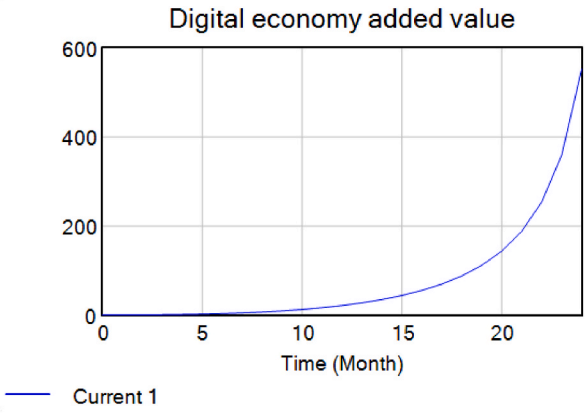


**Fig. 6.** Digital economy added value simulation change chart.

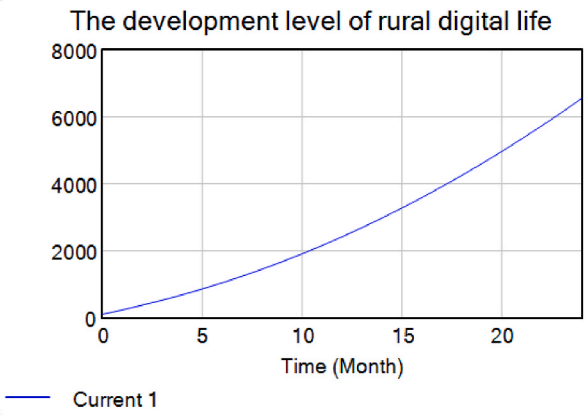


**Fig. 7.** The development level of rural digital life simulation change chart.

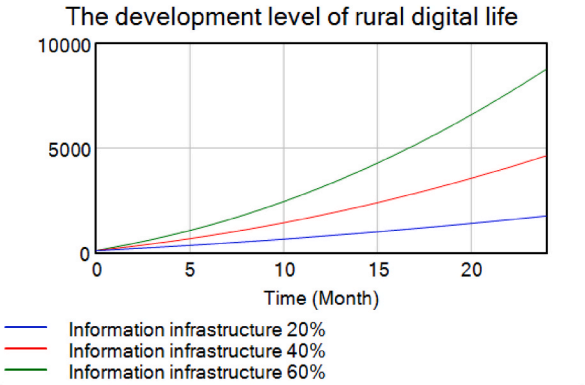


**Fig. 8.** Sensitivity changes of "Information infrastructure".

connections and communication techniques for rural digital living. For instance, accessing the Internet and taking part in online learning, shopping, entertainment, and other activities requires more time and effort in rural areas with a weaker information infrastructure than in areas with a stronger infrastructure. In contrast, the efficiency and convenience of these activities will be higher in the latter. Increasing efforts to build information infrastructure and continuously enhancing service quality can provide rural dwellers more practical, reliable, and efficient digital living options.

*4.2.2.2. Sensitivity analysis of "policy intensity" in organizational dimension.* Improving policy support can encourage the growth of rural digital living. The "policy intensity" was set to 5,10 and 15, and other variables remained unchanged, and the results are shown in

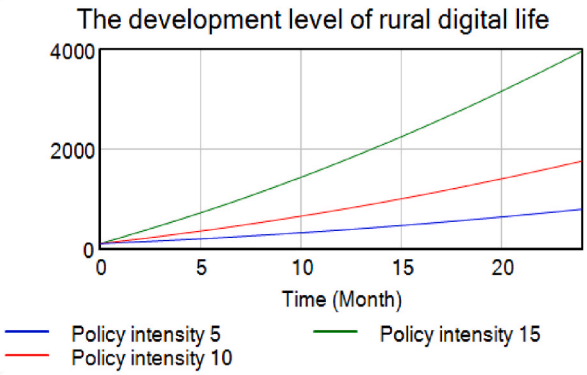


**Fig. 9.** Sensitivity changes of "Policy intensity".

Fig. 9 below.

In Fig. 9, the development level of rural digital living increases at the fastest rate when the simulation time (horizontal axis) reaches the 24th month and the policy strength setting value is 15. This result demonstrates that improving policy strength could promote the sustainable development of rural digital living. The degree to which the government implements a number of measures is referred to as policy strength. The development of digital living can be impacted by a number of policy variables, such as infrastructure building, industry backing, digital education, etc. The enhancement of policy strength offers sound direction, standards, and guarantees for the development of digital living, which is crucial for examining the potential of rural digital living development and raising the level of development. Farmers are more inclined to utilize digital living items like smart homes, intelligent appliances, and smart health management devices as a consequence of under way policy strength strengthening, and the development of rural digital living keeps moving forward.

*4.2.2.3. Sensitivity analysis of "digital learning and development" in environmental dimension.* Digital learning and development refers to the process of acquiring digital knowledge and skills through various channels while improving themselves, which is an important ability performance of farmers' sustainable development in the digital environment. In order to observe their effects on the "development level of rural digital living," the rating for the "digital learning and development" capacity has been modified to 6, 9, and 12 while maintaining the other variables constant. The outcomes are displayed in Fig. 10.

According to the data in Fig. 10, the setting value of digital learning and development at 12 is determined to have the largest promoting influence on the development level of rural digital life when the simulation period reaches the 24th month. The complexity and unpredictability of the digital age can be better adapted to by establishing privacy protection awareness and information security understanding that are in line with the rapidly evolving digital era. For a better standard of living, digital development can enhance digital abilities and make better digital services possible. With digital learning and development, rural residents can improve their digital awareness and skills, increase their quality of life and convenience, support agricultural modernization, and better participate in the development of rural digital living, lending strong support for its development.

In summary, the sensitivity analysis results for "Information Infrastructure," "Policy Intensity," and "Digital Learning and Development" suggest a positive overall impact on rural digital life, albeit with varying magnitudes of influence. Notably, the impact of policy intensity on the variability of rural digital life surpasses that of information infrastructure and digital learning and development. This underscores the overarching significance of policy intensity in influencing the system. Government policy support emerges as a crucial cornerstone for the advancement of rural digital life. By formulating a comprehensive digital life blueprint that spans the entire life cycle process, policies delineate the overall trajectory of rural digital life development, empowering farmers to embrace a high-quality digital lifestyle. To elevate the standard of rural digital life, a heightened focus on cultivating the inherent conditions of the organization is imperative. Harnessing the roles of government planning, coordination, and policy support, among others, offers robust organizational backing for the establishment of rural digital life.

## 5. Discussion

The rapid advancement of information technologies such as big data, mobile Internet, cloud computing, and artificial intelligence in rural areas has gradually integrated intelligent services into all aspects of rural life. The development of rural digital life is the inevitable result of the digital wave and is also the focal point of current research. Most analyses on the factors impacting rural digital life solely focus on a single factor, such as digital infrastructure [39,40], farmers' digital literacy[2,44], rural elite identity [11], digital economy, and digital inclusive finance [7], etc., lacking the perspective of a multi-factor combination. Qualitative comparative analysis is utilized to examine the driving factors of rural digital life in China, which helps in revealing the combination of conditions steering the development of rural digital life and providing development models for reference [46]. Spatial metrology model [62], Questionnaire survey method [63], ISM-MICMAC model [4], Field root interview [64], and other methods are mostly employed to study the interrelationship of variables affecting rural digital life. It is undeniable that they have broadened the methodological base for studying rural digital life, but there is a lack of a system dynamics method to explore the interrelationship of multiple influencing factors, as well as the magnitude of their impact. Therefore, the system dynamics method can further explore the relationship among factors, deeply understand the key factors affecting rural digital life, and further reveal the degree of influence of key factors on rural digital life [32]. Looking back at international research on rural digital living, it is obvious that there is no current consensus on what constitutes high-level digital living development or on the specific components that influence it. This is due rural digital life is complicated and it is challenging to do extensive study that takes into account many counties, a range of resource situations, and varied economic development levels. The main approach in previous research has been to rely on single-case studies or comparative studies of many examples in order to derive general development experiences from particularities because examining multiple locations is tough. The ability to draw general trends for enhancing rural digital life development from these various studies is not evident, though. As a result, the purpose of this article is to bridge the research gap. Based on the TOE analysis framework and considering the characteristics and practices of rural digital life in China, a comprehensive analysis framework is proposed, integrating five antecedent conditions within the Technology-Organization-Environment (TOE) framework. Initially, utilizing the fuzzy set qualitative comparative analysis (fsQCA) method, a configurational analysis is performed for rural digital life across one hundred counties, revealing three patterns associated with high-level rural digital life. Subsequently, employing system dynamics methodology, a simulation model for rural digital life is developed, and through simulation and analysis of the model, key factors influencing rural digital life are explored.

The key conclusions of the study are outlined as follows: Firstly, the influencing factors on rural digital life do not act in isolation

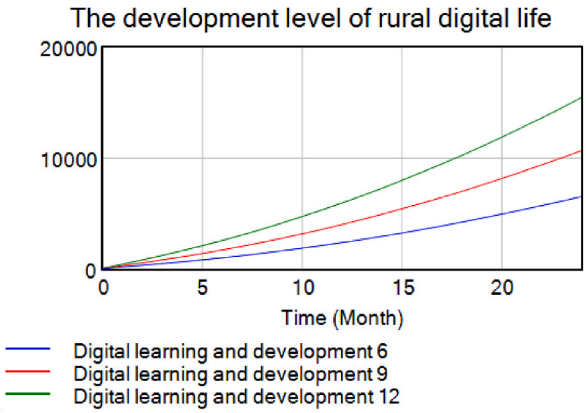


**Fig. 10.** Sensitivity changes of "Digital learning and development".

but are interconnected, exhibiting a collaborative synergy among technological, organizational, and environmental dimensions. The technological aspect, represented by digital infrastructure, along with government policy support and effective utilization of funds in the organizational dimension, and the interplay between digital economic level and farmer digital literacy in the environmental dimension collectively shape the landscape of rural digital life. Secondly, the developmental trajectories of rural digital life demonstrate a "divergent paths converging to a common outcome" phenomenon. Paths leading to the achievement of high-level rural digital life can be categorized into three models: environment-empowered type, organization-pushed type, and compound-driven type. Thirdly, results from system dynamics simulation reveal that the technological, organizational, and environmental dimensions all contribute positively to the advancement of rural digital governance, exhibiting an accelerating rate of improvement. However, organizational factors have the most pronounced impact during simulation, underscoring the substantial influence of the organization's developmental level on rural digital life. Among these organizational factors, the intensity of government policy emerges as the most influential; higher policy implementation intensity directs more external resources toward rural digital life, ultimately enhancing its overall level.

The establishment of rural digital life has explored universally applicable developmental pathways and practical experiences that can offer guidance and inspiration for other regions. Firstly, the synergistic effect of the three-dimensional aspects of technology, organization, and environment highlights the complexity involved in constructing rural digital life. Relying solely on a single factor may fall short of achieving desired outcomes. Therefore, in the process of rural digital life construction, the government should integrate technology, organization, environment and multiple resources from the overall perspective to form a joint force for the development of rural digital life. Secondly, there is no one-size-fits-all solution for satisfactory rural digital life construction, and various regions should customize institutional policies based on their resource endowments and regional characteristics. Implementing localized strategies is essential to forming differentiated paths for rural digital life construction. Thirdly, rural digital life construction is a long-term complexity process, and attention should be directed towards key focus areas during path implementation. (1) Enhancing information infrastructure to fortify technological support for rural digital life development. Improving information infrastructure addresses issues of information asymmetry and flow in rural areas, enhancing the fluidity and transparency of information. This facilitates high connectivity in various domains such as the economy and society. Innovating rural digital life application scenarios enables transformative development. (2) Intensifying policy efforts and establishing a comprehensive organizational system for rural digital life development. Governments can encourage investment from enterprises, develop infrastructure, and enhance information service systems through relevant policies. Increasing the specificity and effectiveness of policies injects vitality, motivation, and confidence into the development of digital life. (3) Elevating villagers' digital learning and development capabilities while optimizing the cultural environment for rural digital life development. Villagers play a central role as participants and ultimate beneficiaries of rural digital life. Their capabilities in digital learning and development directly influence the effective operation of rural digital life. To address this, it is crucial to enhance awareness through publicity campaigns, strengthen education and training to boost villagers' capabilities, and empower farmers to autonomously share in the benefits of the digital dividend.

The following are some of the research's drawbacks. First off, there are a variety of complicated and varied aspects that affect rural digital living, and the factors that are discussed in this article are constrained and do not include all pertinent factors. Therefore, it cannot be considered that the research findings are exhaustive when discussing the development model of rural digital living in China. In order to acquire a thorough understanding of the elements that affect the growth of rural digital living, future studies may take into account include more relevant aspects as conditional variables and using a variety of research methodologies, such as participant observation, in-depth interviews, etc. Secondly, there is still potential for improvement in this article's measurement of public policy support. The measurement indicators in this article are based on records found on the official county government websites, which include a lot of subjectivity. To further support the findings of the research, more impartial measurement standards may be adopted in the future. Lastly, only the digital living index was used to identify the small sample size for this research. To improve the quality of the research findings, the sample could eventually be expanded to include all of China. In order to make the system dynamics equation more accurate, its design can also be further enhanced. On the basis of the additional field survey data, further pertinent study can be

done to improve the specificity of the research findings and the validity of the potential directions.

## 6. Conclusions

This study looked at how various driving forces and their shifting intensities affected the growth of rural digital living in China. In contrast to other studies, we employed the QCA method to take into account the influence pathways of various component combinations on the outcomes, offering a more thorough picture of how rural digital living has developed in China. Conducting such research on a global scale is possible since the digitization of rural living development has distinct characteristics in different countries. While the analysis reveals the general pattern of high-level development of rural digital living in China, the available resources of each village differ and call for optimization and configurations from a multi-factor perspective by comparing the six paths mentioned above, injecting the distinct characteristics of the rural area to improve the development level of rural digital living. In the process of considering combinations of multiple factors, it is crucial to emphasize the substantial impact of individual factor changes on the development of rural digital life. This approach aids in identifying key focal points, implementing effective combinations, and maximizing the influence of relevant conditions, thereby promoting the swift and robust development of rural digital life. In summary, this study offers a fresh viewpoint and approach for the growth of rural digital living in China and offers important references for practitioners and policymakers. Future research can consider introducing other relevant elements of rural digital life, adopt a variety of research methods, such as participant observation, in-depth interview, etc., to deeply understand the factors driving rural digital life, and further combine qualitative comparative analysis method and system dynamics method, so as to make the research results more closely fit with reality and explore a more reasonable path.

## CRediT authorship contribution statement

**Chunlin Xiong:** Writing – review & editing, Supervision, Conceptualization. **Yaling Wang:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Zhenyu Wu:** Formal analysis, Data curation. **Fen Liu:** Formal analysis, Data curation.

## Data availability statement

Most of the data in this paper comes from the County Digital Rural Index (2020), while a small part is collected manually by the author. These data come from the official websites of governments of various counties, so they are not included in public databases, so we can only provide relevant data as required.

## Consent

Informed consent was not required for this study because we're not studying patients or their families.

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## Ethics Declarations

Review and/or approval by an ethics committee was not needed for this study because thesis does not involve human clinical studies.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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