

Digital Rural Planning: Real-World Challenges and Practical Pathways

LI Heping, MOU Lingli, RAO Yuxuan, CHEN Ming

Abstract. Digital rural planning uses digital technologies to support the modernization of agriculture and rural areas, advance digital village development, and promote comprehensive rural revitalization. Its contemporary context is shaped by national policy, expanding academic inquiry, and strategic deployment. Yet digital village development continues to face four major constraints: insufficient realization of the digital economy's potential and slow industrial digitalization; governance platforms that are smart in appearance but weak in substantive decision support; lagging digital infrastructure and limited application coverage; and a shortage of interdisciplinary digital practitioners and technological innovation. To address these problems, this paper develops a theoretical framework for digital rural planning and identifies three principal drivers: the digital economy's capacity to transform industrial planning, the virtual effects of digital technologies on spatial planning, and the contribution of digital space to collaborative planning. Drawing on representative demonstration areas, it proposes practical pathways that include strengthening information infrastructure, creating mutually reinforcing physical and virtual spaces, building professional talent teams, empowering governance through digital technology, preparing integrated urban-rural digital development plans, and improving top-level institutional design. These pathways are intended to support the strategic objectives of digital village development.

Keywords: digital rural planning; rural revitalization; digital technology; digital governance

Chinese Library Classification: TU984 Document code: A DOI: 10.16361/j.upf.202405011 Article number: 1000-3363 (2024) 05-0079-09

* Supported by the National Key R&D Program of China during the 13th Five-Year Plan period, "Digital Simulation and Evaluation Model for the Spatial Restructuring of Rural Settlements" (Project No. 2018YFD1100300).

The rise and evolution of a new round of scientific and technological revolution have accelerated the development of big data, blockchain, artificial intelligence, cloud computing, and other digital technologies. Using digital empowerment to modernize national governance has consequently become an integral part of Chinese modernization. As a major agricultural country, China is responding to the global frontier of digitally transforming conventional agriculture by deeply integrating "Internet Plus" into agriculture and rural affairs. Advancing the digital transformation of agriculture and rural areas in the new era is therefore a priority for the Party [1]. In 2017 and 2018, China successively introduced the concepts of rural revitalization and the digital village, elevating rural development to the strategic level and emphasizing digital and smart agriculture. Since 2018, successive No. 1 Central Documents have issued explicit directives and arrangements for digital villages. The steady release of related policies indicates that construction standards and implementation approaches are becoming more complete, while localities have developed distinctive village models around the national strategy [2]. Digital villages are both a strategic direction of rural revitalization and an important component of Digital China.

The Outline of the Digital Village Development Strategy, issued by the General Offices of the CPC Central Committee and the State Council in 2019, defines the digital village as an endogenous process of agricultural and rural modernization and transformation arising from the application of networking, informatization, and digitalization to rural economic and social development, together with improvements in farmers' modern information skills. The China Digital Village Development Report (2022), released in early 2023, reviewed progress since 2021 and reported a national digital village development level of 39.1%. The eastern, central, and western regions registered 42.9%, 42.5%, and 33.6%, respectively, revealing a pronounced pattern of higher development in the east, intermediate development in the center, and lagging development in the west. Overall agricultural and rural informatization remains

limited. Fiscal capacity, internet penetration, demographic structure, and related constraints mean that the implementation of top-level design and integrated digital rural planning still presents rural areas with more challenges than opportunities.

Locally grounded digital rural planning that combines new-generation information technologies with the rural revitalization strategy can help resolve current construction difficulties and advance comprehensive revitalization. Under the rapid expansion of the digital village strategy, rural areas urgently need to transform constraints into opportunities, identify their weaknesses, use digital development to narrow the urban-rural digital divide, reduce regional, urban-rural, and social-group disparities, and contribute to coordinated national development.

No unified definition of digital rural planning has emerged in either Chinese or international scholarship. Development characteristics and construction content differ across places according to local needs. The European Commission argued in 2017 that innovation should be the core principle of smart village planning, with solutions built on strong social capital and networks connecting stakeholders through both traditional means and digital technology [3]. Implementing such planning in rural areas also requires clear and stable legal provisions and an appropriate degree of digitalization and standardization to enable spatial information to circulate and be shared [4]. Chinese scholarship has rarely defined digital rural planning directly and has paid limited attention to its pathways and policy responses. Because Digital Village Construction Guide 2.0 identifies planning as a method of construction, digital rural planning may be understood as the preparation of a development program aimed at realizing digital village construction. Through necessary arrangements and deployment, it seeks to achieve industrial digitalization, interdisciplinary talent development, modernized governance, spatial virtualization, and long-term planning effectiveness in rural areas.

Influenced by the goal of common prosperity and concern over uneven regional development, current research on digital villages focuses heavily on digital inclusive finance and the urban-rural income gap. It examines how to improve inclusive digital financial systems, raise household income, narrow urban-rural disparities, and promote coordinated regional development [5-6]. Other studies investigate new models of rural digital governance and seek integrated, intelligent governance approaches that improve effectiveness through multiple pathways [7-9]. Measuring digital village development, identifying regional differences, and explaining their determinants are also prominent topics [10-11]. Nevertheless, existing research remains concentrated on socioeconomic questions. It insufficiently examines the combined constraints facing China's digital villages, lacks an integrated planning perspective, and rarely addresses new time-space relations or the interaction between the virtual economy and physical space in the information age [12].

On this basis, the paper clarifies the concept of digital rural planning and constructs a logical framework for its preparation (Figure 1). It first reviews the background of digital village development and diagnoses its practical constraints; it then identifies the major drivers and planning opportunities of the new era and draws on the experience of representative demonstration areas to formulate basic ideas and practical pathways. The objective is to address difficulties in digital rural planning and construction and ensure that agriculture and rural areas are not left behind in the new technological revolution and modernization process.

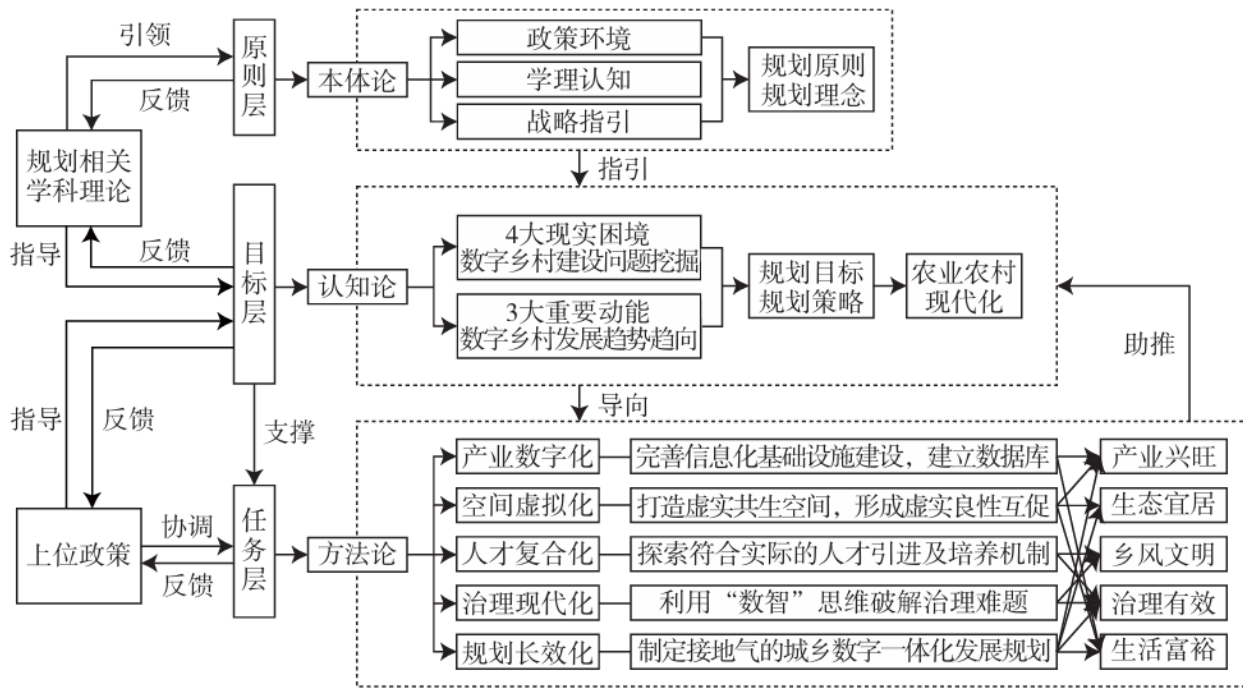


Figure 1. Theoretical framework for preparing digital rural plans

1 Background to Digital Village Development

1.1 Policy Framework: Institutional Design for Digital Village Development

Top-level policy design provides institutional support for digital village development. Against the background of digital transformation, central and local governments have strongly promoted the use of digital technologies to improve rural development and construction [13] (Table 1). The 2018 No. 1 Central Document introduced the digital village strategy for the first time. The 2019 Outline of the Digital Village Development Strategy specified ten priority tasks, and the Digital Village Development Action Plan (2022-2025), issued in early 2022, deployed eight major actions. These documents established new requirements for digitally enabling intelligence, quality, and governance in rural development. The Key Tasks for Digital Village Development in 2023 set future objectives and assigned 26 tasks in ten areas, using digitalization to empower rural industries, construction, and governance. Digital Village Construction Guide 2.0, issued in May 2024, focuses on county-level construction, operation, and management, and identifies planning and design, investment and construction, and operation and management as three principal implementation methods. Digital rural planning is thus a core method of digital village development and has substantial practical value. At the macro level, institutional capacity is the starting point of policy implementation: government uses regulatory capacity to advance established objectives through policies and rules. Construction standards, implementation programs, and the national regulatory system must evolve with the times and are continuing to improve [14].

Table 1. Major policies related to digital village development

Level	N o.	Policy	Date	Summary
Centr al	1	Outline of the Digital Village Development Strategy, issued by the General Offices of the CPC Central Committee and the State Council	2019-05-16	Sets out ten priority tasks and supporting measures for comprehensively developing digital villages.
Centr	2	Opinions of the CPC Central	2021-01-04	Calls for digital village development

Level	N o.	Policy	Date	Summary
al		Committee and the State Council on Comprehensively Advancing Rural Revitalization and Accelerating Agricultural and Rural Modernization		projects, an agricultural and rural big-data system, and digitally enabled public services and social governance.
Central	3	Notice on Issuing Digital Village Construction Guide 1.0, jointly issued by the Cyberspace Administration of China, Ministry of Agriculture and Rural Affairs, National Development and Reform Commission, and other departments	2021-07-23	Covers eleven areas, including information infrastructure, public support platforms, the rural digital economy, smart and green villages, online rural culture, digital governance, and information services for residents.
Central	4	State Council Notice on the 14th Five-Year Plan for Advancing Agricultural and Rural Modernization	2022-01-12	Calls for digital village projects, agricultural and rural big data, and the deep integration of the IoT and other new-generation technologies with agricultural production and management.
Central	5	State Council Notice on the 14th Five-Year Plan for Digital Economy Development	2022-01-12	Promotes digital villages through improved information services for agriculture, an integrated rural information-service system, and expanded use of agricultural and rural big data.
Central	6	Opinions of the CPC Central Committee and the State Council on Priorities for Comprehensively Advancing Rural Revitalization in 2022	2022-01-04	Advances smart agriculture, integrates information technology with agricultural machinery and agronomy, and strengthens farmers' digital literacy and skills.
Central	7	Digital Village Development Action Plan (2022-2025), jointly issued by ten central departments	2022-01-26	Deploys eight major actions, including digital infrastructure upgrading, smart-agriculture innovation, new business models, digital-governance capacity, and revitalization of online rural culture.
Central	8	Implementation Plan for the Rural Construction Initiative, issued by the General Offices of the CPC Central Committee and the State Council	2022-05-23	Promotes the deep integration of digital technologies with rural production and daily life and improves the quality and coverage of rural communication networks.
Central	9	State Council Guiding Opinions on Strengthening Digital Government Development	2022-06-23	Uses digitalization to support modern rural governance, address rural information-infrastructure gaps, and

Level	N o.	Policy	Date	Summary
				build agricultural and rural big-data systems.
Central	10	Guidelines for Building the Digital Village Standards System, jointly issued by four central departments	2022-08-08	Provides guidance for standardization work in digital villages over the present and forthcoming period.
Central	11	Opinions of the CPC Central Committee and the State Council on Priorities for Comprehensively Advancing Rural Revitalization in 2023	2023-01-02	Promotes digital village actions and application scenarios, accelerates agricultural and rural big-data use, and advances smart agriculture.
Central	12	Implementation Opinions of the Ministry of Agriculture and Rural Affairs on the CPC Central Committee and State Council's 2023 Priorities for Rural Revitalization	2023-02-03	Develops smart agriculture and digital villages through digital-agriculture projects, innovation centers, application bases, and pilot programs.
Central	13	Key Tasks for Digital Village Development in 2023, jointly issued by five central departments	2023-04-13	Deploys 26 tasks in ten areas and uses digitalization to empower rural industries, construction, and governance, thereby advancing agricultural and rural modernization.
Central	14	Guiding Opinions on Promoting High-Quality Development of Rural Distribution, jointly issued by the Office of the Central Commission for Financial and Economic Affairs and other departments	2023-08-14	Promotes high-quality rural e-commerce, digital commerce for agriculture, and online channels for moving agricultural products from villages to cities, so that smartphones, data, and livestreaming become new farming tools, inputs, and occupations.
Central	15	Digital Village Construction Guide 2.0, jointly issued by six central departments	2024-05-16	Contains overall requirements, construction content, implementation methods, and safeguards; defines two foundations and six priority areas; and covers planning and design, investment and construction, and operation and management for county-level application.

1.2 Research Trends: Academic Understanding of Digital Village Development

Guided by macro-level policy, Chinese research on digital villages has grown rapidly. A CNKI search used "rural" together with "networking/informatization/digitalization" as subject terms and restricted journal sources to Peking University Core Journals, CSSCI, and CSCD. Because the report to the 18th CPC National Congress in late 2012 first called for the coordinated development of industrialization, informatization, urbanization, and agricultural modernization, and because fewer than ten relevant

papers were published annually before 2013, the study period was set at 2013-2023. After news items, brief reviews, conference remarks, and other non-academic materials were removed, 1,219 papers remained. Annual output exceeded 50 papers in 2019 and approached 350 in 2022, showing a near-linear growth trend (Figure 2).

The selected records were exported in RefWorks format to CiteSpace 6.1.R2 for keyword co-occurrence analysis (Figure 3). "Digital village" and "rural revitalization" formed the largest research clusters, while other topics and keywords diversified over time in response to the complexity of rural systems. Research has examined the continual reorganization and optimization of flows of land, population, capital, information, and technology, providing useful evidence for digital village development and a theoretical basis for digital rural planning. However, insufficient attention has been paid to the relationship between physical rural space and virtual elements in the digital era, or to the constraints and opportunities created by uneven regional development. Research must therefore remain problem-oriented, narrow development gaps, and respond to the broader national agenda of Digital China.

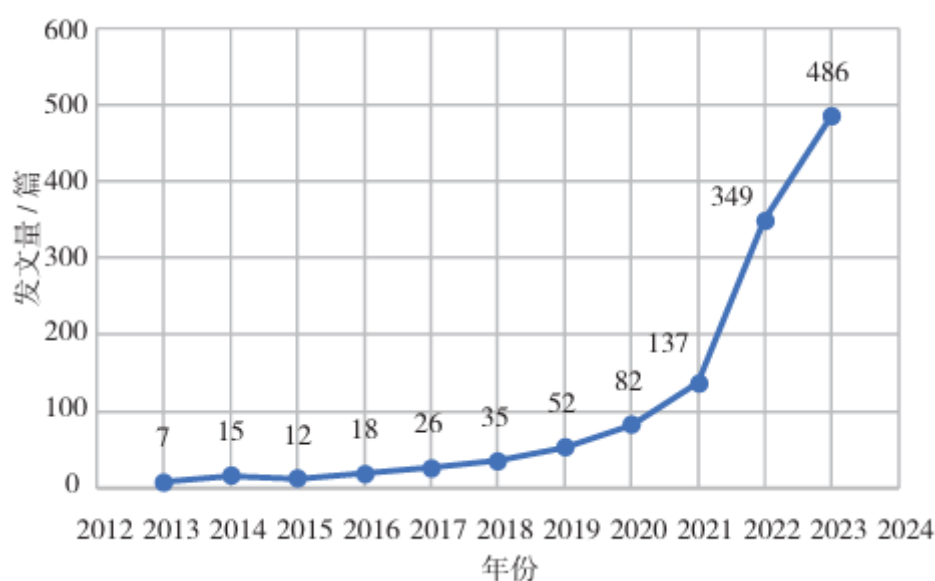


Figure 2. Annual number of publications on digital villages, 2013-2023

in the central region [18]. Digital agriculture and rural digitalization have therefore become a conspicuous weakness in Digital China.

As a new economic form, the digital economy should use internet technologies, information and data, and digital thinking to improve the rural industrial environment, expand rural industries, serve entire agricultural value chains, and raise rural information-service capacity. In practice, however, some digital technologies are disconnected from actual industrial needs, and digital guidance in rural industrial planning lacks precision. Large-scale application to agricultural production and management has not yet occurred. Digital technology is concentrated in emerging sectors such as e-commerce, while planning awareness of digitally driven transformation in traditional agriculture remains weak. The digital value of fisheries, forestry, crop production, and animal husbandry has yet to be fully released.

2.2 Superficially 'Smart' Digital Governance and Difficulties in Precise Decision-Making

The digital governance system remains the weakest link in digital rural planning during the comprehensive implementation of rural revitalization [17]. Flows of resources between villages are constrained by geography and transport, traditional hierarchical structures function poorly, and the transmission of county-level governance tasks is often delayed, increasing the difficulty of coordination. Digital governance indicators, including online disclosure of village, Party, and financial affairs, remain weak. The limited deployment of broadband and intelligent equipment in the governance 'last 100 meters' has made the urban-rural digital divide increasingly difficult to bridge [7].

More importantly, information silos and fragmented management are common in less-developed rural governments. A strong "data protection" mentality prevents sharing and interoperability across departments, making intelligent analysis and precise decision-making difficult [19]. Limited technical investment and weak digital thinking have also produced platforms that are smart in appearance but narrow in function. Many focus on policy releases, inspection speeches, and activity summaries while neglecting intelligent public services related to villagers' daily lives. This inefficient and performative governance aggravates rural information fragmentation and leaves governance effectiveness in need of improvement.

2.3 Lagging Digital Infrastructure and Limited Coverage of Application Scenarios

Infrastructure is a fundamental safeguard for economic development and a major driver of growth [20]. Although rural infrastructure has been digitally upgraded as poverty alleviation and rural revitalization have advanced, digital infrastructure remains uneven and inadequate. Modern logistics and smart warehousing are poorly distributed, and information networks require further improvement [21]. Existing rural facilities face funding shortages, limited financing channels, high maintenance costs, rapid depreciation, low carrying capacity, and shallow coverage. These conditions have become bottlenecks in high-quality rural industrial development [22].

Lagging infrastructure also limits the breadth and depth of links between technology and application scenarios. Rural platform construction is often repetitive, homogeneous, and inefficient, and diversified platforms covering the full range of rural economic and social life have not yet formed. This constrains the diffusion of digital products. Rural internet use remains concentrated on online shopping and entertainment, while professional applications in education, health care, office work, commerce, and government services are relatively limited. The internet's applied value must be strengthened so that data can genuinely function as a new farming tool and input.

2.4 Shortages of Interdisciplinary Digital Talent and Limited Technological Innovation

Digital skills are essential to improving farmers' quality of life. Yet by December 2023, rural internet penetration was 66.5%, and China's 326 million rural internet users represented only 29.85% of the national total, according to the 53rd Statistical Report on China's Internet Development released by the

China Internet Network Information Center (CNNIC) on 22 March 2024. Low digital literacy leaves many farmers without specialized digital agricultural knowledge or information-processing skills and contributes to weak online sales of agricultural products. Digital applications therefore lack a solid social foundation.

Traditional agricultural attitudes can also reduce receptiveness to new technologies. Some farmers resist agricultural digital equipment and reject digital-skills training or public lectures on digital transformation [22], reinforcing a vicious cycle of weak digital development. Population aging and the out-migration of young and middle-aged workers further intensify talent shortages and limit the human-resource basis of digital rural planning.

The shortage of interdisciplinary digital practitioners also contributes to weak basic research, impractical plans, and limited innovation supply [23]. Current top-level design emphasizes general methodologies, while county, town, and village levels lack differentiated, locally grounded development plans. Most areas have not prepared digital rural plans suited to their actual conditions. Talent shortages, unclear planning frameworks, and delayed technological innovation seriously obstruct digitalization in agriculture and rural affairs. More targeted digital rural planning is urgently needed.

3 Major Drivers and Planning Opportunities in the New Era

3.1 Releasing the Potential of the Digital Economy and Transforming Industrial Planning

Under digital village development, industrial demand is a primary force reshaping rural space. The insertion and reorganization of industries constitute the material carrier and practical foundation of digital rural planning [24]. Industrial coordination and e-commerce, guided by a digital-economy concept in which data and information are key factors, can transform rural production and industrial planning.

Short-video platforms, social-media livestreaming, and other digital marketing methods remove geographical constraints from agricultural sales and promotion. They strengthen the value-chain position and digital-economic value of peripheral villages, giving them a potential latecomer advantage. The digital economy breaks the former dependence of industrial location on geographical proximity, reduces transaction costs, and integrates fragmented demand across space [12]. Remote division of labor through online platforms has become normal. Industrial chains no longer depend exclusively on physical agglomeration; production stages can be geographically dispersed while virtual platforms integrate factors of production, overcome spatial isolation, and promote innovation [25].

Small industrial spaces distributed along major roads can thus connect to higher-level markets through decentralized coordination and participate in regional digital-economic specialization (Figure 4). As online sales systems reach rural markets, e-commerce serving agricultural production and rural life will reshape village functional networks and spatial patterns and connect rural areas to modern urban-rural industrial systems [26].

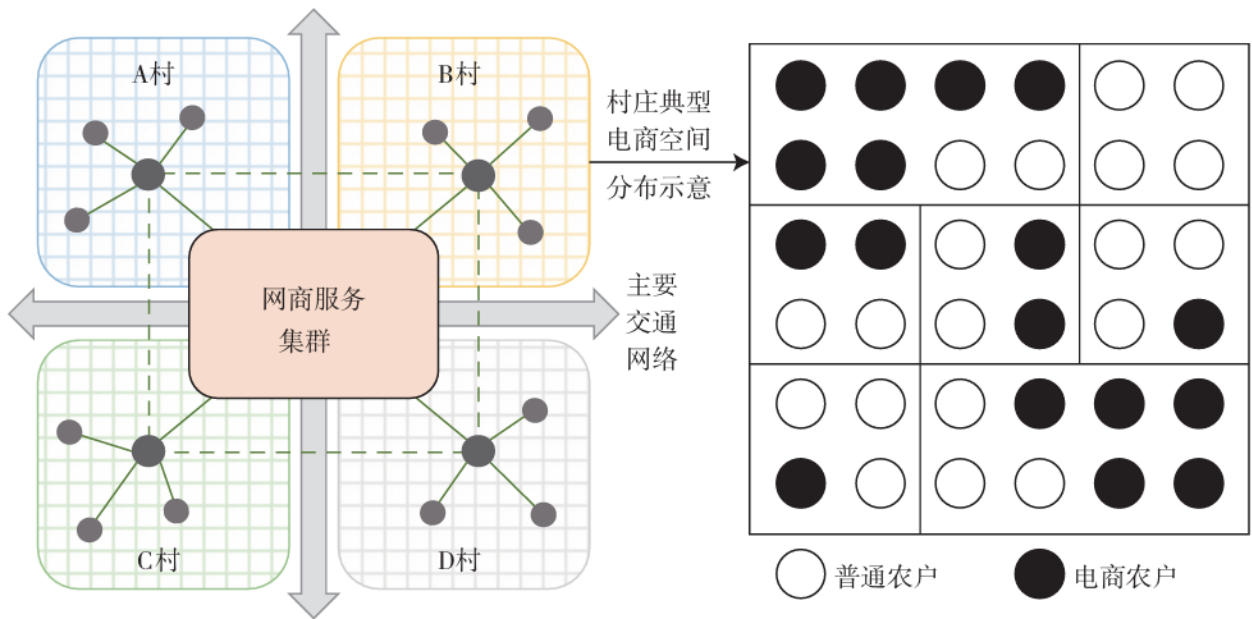


Figure 4. Spatial patterns of village e-commerce development

3.2 Integrating the Advantages of Digital Technology and Activating the Virtual Effects of Spatial Planning

As artificial intelligence, big data, blockchain, cloud computing, the Internet of Things, and other digital-intelligent technologies extend into rural areas, network infrastructure, information-service facilities, and conventional infrastructure will become more efficient, digital, and intelligent. These systems are foundational, supportive, and decisive preconditions for rural digital transformation.

By connecting to networks and communication systems, digital infrastructure links village groups to wider regional development systems, strengthens connections between rural territories and external environments, and accelerates flows of people, goods, capital, and information. New forms of rural spatial organization emerge, amplifying the virtual effects of spatial planning. Ubiquitously connected infrastructure reconstructs rural accessibility and allows virtual space to generate agglomeration economies [27].

Offline service facilities can use instant logistics and online platforms to support point-to-point circulation. Information is transmitted online and received through dispersed and diverse physical spaces, allowing more flexible facility layouts and greater equality between location and service benefits. Agglomeration effects are partly transferred online, reducing inequities associated with economies of scale and offline concentration (Figure 5). Free data flows also replace closed hierarchical village-town relations with more open and interconnected flat networks. Digital technologies therefore enable an efficient low-density model in which physical space is dispersed but virtual factors are concentrated [28].

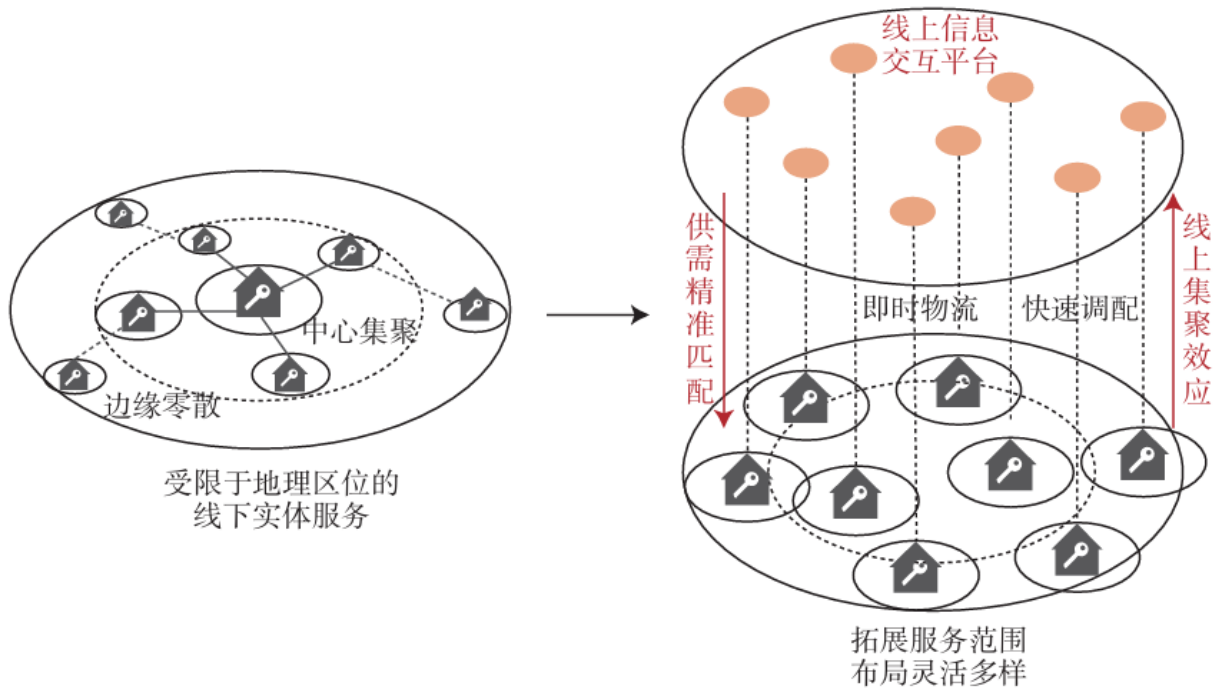


Figure 5. Service-facility layout enabled by digital technology

3.3 Expanding Digital Space and Improving the Effectiveness of Collaborative Planning

Digital space is a new physical-virtual hybrid generated by digitally driven social development. Its extensibility and interactivity can overcome resource-endowment constraints, enable the integration of diverse resources, and support cross-temporal and cross-spatial interconnection and sharing [29]. It can thereby improve collaborative rural planning.

Decentralized digital space corresponds to the dispersed character of rural settlements. It challenges traditional central-place organization, changes the allocation of social resources and the operation of rural economies, and allows interactive virtual space to assume some functions of physical space. Village space is consequently transformed and upgraded within a new development pattern based on data resources [30] (Figure 6).

Because digital space is less constrained by distance, it can improve the compatibility of technological capacity across regions, urban and rural areas, towns and villages, and individual settlements. Lower barriers to use and matching produce distributional effects of gain and sharing, reduce resource mismatch, and improve allocation efficiency. Richer digital spaces also support grid-based governance across village clusters and town-village systems. Network immediacy and accessibility allow actors in different places to participate in area-based self-governance, stimulate the leading role of stronger villages and the collective vitality of village groups, and create open regional resource circulation. As smart terminals and information exchange expand, collaborative development can combine the scale benefits of agglomeration with the environmental advantages of dispersion, supporting cross-regional coordination and overall efficiency.

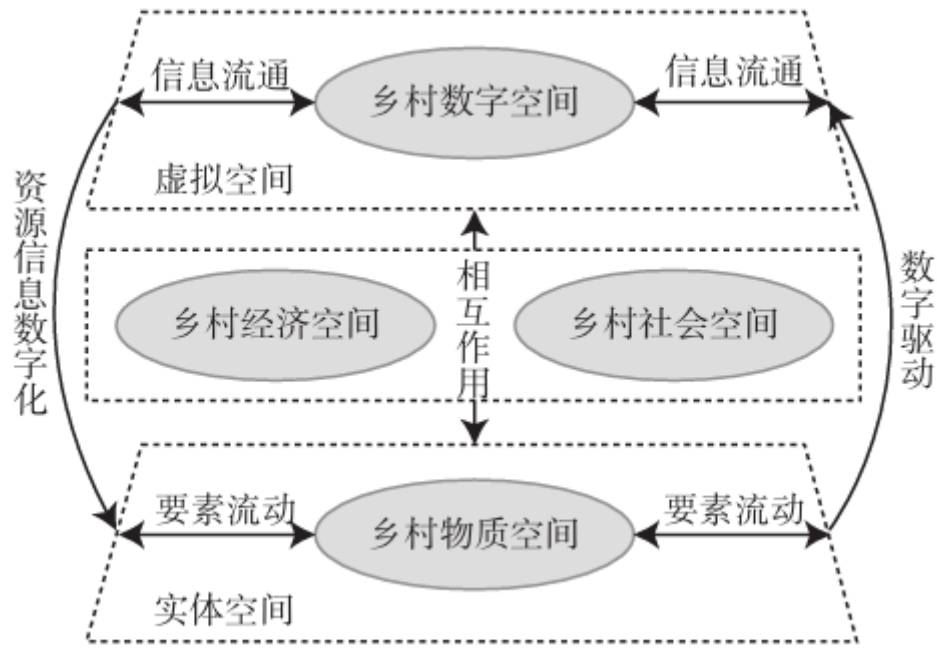


Figure 6. A new development pattern based on data resources

4 Basic Approaches and Practical Pathways for Digital Rural Planning

4.1 Strengthen Information Infrastructure and Raise the Digital Capacity of Rural Industries

The digital economy and digital technologies create both new requirements and external support for rural information infrastructure. New infrastructure programs should promote the wide application of AI, big data, and the IoT; expand rural broadband coverage and accessibility; increase mobile base-station construction; and improve digital village service networks [31]. Agricultural and rural resource databases and deeply integrated "Internet Plus Agriculture" big-data platforms should be established. Continued digital commerce for agriculture can incorporate local rural characteristics into data-industry systems and raise the digital capacity of rural industries.

Xi County in Shanxi, one of China's first national digital village pilots, provides an instructive example [32]. Formerly a national priority county for poverty alleviation in the deeply dissected Loess Plateau, it faced resource constraints similar to many rural areas. Using "Internet Plus" and its pear industry, Xi County developed smart agriculture and digitally transformed rural production. Its digital village platform centers on the Yuluxiang pear and has built a modern agricultural internet ecosystem in which agricultural big data are the core and data applications the operational key. The county has progressed from being known as China's leading Yuluxiang pear county to recognition as a national advanced county in digital agricultural and rural development, achieving digital coordination across the full value chain and the three sectors.

Because e-commerce depends on network platforms, rural areas must install supporting infrastructure from broadband lines to terminal equipment. Demonstration-area experience should be used to upgrade infrastructure and expand application scenarios. Radio and television equipment should be digitally renovated, obsolete facilities identified and retired, universal telecommunications-service pilots continued, and comprehensive digital infrastructure systems established. Xi County's experience also suggests that dispersed settlement can increase locational flexibility. Decentralized production units can diversify village functions while generating hub-like service nodes, and shared information networks can provide complete value-chain services (Figure 7), maximizing digital dividends.

通过互联网在区域范围内寻找优质资源
借助基础设施网络实现产业链数字驱动

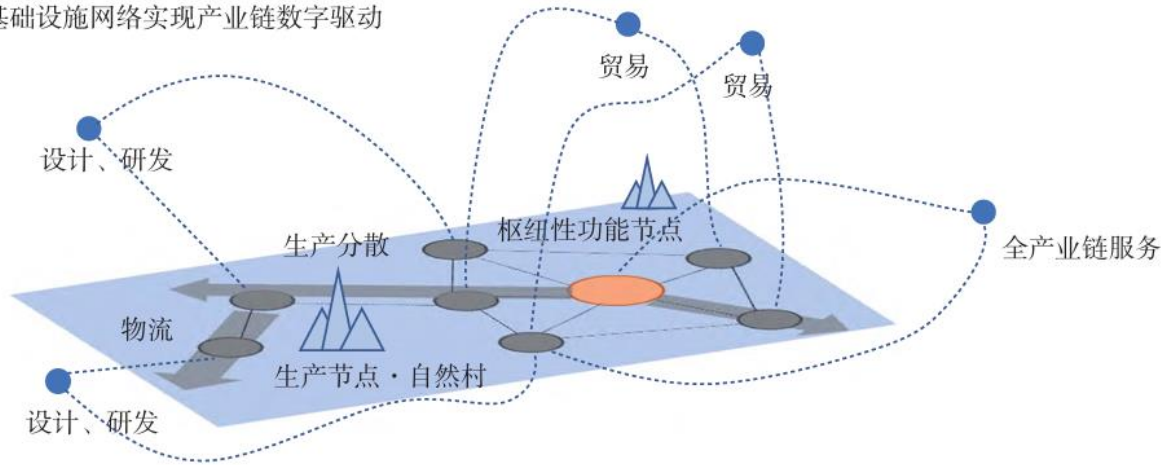


Figure 7. Digital enablement across the full industrial chain of a digital village

4.2 Create Mutually Reinforcing Physical and Virtual Spaces and Strengthen Endogenous Industrial Vitality

Digital networks connect local space to wider spatial systems. The scale effects of agglomeration now influence not only physical space but also extensive virtual concentration [33]. Rural areas can retain low development intensity and density while expanding markets, increasing transactions, and strengthening external connections. E-commerce-driven industrial transformation inevitably restructures traditional village space. Processing and warehousing emerge, while home-based workshops created through housing conversion form mixed production-residential spaces. Information, capital, and goods circulate across both regional physical space and e-commerce platforms.

Sunzhuang and Dinglou villages in Daji Town, Cao County, are representative Chinese Taobao Villages and integrated "Internet Plus Rural" complexes [34]. Daji Town is geographically remote, and its villages previously depended on agriculture, had weak economic foundations, and experienced extensive labor out-migration. The internet enabled the two villages to create a commerce-plus-industrial-production model virtually from nothing. Specialized and scaled industrial spaces emerged, and a planned "Taobao Street" along Yanqing and Sangwan roads at the village boundary concentrated supporting services and resolved warehousing and logistics problems for dispersed producers, giving the area the initial form of a new small town.

Poor physical accessibility raises industrial costs and constrains rural modernization, but virtual agglomeration means that physical accessibility is no longer decisive. The flow-space e-commerce model of Sunzhuang and Dinglou can be used to develop an attention economy. Mobile internet can channel capital, technology, and other factors, while low-cost online entrepreneurship, local non-agricultural industries, and distinctive agricultural resources provide the foundations for endogenous rural industrial vitality. Society is reorganized in space and time: the online aggregation of services improves offline spatial quality and creates a mutually reinforcing physical-virtual cycle (Figure 8).

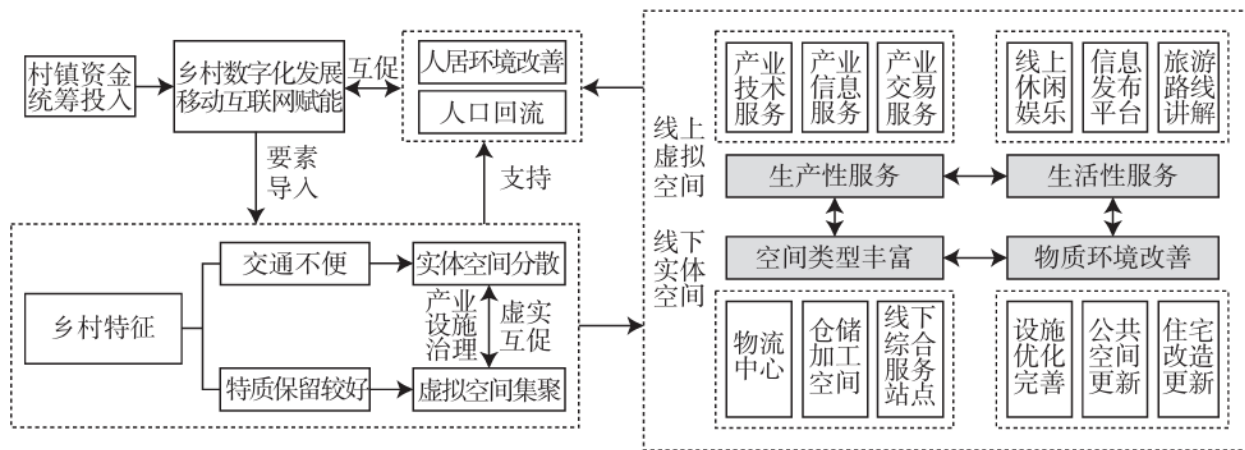


Figure 8. Mutually reinforcing physical and virtual rural spatial development

4.3 Build Professional Talent Teams and Cultivate New Actors in Rural Industrial Development

People are the key to linking the consolidation of poverty-alleviation gains with rural revitalization. Training digitally skilled agricultural and rural personnel and cultivating new industrial operators are essential to rural modernization. Digital knowledge and skills programs should be differentiated by participant and need, embed digital thinking in the daily work of grassroots officials and villagers, and mobilize multi-level local talent so that the digital economy can be adapted to local conditions.

Germany's digital rural practice under an integrated-development model offers useful lessons. Although China and Germany differ in policy and fiscal conditions, rural areas in both countries face aging, depopulation, and declining social networks in a globalized and digital society [35]. German rural regions have therefore adopted digital strategies based on integrated development to strengthen internal social organization. The central approach is to create bottom-up actors that cross administrative boundaries and connect local government, enterprises, research institutions, and civic knowledge groups in cooperative networks. Digital-capacity training for villagers is the most critical step (Table 2). Mobilizing local strengths and creating broad participation are necessary for sustainable digital rural planning [36].

In East Westphalia-Lippe, North Rhine-Westphalia, trained villagers helped build information platforms and participated in creating and maintaining digital environments. Long-term exchange improved their ability to use devices independently, and continued local training sustained the talent pool and the effectiveness of facilities. Rural China can adapt this framework to local conditions, integrate local knowledge into specialized training, and build online rural education platforms jointly with governments and local educational institutions. Video-on-demand, face-to-face teaching, and rural revitalization training bases can provide vocational training and re-employment skills for priority groups and cultivate local talent at its source (Figure 9).

Table 2. Digital-development measures under Germany's integrated-development initiative

Measure	Content
Build information platforms	1. Village Radio website and app: provides local online-transaction information, regional news and events, and communication channels with government departments. 2. Faith Platform: uses local school resources to provide middle-aged and older residents with information about church services and related religious ceremonies.
Create digital spatial environments	3. Smart Village Living Room: establishes a shared space equipped with smart-home facilities needed by residents; its business model is determined through village discussion.

Measure	Content
	4. Smart Bus Stops: provide unrestricted wireless internet access and charging facilities for personal mobile devices.
Provide digital training	5. Digital-capacity training: approximately 150 local volunteers from 16 villages undertake an 18-month program covering digital agriculture, information security, media law, and Education 4.0. 6. Drone training: encourages young people to participate in village affairs; images and videos are used on town and village websites and Village Radio platforms.
Use digital technology to strengthen mutual aid	7. Reciprocal group "Village of Care": villagers form a self-organized group under project guidance, conduct door-to-door surveys to map supply and demand for virtual community services, match people offering knowledge or skills with those needing assistance, strengthen neighborly support, and improve social cohesion. 8. Digital emergency-call system: assists older residents in health emergencies, equipment failures, accidents, and related situations.

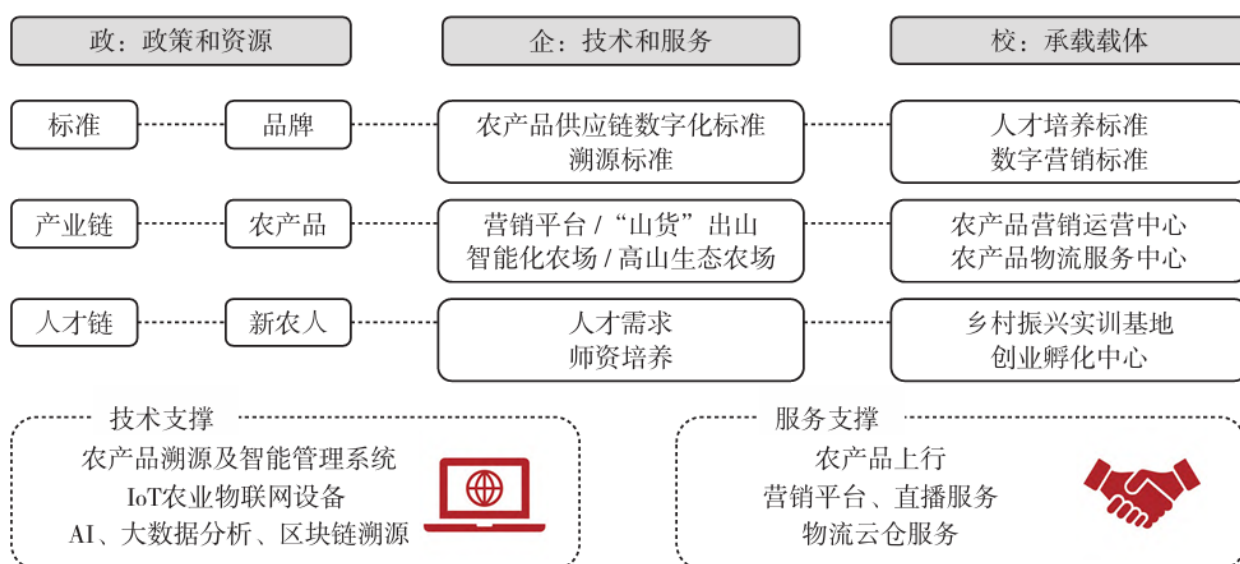


Figure 9. Digital education application scenarios in rural areas

4.4 Empower Governance through Digital Technology and Improve Digital Services for Rural Industries

The ultimate objective of digital rural planning is to modernize agriculture and rural areas and create beautiful villages governed and shared by all. Reform in big-data application should be deepened, and networked, intelligent platforms for rural social governance should activate the endogenous contribution of multiple actors [37] and improve digital services for rural industries.

A collaborative "Internet Plus Grid Governance" model should mobilize new agricultural operators and smallholders, while enterprises, industry associations, and other actors participate in cross-sector and cross-regional data-sharing platforms. Such collaboration strengthens the capacity of governance to empower rural industrial revitalization.

Deqing County in Huzhou, Zhejiang, provides a county-level model of integrated smart governance. Its Remote-Sensing Monitoring through a "One Map for the Digital Village" to Support Smart Rural Governance was the only Zhejiang case selected for Digital Village Construction Guide 1.0, while its countywide digital rural governance system was China's only case selected as a United Nations good practice for implementing the 2030 Agenda. Deqing initially faced a digital divide and a loss of trust caused

by absent service providers in online administrative procedures. Through pilots and learning, it developed a new path in which digital empowerment became a lever for rural governance [38].

Following the principle of integrated smart governance, Deqing linked its urban brain to a "One Map for the Digital Village" and created a two-way collaborative framework involving government, enterprises, residents, and visitors. Countywide rural coverage was achieved in 2020. Because rural governance is the foundation of social governance, widely scattered data must be integrated and gaps in data repaired. Digital rural planning can adapt Deqing's approach by establishing county-level grid platforms and three-tier mechanisms covering counties or districts, towns or subdistricts, and villages or communities. These systems can dismantle information silos and institutional barriers (Figure 10), extend "Internet Plus Government Services" into rural areas, and establish management systems with clear responsibilities, refined administration, shared information, open channels, and effective service. Villager self-organization can serve as the terminal data interface, transmitting real-time and dynamic information upward and enabling diverse, precise, and personalized services with comprehensive coverage and no service gaps.

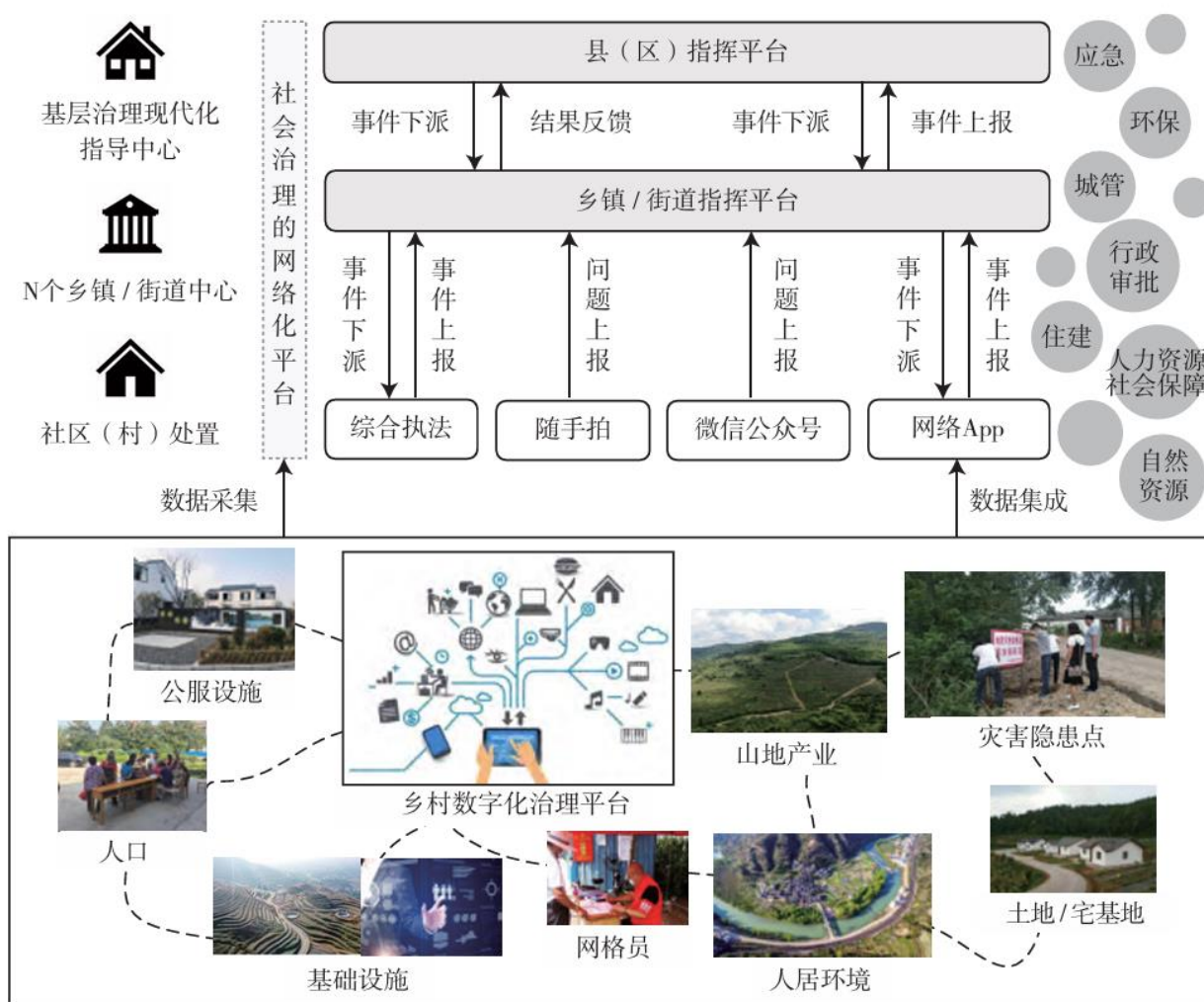


Figure 10. Integrated smart governance for rural areas

4.5 Prepare Integrated Urban-Rural Digital Development Plans and Improve Top-Level Design

Integrated urban-rural development serves the national development agenda. The Outline of the Digital Village Development Strategy, the Implementation Plan for Using the Digital Economy to Promote Common Prosperity, and other policies call for urban-rural integration, coordinated development of digital villages and smart cities, integrated urban-rural design, and stronger technological innovation for agriculture and rural areas.

German experience also shows that top-level integrated urban-rural digital plans and actionable management procedures can reduce disparities among regions, urban and rural areas, and social groups [36], allowing all residents to share the dividends of the digital era. Integrated planning should clarify common urban-rural objectives, establish coherent institutions aligned with the digital village strategy, define implementation frameworks and steps, create specialized supervisory and guidance bodies, and improve supporting arrangements for organizational leadership and talent development.

Top-level planning must remain demand-oriented and interact with bottom-up grassroots innovation. Local service and support networks should be used to prepare practical, context-sensitive digital rural plans. Village planning in the new era will inevitably be closely integrated with the digital village strategy. It should explore plan preparation from a digital perspective, draw on the experience of the Ten-Thousand Villages Project, set tasks scientifically in accordance with regional economic conditions, and establish clear planning directions.

5 Conclusion

Digital village development is spreading across rural China in an increasingly project-based form. To use digitalization effectively and maximize its dividends, sound digital rural planning is urgent. Rural planning under digital conditions is a continuous and dynamic process. Precisely introducing information technologies, accelerating the application of new quality productive forces in rural areas, and ensuring that rural plans embody the advanced productive capacity required by the new development philosophy will require sustained attention and deeper investigation by government, academia, and other stakeholders.

References

- [1] Zhao Xingyu, Wang Guibin, Yang Peng. Digital village development under the rural revitalization strategy. *Journal of Northwest A&F University (Social Science Edition)*, 2022, 22(6): 52-58. [in Chinese]
- [2] Cui Kai. A practical analysis of digital village development: progress, patterns, and pathway optimization. *Studies on Socialism with Chinese Characteristics*, 2023(2): 74-84. [in Chinese]
- [3] ENRD. Smart villages revitalising rural services. *EU Rural Review*, 2018, 26: 1-52.
- [4] Wójcik M., Dmochowska-Dudek K., Tobiasz-Lis P. Boosting the potential for geodesign: digitalisation of the system of spatial planning as a trigger for smart rural development. *Energies*, 2021, 14(13): 3895.
- [5] Wang Liang, Zan Lin. The impact of digital inclusive finance on rural revitalization. *Financial Theory & Practice*, 2023(4): 77-87. [in Chinese]
- [6] Pan Mingqing, Fan Yajing. Mechanisms and effects of digital inclusive finance in promoting rural revitalization. *Macroeconomics*, 2023(3): 35-47. [in Chinese]
- [7] He Lijun, Fang Kun. The logical pathway of rural digital governance in western China from the perspective of integrated smart governance. *Social Governance Review*, 2023(2): 30-39. [in Chinese]
- [8] Xiong Chunlin, Wang Yaling. Driving mechanisms of rural digital governance: model construction and simulation. *Chongqing Social Sciences*, 2024(4): 6-25. [in Chinese]
- [9] Zhou Suhong, Wu Shuailin, Lin Yuancheng, et al. Building a technical system for digital governance of rural territorial space under digital transformation. *Planners*, 2024, 40(3): 22-27. [in Chinese]
- [10] Sun Shuhui, Chen Xiaonan. Measuring regional disparities in China's digital village development: structural decomposition and identification of influencing factors. *Statistics & Decision*, 2024(10): 69-74. [in Chinese]
- [11] Li Xuhui, Chen Mengwei. China's rural digital transformation: measurement, regional differences, and advancement pathways. *Issues in Agricultural Economy*, 2023(11): 89-104. [in Chinese]

- [12] Rao Yuxuan, Chen Ming, Mou Lingli. Collaborative village development under the digital village agenda: the case of Changleping Town, Hubei Province. *Development of Small Cities & Towns*, 2022, 40(8): 17-26. [in Chinese]
- [13] Liao Chengzhong, Zhai Kunzhou, Mao Lei. Data-governance-driven digital village development: functions, scenarios, and pathways. *Reform*, 2023(12): 113-127. [in Chinese]
- [14] Xing Zhenjiang, Li Xinyi. Rural digital governance in the new era: system framework, opportunities, and implementation pathways. *Journal of Shandong Academy of Governance*, 2023(5): 81-89. [in Chinese]
- [15] Zeng Yiwu, Song Yixiang, Lin Xiazhen, et al. Reflections on several issues in China's digital village development. *Chinese Rural Economy*, 2021(4): 21-35. [in Chinese]
- [16] Li Heping, Mou Lingli, Lin Tao. Planning and construction in western China under a holistic approach to national security: the case of Chongqing. *Urban Development Studies*, 2024, 31(2): 53-61. [in Chinese]
- [17] Zhong Yu. Digital village development: situation, characteristics, and priorities. *People's Tribune*, 2023(21): 54-58. [in Chinese]
- [18] Cyberspace Administration of China. China Digital Village Development Report (2022) [EB/OL]. 2023-03-01 [accessed 2024-01]. http://www.cac.gov.cn/2023-03/01/c_1679309718486615.htm. [in Chinese]
- [19] Tan Xinxi. Difficulties and solutions in rural digital governance in western China. *Rural Areas, Agriculture & Farmers (Edition A)*, 2022(9): 32-34. [in Chinese]
- [20] Liu Xiaoqing, He Rui. Planning new urban information infrastructure: practice and exploration in Xiong'an. *Urban Planning Forum*, 2022(5): 112-118. [in Chinese]
- [21] Wen Feng'an. Digital technologies enabling the modernization of rural development: significance, constraints, and pathways. *Journal of Hubei University (Philosophy and Social Science)*, 2022, 49(5): 134-141. [in Chinese]
- [22] Lu Jiutian, Chen Canping. Digital village development in ethnic minority regions: logical starting points, potential pathways, and policy recommendations. *Journal of Southwest Minzu University (Humanities and Social Sciences)*, 2021, 42(5): 154-159. [in Chinese]
- [23] Sun Ying, Zhang Shangwu. Governance issues in rural planning in China: conceptual clarification, research review, and prospects. *Urban Planning Forum*, 2024(1): 46-53. [in Chinese]
- [24] Liu Yuan. Principles, problems, and pathways of digital village development: less-developed western regions as an example. *Theoretical Horizon*, 2023(2): 68-73. [in Chinese]
- [25] Rao Yeling, Luo Zhendong. Digital transformation and deep diffusion: the evolution of industrial space in the Yangtze River Delta based on B2B e-commerce enterprises. *Urban Planning Forum*, 2021(3): 82-89. [in Chinese]
- [26] Yang Baojun, Cao Lu. Eight scenarios for future villages. *Development of Small Cities & Towns*, 2021, 39(7): 10-15. [in Chinese]
- [27] Niu Qiang, Jiang Yixiao, Chen Shulin, et al. The internal mechanism for equalizing life services in suburban new towns under online-offline models. *Planners*, 2022, 38(12): 57-64. [in Chinese]
- [28] Luo Zhendong, Chai Yanwei, Wang De, et al. New urban-rural spaces in the digital era. *City Planning Review*, 2023, 47(11): 20-24. [in Chinese]
- [29] Liu Xianchun, Sun Zhicheng. Empowerment and restructuring: innovative mechanisms through which digital space advances rural revitalization. *Journal of Northwest A&F University (Social Science Edition)*, 2023, 23(3): 1-10. [in Chinese]
- [30] Yang Ren, Lin Yuancheng. Rural digitalization and rural spatial transformation. *Acta Geographica Sinica*, 2023, 78(2): 456-473. [in Chinese]

- [31] Dai Shenzhi, Liu Tingting, Song Haiyu. Application of smart-society data infrastructure in territorial spatial planning. *City Planning Review*, 2020, 44(2): 27-31. [in Chinese]
- [32] Xu Xuchu, Ge Ping, Wu Bin. The practical logic and key mechanisms of agricultural industrial digitalization: a multi-case analysis of four counties in four provinces. *Journal of Agro-Forestry Economics and Management*, 2023, 22(2): 133-141. [in Chinese]
- [33] Luo Zhendong. Emerging garden cities: reconstructing urbanization theory in the mobile internet era. *City Planning Review*, 2020, 44(3): 9-16. [in Chinese]
- [34] Luo Zhendong. *New Bottom-Up Urbanization*. Nanjing: Southeast University Press, 2020. [in Chinese]
- [35] Huang Huang, Yang Guiqing, Philipp Misselwitz, et al. Post-rural urbanization and rural revitalization: contemporary rural planning in Germany and implications for China. *City Planning Review*, 2017, 41(11): 111-119. [in Chinese]
- [36] Li Yinong, Li Yang. Rural digitalization within an integrated-development framework: the case of East Westphalia-Lippe, North Rhine-Westphalia, Germany. *Urban Planning International*, 2021, 36(4): 126-136. [in Chinese]
- [37] Ge Chunhui, Zhang Yongbo, Li Haitao, et al. Exploring new pathways for governance transformation in territorial spatial planning: the case of Ningbo. *Urban Planning Forum*, 2022(S2): 241-246. [in Chinese]
- [38] Liu Neng, Lu Bingzhe. Alignment and adaptation: the practical logic of digital governance in rural society - a case study of digital village governance in Deqing, Zhejiang. *Journal of China Agricultural University (Social Sciences)*, 2022, 39(5): 25-41. [in Chinese]

AI-assisted translation