

# BLOCKCHAIN TECHNOLOGY EMPOWERING RURAL TOURISM: APPLICATION SCENARIOS AND SOLUTIONS

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**Abstract:** In the context of the deep integration of rural revitalization strategy and digital technology, the digital transformation of rural tourism faces threefold dilemmas of efficiency, trust, and cultural preservation. This paper, taking blockchain technology as a starting point, systematically explores the internal logic and practical paths of its empowerment in rural tourism, aiming to construct a "technology-scenario-governance" collaborative framework to resolve structural contradictions in industrial development. The study is based on the Social-Technical Systems Theory (SST), adopting interdisciplinary research methods, and uses typical cases to demonstrate how blockchain technology drives high-quality development in rural tourism by reconstructing production relations. The study finds that blockchain technology, through mechanisms of "trusted data flow" and "autonomous smart contracts," reshapes the power structure, value transfer, and governance models in rural tourism. Its distributed ledger feature solves issues such as data islands and the loss of trust in stakeholders, while its DAO governance and Token economic models activate villagers' participation. The paper also proposes four-dimensional application scenarios covering trusted service chains, value co-creation chains, green governance chains, and inclusive finance chains, achieving the reconstruction of consumption scenarios, cultural IP development, ecological supervision optimization, and investment and financing innovation through technological integration. Furthermore, the paper warns of three major challenges for the technology's implementation: the gap between computing power and rural infrastructure, the institutional coupling difficulties between on-chain and off-chain systems, and the conflict between technological rationality and rural ethics. It proposes a "lightweight blockchain + edge computing" technical solution and designs a "multi-party chain governance committee" system to balance the rights and responsibilities of government, enterprises, and villagers, incorporating "ethical coding" into the design of technology to embed rural culture. Future research should focus on the integration of the metaverse, AI, and blockchain technologies, enhancing service personalization while preventing cultural alienation risks, thus providing solutions for rural common prosperity that combine technological innovation with the protection of cultural roots.

**Keywords:** Blockchain technology; Rural tourism; Application scenarios

## 1 INTRODUCTION

The rural tourism sector under the rural revitalization strategy urgently requires digital transformation. As the overarching strategy for rural development in the new era, the rural revitalization strategy explicitly states the goals of "prosperous industries, beautiful rural environments, civilized rural customs, effective governance, and improved livelihoods." Rural tourism, as an important carrier of rural industrial revitalization, is transitioning from the traditional "farm stay" model to a more comprehensive, quality-driven, and intelligent approach. According to data from the Ministry of Culture and Tourism's Rural Tourism Data Center, in the first three quarters of 2024, China's rural tourism received 2.248 billion visitors, accounting for 52.3% of total domestic tourism, with total revenue reaching 1.32 trillion Yuan, accounting for only 30.3%, reflecting issues such as low added value in the industry chain, serious homogenization, and insufficient digitalization. At the same time, the National Development and Reform Commission's "Digital Rural Development Strategy Outline" emphasizes "promoting the deep integration of digital technology with agricultural and rural development." In this context, the digital transformation of rural tourism is not only an inevitable choice driven by technology, but also a key path to resolve the structural contradiction of "high traffic, low income."

In recent years, blockchain technology, due to its "distributed trust" nature, has been incorporated into national strategy. The State Council's "14th Five-Year Plan for Digital Economy Development" includes blockchain as a "strategic and forward-looking field," and the Ministry of Culture and Tourism's "Opinions on Promoting the High-Quality Development of Digital Cultural Industries" emphasizes the "exploration of innovative applications of blockchain in the cultural and tourism sectors." However, there is still a significant gap between policy benefits and technological implementation: first, the technical adaptation contradiction. Most existing blockchain solutions are designed for urban high-computing scenarios and are disconnected from rural low-bandwidth, weak computing infrastructures. For example, the high gas fees and energy consumption of Ethereum's public chain are incompatible with the payment capabilities of rural micro-economies. Second, there is a lack of governance coordination. Rural tourism involves multiple stakeholders such as governments, enterprises, villagers, and tourists, and the on-chain rules and off-chain systems lack effective coupling. For instance, a "homestay alliance chain" pilot in a province ran into problems because villagers' awareness of data sovereignty was weak, leading to the "empty circulation" of on-chain data. Third, there are concerns about cultural conflicts. The logic of blockchain driven by technological rationality may erode the ethical

relations within rural society. For instance, the rigidity of smart contracts in execution conflicts with the flexible governance tradition in rural "social relations."

So how does blockchain technology systematically reconstruct rural tourism scenarios? Existing research often focuses on single technical functions such as traceability and payment, lacking holistic consideration of the "technology-scenario-governance" collaborative mechanism. This study attempts to answer the following questions: How can blockchain technology deeply integrate with the complex social networks of rural tourism? How can "lightweight" technical solutions be designed to address the constraints posed by the weak digital infrastructure in rural areas? How can on-chain rules reconstruct the trust relationships and benefit distribution mechanisms of multiple stakeholders? Based on this, this paper attempts to construct a "technology-scenario-governance" collaborative framework at the theoretical level, proposing a three-level analysis framework: first, from the technical layer, analyzing blockchain's consensus algorithms, smart contracts, and other technical features; second, from the scenario layer, deconstructing the core scenarios of rural tourism such as consumption chains, supply chains, and governance chains; third, from the governance layer, designing a collaborative mechanism for government guidance, market-driven forces, and villagers' participation. This framework breaks through the limitations of "instrumental rationality" and reveals the bi-directional interaction between technological empowerment and social construction, providing a new paradigm for digital rural research. In practical terms, it addresses the trust crisis and collaboration difficulties in rural tourism. Currently, trust issues in rural tourism manifest in three aspects: first, tourists' doubts about false advertising, overcharging, and service quality; second, villagers' rejection of external capital due to land transfer disputes; third, the government's failure to effectively supervise issues like ecological data falsification. Blockchain can solve this by using features like "immutable timestamps" and "multi-party consensus mechanisms" to create a trusted data flow throughout the entire process of "tourist booking-service delivery-post-evaluation."

## 2 LITERATURE REVIEW AND THEORETICAL GAPS

### 2.1 Research Trajectory of Rural Tourism Development

#### 2.1.1 Concept evolution: from "suburban leisure" to "reproduction of rural values"

The concept of rural tourism has continuously evolved in response to shifting urban-rural dynamics and technological advancements. Early studies (Lin Gang, 2006) defined rural tourism as "short-distance leisure activities in suburban areas," primarily emphasizing urban residents' demand for natural landscape consumption. However, since the advent of the 21st century and the implementation of the rural revitalization strategy, the conceptual focus of rural tourism has transitioned toward the "reproduction of rural values". First, economic value production has expanded beyond the traditional agritainment-based economy to a more integrated industrial model that combines "cultural tourism, agriculture, and e-commerce". For instance, blockchain technology has been leveraged to enhance "agricultural product traceability and the integration of cultural tourism intellectual property (IP)", thereby increasing added value. Second, cultural value production has undergone a transformation, with rural areas shifting from being mere "objects of external gaze" to becoming "active cultural subjects". The digitization of intangible cultural heritage and the promotion of localized narratives have emerged as key research focal points. A notable example is Zhangjiajie's application of blockchain technology to establish digital ownership of Tujia brocade, facilitating the conversion of cultural resources into valuable assets. Third, ecological value production has moved away from a resource-consumptive model toward a more environmentally sustainable approach, emphasizing carbon footprint tracking and incentives for eco-friendly behaviors. In Jiangsu Province's pilot initiatives, blockchain technology has been employed to record tourists' ecological behavior data and integrate it into a carbon credit exchange system. This evolutionary trajectory highlights a fundamental paradigm shift in rural tourism—from spatial consumption to value co-creation. Nevertheless, the digital transformation of rural tourism continues to face structural challenges that warrant further exploration.

#### 2.1.2 Pain points: data silos, subject dishonesty, and ecological loss

Xu Hong and other scholars have systematically identified three core challenges confronting rural tourism[1]. First, the issue of data fragmentation. The data systems utilized by governments, enterprises, and local villagers remain disconnected, hindering seamless information exchange. For instance, rural tourism reservation systems and homestay management platforms operate independently, leading to inefficiencies and an imbalance in tourist distribution. Second, a crisis of trust among key stakeholders. Tourists often express skepticism regarding service quality (e.g., misleading advertising), villagers exhibit distrust toward external capital inflows (e.g., disputes over land transfers), and government authorities question the efficacy of regulatory mechanisms (e.g., potential falsification of ecological data). Empirical studies indicate that 72% of rural tourism-related complaints stem from information asymmetry. Third, environmental degradation. Excessive development has significantly strained the ecological carrying capacity of rural areas. While blockchain technology presents a potential solution through an "immutable environmental monitoring data chain" that could facilitate early warnings for ecological red lines, current implementations remain largely theoretical[2]. These challenges underscore the dual predicament of "insufficient technological empowerment" and "lagging governance mechanisms" in rural tourism, highlighting the urgent need for industrial ecosystem reconstruction through technological innovation.

### 2.2 Theoretical Extension of Blockchain Technology

#### 2.2.1 Technical essence: distributed trust machine

The blockchain architecture introduced by Satoshi Nakamoto (2008) fundamentally operates as a decentralized trust mechanism, leveraging cryptographic techniques and consensus algorithms to ensure data integrity and security. Its core attributes include the following: first, a time-sequenced data chain, where blocks are chronologically linked to maintain data traceability; second, smart contracts, which autonomously execute predefined rules to minimize human intervention (e.g., ticket splitting); and third, consensus mechanisms, such as Proof of Work (PoW) and Proof of Stake (PoS), which guarantee data consistency across the network. In the context of rural tourism, blockchain technology offers a potential solution to the “trust deficit” by enhancing transparency and accountability. For instance, an alliance chain-based scenic reservation system could enable the fair and transparent allocation of tourist traffic, thereby mitigating issues such as ticket scalping.

### **2.2.2 Social empowerment: from “efficiency tool” to “reconstruction of production relations”**

Blockchain extends beyond its role as a mere efficiency-enhancing tool and actively reshapes social production relations through distributed collaboration[3]. This transformation is reflected in three key dimensions: first, the decentralization of power, whereby villagers can directly participate in the distribution of tourism-generated revenue through Decentralized Autonomous Organizations (DAOs), thereby challenging traditional capital monopolies; second, the reconfiguration of value circulation, facilitated by token-based economic models that convert tourist behavior data into tradable digital assets. For example, within a specific industry alliance chain, tourists’ review data could be exchanged for commodity discounts, fostering an ecosystem of value-sharing; and third, the innovation of governance models, where on-chain protocols operate in tandem with off-chain regulatory frameworks. For instance, smart contracts can be programmed to trigger automated emergency responses, thereby improving governance efficiency and crisis management. This theoretical extension underscores that blockchain is not merely a technical instrument for optimizing efficiency but also serves as a “technological lever” capable of fundamentally reshaping rural socio-economic structures.

## **2.3 Research gaps and breakthrough directions**

### **2.3.1 Current limitations: scenario fragmentation and insufficient research on technology-rural adaptability**

While research on blockchain-enabled rural tourism has made notable strides[4], several critical limitations remain. First, scenario fragmentation. Existing studies predominantly focus on isolated functions—such as traceability and payment systems—without a comprehensive, systematic integration of blockchain applications[5]. Second, insufficient technology-rural adaptability. Many blockchain solutions are designed for urban contexts and fail to align with the realities of rural environments. For instance, Ethereum’s public blockchain, with an annual average power consumption of approximately 110 TWh, poses significant challenges in rural areas with limited computing infrastructure, leading to excessive implementation costs[6]. Third, a lack of governance coordination. Most research overlooks the potential conflicts between on-chain governance rules and traditional rural social ethics. For example, the rigid automation of smart contracts may erode the flexibility of rural dispute mediation mechanisms, which are often embedded in deeply rooted social networks and informal negotiations.

### **2.3.2 Systematically build scenario-based logic for blockchain empowerment**

To address these research gaps, this study proposes three key breakthrough directions. First, the development of a scenario integration framework based on SST, constructing a “technology layer–scenario layer–governance layer” collaborative model. In this model, the technology layer emphasizes the design of lightweight blockchain architectures, the scenario layer integrates blockchain applications across consumption, supply chain, and governance functions, and the governance layer prioritizes government leadership and community co-governance. Second, adaptive technological innovation, achieved through an “edge computing + layered consensus” approach to reduce technical barriers and enhance blockchain's compatibility with rural infrastructures. Third, cultural compatibility mechanisms, which aim to balance technical rationality with rural social norms through “on-chain rule flexibility.” For instance, in dispute resolution scenarios, smart contracts could incorporate an artificial arbitration interface, ensuring that automated processes retain space for traditional local mediation practices[7]. This theoretical framework not only addresses existing research gaps but also offers a replicable practical paradigm for the integration of blockchain technology into rural tourism.

In conclusion, while existing research has underscored the urgency of rural tourism’s digital transformation and explored blockchain’s application potential, its fragmented perspective and lack of technological adaptability have constrained both theoretical depth and practical impact. This study systematically integrates technological logic, scenario-specific requirements, and governance mechanisms to develop an empowerment framework that is both academically innovative and practically viable, providing robust theoretical support and concrete technical solutions for advancing the rural revitalization strategy.

## **3 THEORETICAL FRAMEWORK OF BLOCKCHAIN EMPOWERING RURAL TOURISM**

### **3.1 Logical Basis of Technology Empowerment**

#### **3.1.1 The “trilemma” of rural tourism: efficiency, trust, and cultural protection**

The sustainable development of rural tourism faces the three-dimensional contradiction of “efficiency-trust-cultural protection”. This paradox is essentially a microcosm of the conflict between the modernization process and the traditional rural social structure. The first is the efficiency dilemma. Rural tourism's long supply chains and fragmented

stakeholders lead to slow information transmission. For example, a province's fragmented homestay reservation platforms resulted in a 35% vacancy rate, while peak seasons faced overbooking disputes. Reports indicate that rural tourism enterprises take 2.3 times longer to process orders than urban counterparts, with manual verification costs accounting for 12% of revenue. The second is a crisis of trust. On the one hand, Between tourists and businesses: Frequent issues such as false advertising and hidden charges. 68% of rural tourism complaints are service-related, with 82% involving information opacity. On the other hand, development projects often trigger revenue-sharing disputes between villagers and external capital. In one Yunnan village, a tourism project was halted due to unfair land income distribution, stranding billions in investments. The third is the paradox of cultural protection. Commercial development accelerates the symbolization and hollowing out of rural culture. Blockchain technology can preserve cultural genes through "digital twins", but existing practices mostly stay on the surface of intangible cultural heritage QR code labels, lacking in-depth value mining. Wuzhen, Zhejiang, established a "cultural asset library" through blockchain, which put the traditional handicraft production process on the chain, increasing the income of craftsmen by 40%; while most regions still rely on the ticket economy, and the cultural added value is less than 15% of the total income. The essence of the above three paradoxes is that traditional technical solutions often lose one thing while taking care of another. Improving efficiency may aggravate capital monopoly, strengthening supervision will increase administrative costs, and cultural protection requires sacrificing short-term economic benefits. Blockchain technology provides new possibilities for solving this dilemma by reconstructing production relations.

### **3.1.2 Blockchain's path to success: trusted data flow and smart contract autonomy**

Blockchain technology reshapes the value transfer rules of rural tourism from the underlying logic, and its breakthrough path is reflected in two core mechanisms. The first is the innovation of the trusted data flow mechanism[8]. On the one hand, the whole process is recorded. From tourist reservations, service delivery to post-evaluation, all behavioral data are uploaded to the chain by timestamp, forming an unalterable "digital footprint". For example, Zhouzhuang Ancient Town of Suzhou records merchant credit data through the alliance chain, and the tourist complaint rate has dropped by 57%. On the other hand, cross-subject sharing is achieved. Break the data silos of government, enterprises, and villagers. After the "Rural Tourism Big Data Platform" in Nanjing was connected to the blockchain, the vacancy rate of homestays dropped from 28% to 11%, and the congestion index of scenic spots dropped by 34%. The second is to innovate the autonomous mechanism of smart contracts. The first is to execute automatic execution rules. In scenarios such as ticket splitting and ecological compensation, smart contracts automatically distribute income according to preset conditions. For example, in the Moganshan homestay alliance chain in Zhejiang, 15% of the income of each order is automatically transferred to the village collective account, and disputes are reduced by 83%. The second is to develop flexible governance design. In view of the characteristics of rural society, the contract can set up a "manual arbitration interface". For example, for orders canceled due to weather conditions, the system will prioritize triggering negotiations between villagers and tourists, and will only initiate on-chain arbitration if the dispute exceeds 48 hours. Obviously, different from the "instrumental empowerment" in the traditional technological sense, blockchain reconstructs the operating rules of rural society through "institutional empowerment", and its core is to embed technological logic into the governance structure.

## **3.2 Empowerment Model based on SST Theory**

### **3.2.1 Socio-technical system (STS) integration**

The theory of social-technical systems emphasizes the co-evolution of technology and social elements. Blockchain empowers rural tourism and can build a "technology-society" two-layer integration model, revealing the three-stage law of blockchain technology "embedding-adapting-reshaping" rural society[9]. First, build a distributed ledger and consensus mechanism at the technical level. Adopting a "main chain-subchain" hybrid architecture, the provincial cultural and tourism alliance chain is responsible for cross-regional collaboration as the main chain, and the village chain is used as a subchain to handle local high-frequency transactions. At the same time, cross-village transactions use the PBFT (Practical Byzantine Fault Tolerance) algorithm for consensus algorithm adaptation, and intra-village transactions use a lightweight PoA (Proof of Authority) algorithm to reduce energy consumption. In terms of performance optimization, the throughput is improved through "edge computing + off-chain channels", which is several times higher than that of traditional public chains. Second, create a culture of villager participation and governance at the social level. On the one hand, innovate the participation mechanism. The DAO governance model can be adopted, and villagers participate in decision-making by holding governance tokens such as the Rural Tourism Token, and the voting weight is linked to resource contribution. On the other hand, we can strengthen the cultivation of villagers' digital literacy by establishing a "chain school" training system, covering courses such as smart contract writing and node operation and maintenance, so as to greatly improve villagers' technical acceptance. The third is cultural integration. Embed "rural ethics code" in the chain rules. For homestays operated by left-behind elderly people, smart contracts automatically reduce or exempt platform commissions, and the village collective votes on the chain to decide the subsidy amount.

### **3.2.2 The "double helix structure" empowered by blockchain**

The dynamic evolution law of blockchain-enabled rural tourism can construct a "demand-driven-technology-driven" double helix model to make up for the split between technological determinism and social constructivism, and provide dynamic analysis tools for digital rural research. First, the demand-driven spiral: rural tourism pain points force technological innovation. In the first stage, problem identification can be carried out, and ecological loss can be used to force green governance technology; in the second stage, technical response can be carried out, and a "rural tourism asset tokenization" plan can be designed to address financing difficulties, splitting farmhouse use rights, cultural IP, etc.

into NFTs to attract small and micro investors. Second, the technology-driven spiral: blockchain characteristics give birth to new scenarios. In the first stage, technology spillover can be carried out, and the programmability of smart contracts can be used to give birth to a "dynamic pricing chain"; in the second stage, innovative application scenarios, based on zero-knowledge proof privacy protection technology, develop a "tourist behavior data market", where tourists can choose to sell desensitized data to obtain income while ensuring privacy and security.

#### **4 FOUR-DIMENSIONAL APPLICATION SCENARIOS ENABLED BY BLOCKCHAIN TECHNOLOGY**

##### **4.1 Trusted Service Chain: Reconstruction of Tourism Consumption Scenario**

Blockchain helps the service process to be on-chain, and the whole cycle from booking to evaluation is credible[10]. The fragmentation and information asymmetry of the rural tourism service chain are the core problems that cause the crisis of trust among tourists. By building a "full-cycle credible service" mechanism, blockchain technology can achieve breakthroughs in the following aspects. First, the automatic execution of smart contracts. In ticket verification, after tourists book tickets, the smart contract automatically generates a unique digital certificate (NFT ticket), and the on-chain verification triggers the split account during verification. In insurance claims, combined with IoT devices such as scenic area cameras and wearable devices, when an accident occurs, the smart contract automatically calls on-chain evidence such as geographic location and medical records to complete the claim. Second, the balance between tourist credit portrait and privacy protection. In credit dynamic assessment, a tourist credit scoring model is constructed based on on-chain behavioral data such as performance records and consumption preferences. Tourists with high credit scores can enjoy rights such as deposit reduction and priority reservation. In privacy computing technology, zero-knowledge proof is used to achieve "data available but invisible", and tourist identity information is encrypted and stored in IPFS, and only desensitized credit scores are provided to homestay owners, which not only protects privacy but also builds trust. The third is the local trust value-added of agricultural product traceability. The deep integration of rural tourism and agricultural product sales faces the dual dilemma of "origin fraud" and "premium ownership". Blockchain can trace the entire chain, from planting, processing to sales, and data from each link such as pesticide test reports, logistics temperature and humidity are uploaded to the chain in real time; blockchain can build local brands, consumers can scan the code to view farmers' information and directly reward them, and the on-chain account sharing rules ensure that 70% of the profits belong to the producers.

##### **4.2 Value co-creation chain: digital development of cultural and tourism resources**

First, the on-chain confirmation of rights and distributed creation of rural cultural IP. Traditional cultural tourism resource development often falls into a vicious cycle of "capital dominance-cultural alienation". Blockchain reconstructs value distribution through the following paths. In digital confirmation of rights, intangible cultural heritage skills and folk activities are transformed into digital assets (NFT), and ownership information is permanently stored. In distributed creation, tourists can participate in the co-creation of cultural content through the on-chain platform. For example, the Guizhou Dong Nationality Song NFT album allows tourists to record harmony fragments, and creators distribute royalties according to their contribution. The project attracted 12,000 participants within 3 months of its launch. Second, the design of the Token economic model, innovative points exchange and community incentives. In the tokenization of cultural tourism points, tourist consumption, environmental protection behavior, etc. can be exchanged for "rural tourism tokens" to offset accommodation costs or exchange for agricultural products. In terms of community governance incentives, villagers obtain governance tokens by maintaining nodes and participating in voting, which are used to determine the direction of reinvestment of tourism revenue, such as infrastructure upgrades or cultural protection.

##### **4.3 Green Governance Chain: Ecological Protection and Regulatory Innovation**

First, blockchain empowers rural tourism and forms smart contracts for carbon footprint tracking and ecological compensation. The ecological loss of rural tourism is mostly due to the lack of accurate measurement and incentive mechanisms. Blockchain technology provides the following solutions. In terms of carbon footprint quantification, IoT devices are used to collect carbon emission data from tourists' transportation, accommodation, and activities, and personal carbon accounts are generated on the chain in real time. In terms of intelligent compensation mechanism, carbon credits are automatically deducted from excess emitters and transferred to the ecological fund, while low-carbon actors receive token rewards. Second, blockchain empowers rural tourism and forms a chain of co-governance with "government-enterprise-villager" multi-subject collaborative supervision. In terms of transparent data sharing, government regulatory departments join the alliance chain as consensus nodes to obtain real-time data on corporate pollution discharge, tourist capacity, etc. In terms of joint decision-making on the chain, the three parties reach a resolution through on-chain voting on ecological protection disputes such as the felling of ancient trees, and the entire process is auditable.

##### **4.4 Inclusive Finance Chain: Reform of Rural Tourism Investment and Financing**

The first is the crowdfunding model based on DAO. Traditional rural tourism project financing is constrained by the

bottleneck of "lack of collateral-difficult credit assessment". Blockchain technology has achieved the following breakthroughs: In decentralized crowdfunding, villagers can publish projects such as homestay renovation through the DAO platform, and investors exchange small amounts of funds for future income rights. In dynamic income distribution, smart contracts automatically distribute income based on operational data such as project occupancy rates to avoid profit squeezes from traditional PE/VC. The second is on-chain data sharing for microcredit risk assessment. In multi-dimensional credit portraits, tourist consumption data, villagers' production data (such as agricultural product sales), government subsidy records, etc. are integrated to build an on-chain credit scoring model. In terms of risk sharing mechanism, financial institutions, guarantee companies, and village collectives jointly join the alliance chain, and automatic liquidation is carried out according to the preset ratio when a default occurs.

#### 4.5 Scenario synergy and technology adaptability

The above four-dimensional scenarios do not exist in isolation, but are organically linked through the underlying architecture of blockchain. First, data interoperability. The credit points accumulated by tourists in the trusted service chain can be used as the basis for loans in the inclusive finance chain; second, value circulation. The carbon points generated by the green governance chain can be exchanged for cultural IP derivatives in the value co-creation chain; third, governance coordination. The on-chain voting data of DAO crowdfunding projects provides a decision-making basis for government supervision. The in-depth analysis of the four-dimensional scenarios shows that blockchain technology provides a systematic solution for the high-quality development of rural tourism by reconstructing the trust mechanism, activating data value, and innovating governance models.

### 5 REAL CHALLENGES AND BREAKTHROUGH PATHS FOR BLOCKCHAIN -ENABLED RURAL TOURISM

#### 5.1 Technical Adaptability Challenges

There is a gap between the demand for computing power and rural digital infrastructure in blockchain-enabled rural tourism. The contradiction between the high computing power demand of blockchain technology and the weak rural digital infrastructure is the primary obstacle to the implementation of technology. Rural tourism is mostly distributed in remote areas with a lack of computing power resources. According to the 2023 "White Paper on Digital Infrastructure in Chinese Counties", the server computing power of 75% of rural areas is less than 10% of the average level in cities, making it difficult to support high-energy consumption consensus algorithms such as PoW (proof of work)[11]. At the same time, rural network coverage is uneven. The coverage rate of 5G base stations is less than 30%, and bandwidth bottlenecks cause serious delays in on-chain transactions. As a result, high-performance public chains require dense node deployment, and urban-dominated technical solutions ignore the characteristics of rural scenarios. In rural areas, the node downtime rate is often as high as 35% due to unstable power supply and shortage of operation and maintenance personnel. In view of rural resource constraints, the three principles of "low energy consumption-high availability-easy expansion" of lightweight blockchain architecture design must be followed: First, the layered consensus mechanism, cross-regional transactions use the PBFT algorithm, which is suitable for government-enterprise collaboration, and high-frequency transactions within the village use the PoA algorithm, which is verified by trusted nodes such as village committees and cooperatives. The second is edge computing integration, where data preprocessing and simple contract execution are transferred to village servers. The third is modular pluggability, where identity authentication, smart contracts, storage and other functions can be modularized and dynamically configured according to the size of the village.

#### 5.2 Governance synergy challenges

The blockchain-enabled rural tourism faces the dilemma of coupling the on-chain and off-chain systems. The logic of "code is law" is in structural conflict with the existing rural governance system. First, there is a conflict of rules. The automatic execution of smart contracts may override the traditional mediation mechanism. For example, in a cancellation dispute, the contract forcibly deducts the full room fee, triggering a conflict between villagers and tourist groups. The government is forced to intervene in mediation, increasing governance costs. At the same time, there is an overlap of rights and responsibilities between the on-chain DAO governance and the "Organization Law of Village Committees". Once the results of the villagers' on-chain voting conflict with the village committee's resolution, the project will be shelved. Second, data silos are deepened. The government regulatory system is incompatible with the on-chain data format, and cross-platform data calls fail. In response to the above-mentioned rule conflicts and data silos, it is urgent to build a data sovereignty and benefit distribution mechanism. On the one hand, the ownership is unclear. The property rights of tourist behavior data and villagers' production data after being put on the chain are not clearly defined. On the other hand, the distribution is unbalanced. Technology companies often extract 20%-30% of the revenue in the name of "platform operation and maintenance", squeezing the villagers' profit space.

#### 5.3 Cultural Conflict Challenges

There is a value tension between technical rationality and rural ethics in blockchain-enabled rural tourism. The

"dehumanization" logic of blockchain is in deep contradiction with the "relationship network" tradition of rural society[12]. The on-chain credit scoring mechanism ignores the "reciprocal ethics" of rural areas. For example, left-behind elderly people are restricted from accepting orders by the system due to low credit scores caused by operational errors, which has caused ethical disputes. At the same time, there is also a risk of cultural erosion. The value system dominated by technology, such as the Token economy, may weaken rural cultural identity. Based on this, we can innovate the path to improve the digital literacy of villagers. According to the 2023 "China Rural Digital Literacy Report", only 29% of villagers can operate blockchain applications independently, and 56% have "technophobia", which requires improving the digital literacy of villagers. First, in terms of education strategy, a hierarchical training system can be adopted: at the basic level, the concept of blockchain can be popularized through short videos and dialect manuals; at the advanced level, "rural blockchain operation and maintenance" courses can be opened in vocational colleges to train local technicians. Second, in encouraging participatory design, villagers are invited to jointly develop a "rural-friendly" interactive interface.

#### 5.4 Breakthrough Path Design

In response to the above three challenges, we can innovate the paths from three aspects: technology iteration, institutional innovation, and cultural integration. The first is technology iteration, building a "modular blockchain + edge computing" solution. From the technical architecture, modular design is carried out to split the core functions into independent modules, and villages can choose them as needed. Implement edge-cloud collaboration, local servers process real-time transactions, and periodic data is synchronized to the provincial main chain. The second is institutional innovation, building a multi-party chain governance committee. In terms of organizational structure, the on-chain governance committee is composed of the government, enterprises, villagers, and technical parties, and major matters are decided through on-chain voting; in terms of operating mechanism, dynamic equity distribution is carried out, and voting weights are adjusted according to participation. At the same time, the on-chain and off-chain arbitration are well connected, and a "hybrid dispute mediation pool" is established. Disputes are automatically adjudicated by smart contracts, and the excess is transferred to the offline villager mediation committee. The third is cultural integration, a technology domestication strategy based on rural standards. In terms of ethical coding, rural ethical rules are embedded in smart contracts. In terms of cultural symbol implantation, rural totems, dialects and other elements are integrated into the on-chain interface design. In terms of localized narrative, blockchain technology is presented through channels such as village history museums and cultural festivals as a "collective accounting tool of the new era" rather than "foreign technology invasion."

## 6 CONCLUSION AND OUTLOOK

### 6.1 Research Conclusions

First, blockchain reshapes the production relations of rural tourism through "trusted machines". Blockchain technology has profoundly changed the production relations structure of rural tourism by building "unalterable trust mechanisms" and "decentralized value distribution rules". First, the power structure is reconstructed. In traditional rural tourism, capital and local governments dominate resource allocation, and villagers are in a passive position. Blockchain gives villagers on-chain voting rights through DAO (decentralized autonomous organization), allowing them to directly participate in profit distribution decisions. Second, value transfer innovation. Blockchain transforms "implicit values" such as tourist behavior data, cultural IP, and ecological contributions into quantifiable and tradable on-chain assets. Third, the governance model is upgraded. The automatic execution of smart contracts replaces traditional manual supervision, reducing administrative costs while improving governance transparency.

Second, technology empowerment must follow the "rural-friendly" adaptation principle. The implementation of blockchain in rural areas must overcome the tendency of "technological hegemony" and build an adaptation strategy that respects the rural social and cultural orientation. First, the technology is lightweight, using "edge computing + modular architecture" to control the system computing power requirements within the affordable range of the countryside. Second, the system is flexible, reserving a "local mediation interface" in the on-chain rules. For example, for orders canceled due to weather reasons, the system will give priority to triggering negotiations between villagers and tourists, rather than mechanically executing the deduction of liquidated damages. Third, cultural compatibility, integrating rural traditional values into technical design through "ethical coding."

### 6.2 Theoretical Contributions and Practical Implications

First, improve the empowerment framework from the perspective of social technology system at the theoretical level. The first is to build a "technology-scenario-governance" collaborative model. Reveal the process of blockchain technology being embedded in the rural social network through "trusted data flow", and propose that technology empowerment needs to go through three stages: "instrumental application-institutional embedding-cultural integration". For example, it is used for ticket verification in the early stage (instrumental), reconstructing the accounting rules in the medium term (institutional), and finally promoting villagers' participation in governance (cultural). The second is the double helix evolution mechanism. Construct a "demand-driven-technology-driven" dynamic model to explain how the pain points of rural tourism force technological innovation (such as carbon tracking chain), and how the new

technological characteristics give rise to new scenarios (such as Token economy). The third is the rural adaptability theory. The three major adaptation principles of "lightweight, elastic, and culturally friendly" are proposed, filling the gap in the theory of technological adaptability in digital rural research.

Second, a phased implementation roadmap of "Rural Blockchain +" is proposed at the practical level. A "three-step" implementation path is designed to verify the technical feasibility during the pilot period, build a regional collaborative network during the promotion period, and form a rural digital ecology during the deepening period.

### 6.3 Future Prospects

In the future research direction, the integration of cultural tourism scenes of Metaverse, AI and blockchain will be promoted, and the next generation of digital technology will promote rural tourism into a new stage of "virtual and real symbiosis". First, the cultural experience will be upgraded through "Metaverse + Blockchain". Through the construction of virtual rural landscapes by digital twin technology, tourists can enter the Metaverse space through NFT tickets, participate in virtual farming activities or intangible cultural heritage creation, record behavioral data on the chain and exchange physical rights. Second, the personalized service revolution will be completed through "AI + Blockchain". AI analyzes on-chain tourist data (such as consumption preferences and carbon footprints), dynamically generates personalized travel plans, and automatically executes services through smart contracts. Third, to meet the ethical challenges of technological integration, we must be wary of the tendency of "technological utopia". Cultural symbols in the Metaverse may be alienated into consumer labels by capital, and the subjectivity of rural culture must be guaranteed through the on-chain right confirmation mechanism.

In terms of policy orientation, a rural revitalization blockchain innovation experimental zone is established to accelerate the implementation of technology and propose a four-dimensional policy framework. The first is institutional innovation. Revise the "Rural Tourism Service Quality Standards", clarify the legal effect of on-chain credit data, and allow blockchain evidence to be used as a basis for dispute arbitration. The second is financial support. Establish a "Rural Revitalization Blockchain Special Fund" to provide 30%-50% hardware subsidies to villages that adopt lightweight technology. The third is talent cultivation. Set up a "Rural Blockchain Operation and Maintenance" major in vocational colleges, implement the "One Village, One Technician" plan, and cultivate local technical talents. The fourth is risk prevention and control. Formulate the "Rural Blockchain Application Security Guidelines" and establish a technical ethics review committee to prevent data abuse and cultural erosion.

In summary, the essence of blockchain empowering rural tourism is not "technological colonization", but to activate the endogenous power of rural areas through "trusted machines" and realize the ultimate return of technology for good and rural-based. The core proposition of the future is: how to protect the roots of local culture while improving efficiency and achieve common prosperity in digital transformation. This requires continuous dialogue between academia, politics and rural society, so that technology can truly become "a force for innovation with the fragrance of soil."

### COMPETING INTERESTS

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