Research on the Mechanism and Pathways of Green and Low-carbon Transition for Rural Cultural Tourism in Hebei Driven by Digital Technology

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Abstract

Under the dual strategic context of "carbon peak and carbon neutrality" and "rural revitalization", how to achieve a rapid and high-quality green and low-carbon transition in rural cultural tourism has become a pressing practical issue. Taking Hebei Province as a case study, this research focuses on the underlying mechanisms through which digital technology drives this transformation. By conducting a systematic analysis, a theoretical framework of "technology empowerment - industry integration - green transition" is constructed. Accordingly, targeted implementation pathways are proposed, including platform-based integration, intelligent upgrading, and green development. The study aims to provide valuable insights for promoting high-quality development in the culture and tourism sectors of Hebei and supporting its rural revitalization efforts.

Keywords

Digital technology, Rural cultural tourism, Green and low-carbon, Transition mechanism, Hebei Province

Introduction

With the growing severity of global climate change, the green and low-carbon transition has become a consensus within the international community for addressing climate challenges. In 2020, China proposed the "Dual Carbon" goals (carbon peak and carbon neutrality), charting a course for high-quality economic and social development while also placing higher demands on the transformation and upgrading of various industries [1]. As a key driver of rural revitalization, the quality of the green and low-carbon transition in the rural cultural tourism sector not only affects the sustainability of the industry itself, but also directly influences the progress and outcomes of comprehensive rural revitalization.

In recent years, the rapid development and widespread application of digital technologies have injected strong momentum into the green and high-quality development of rural cultural tourism [2,3]. Digital technology is not only reshaping traditional models of cultural and tourism services, but also providing robust technical support for steering the industry toward a green and low-carbon direction. Therefore, how to effectively leverage the driving role of digital technology and promote the green and low-carbon transformation of rural cultural tourism has become a critical issue requiring urgent attention from both academia and industry.

Analysis of the mechanisms for digital technology driving the green and low-carbon transition in rural cultural tourism

The driving effect of digital technology on the green and low-carbon transition of rural cultural tourism is primarily realized through three core mechanisms:

technology empowerment, industry integration, and green transition.

Technology empowerment

Technology empowerment forms the foundation for digital technology to drive the green and low-carbon transition of the cultural tourism industry.

First, digital technology establishes a more precise decision-making mechanism. By leveraging big data collection, analysis, and processing, it provides scientific decision-making support for policymakers, managers, and operators. This effectively addresses historical issues of resource misallocation and excessive environmental load caused by over-reliance on experience and intuition. For instance, through tourist flow monitoring systems, operators can obtain real-time data on visitor numbers and movement patterns across different areas and time periods. Flow guidance based on this data helps prevent localized overcrowding in scenic areas, thereby avoiding problems like vegetation trampling, waste accumulation, and facility damage. Simultaneously, the monitoring data aids operators in scientifically formulating reservation and visitor quota strategies, keeping the total tourist volume within the environmental carrying capacity of the site [4,5].

Second, technology empowerment significantly enhances resource allocation efficiency. Utilizing AI algorithms and automated control systems, digital technology enables dynamic, precise, and automated resource management. This greatly improves resource utilization efficiency and reduces waste. For example, AI technology can analyze historical data (such as past occupancy rates and tourist consumption habits) alongside current real-time data (like instant booking numbers, weather changes, and real-time visitor flow) to accurately forecast future demand (e.g., required rooms and meals) and resource availability (e.g., available rooms, food inventory).

Third, by constructing integrated platforms, digital technology can interconnect the entire rural cultural tourism industry chain, facilitating efficient collaboration between upstream and downstream sectors. This not only improves the overall efficiency of the industry but also provides technical support for its green and low-carbon transition. In supply chain management, for example, such platforms enhance supply efficiency by integrating and optimizing industry chain resources. Furthermore, by reducing intermediate links like transportation and storage, they effectively lower both costs and carbon emissions.

Industry integration mechanism

The widespread application of digital technology promotes the coordinated development of the rural cultural tourism industry and other industries. For example, the integration of agriculture and tourism innovatively combines traditional agriculture with tourism, giving rise to diverse formats such as agricultural experience activities, rural sightseeing, and direct sales of agricultural products. The integration of culture and tourism relies on digital technologies such as Virtual Reality (VR) and Augmented Reality (AR) to innovate cultural presentation forms, provide immersive experiences, and effectively promote the revitalization and utilization of traditional cultural resources [6]. Digital technology also optimizes industrial operation models, promoting the effective enhancement of efficiency and value. This is reflected in its partial alteration of the traditional rural cultural tourism model, which in the past could only provide relatively simple and limited-value services (primarily basic services such as accommodation, dining, and sightseeing).

Through the analysis of tourist data by digital technology, more precise personalized recommendations and services can be provided to a greater extent, effectively enhancing tourist experience and satisfaction. At the same time, by constructing digital platforms that connect various service providers such as homestays, restaurants, scenic spots, and suppliers, transparent information sharing, intelligent resource scheduling, and reasonable profit distribution can be achieved, effectively improving overall benefits.

Green transition mechanism

Digital technology achieves its sustainable development goals by constructing an efficiency optimization mechanism oriented towards resource conservation: It accomplishes intelligent and dynamic allocation of resources through accurate demand prediction (e.g., for energy, water, material consumption), thereby avoiding excessive input and waste at the source. Through real-time monitoring and optimized management of equipment and operational processes, it promotes the effective improvement of equipment utilization rates and overall operational efficiency [7,8]. The use of systems such as e-ticketing and online platforms effectively reduces the excessive reliance on paper materials and human resources in traditional operations. The use of a digital environmental monitoring system can establish real-time dynamic monitoring, risk warning, and emergency response for environmental elements such as PM 2.5, PM 10, water bodies, and soil within tourism areas, providing data support for refined environmental governance. By constructing a carbon emission management system covering accounting, tracking, trading, and other aspects, along with blockchain technology, precise measurement of multi-dimensional emission sources and traceability of footprints can be achieved, promoting the efficient market circulation and optimal allocation of carbon emission rights.

Current status of digital empowerment in Hebei's rural cultural tourism

In recent years, the rural cultural tourism industry in Hebei Province has shown a trend of continuous expansion, with its scale constantly increasing [9]. Statistical data indicates that the number of tourist receptions in Hebei's rural tourism grew from 85 million in 2016 to 205 million in 2019, while tourism revenue surged from 14.8 billion yuan to 44.24 billion yuan. The average annual growth rates reached 34.13% and 44.42% respectively, demonstrating the vast potential of the regional market and the broad prospects for industrial development. With the implementation of the rural revitalization strategy and increased government investment, rural digital infrastructure has been continuously optimized: He breadth of 5G network coverage has significantly improved, broadband network coverage in rural areas has reached a high level. The construction of new digital infrastructure systems such as cloud computing centers and big data platforms has been accelerating. The application of digital services is becoming increasingly widespread: The coverage rate of online booking systems has reached 85%, becoming the main channel for tourists to access services such as accommodation, dining, and tickets; the penetration rate of digital payments has reached 90%, with mobile payments and QR code payments becoming the dominant payment methods; the coverage rate of smart guide systems has reached 65%, providing personalized tour guide services for visitors. Although the application of VR/AR experiences started relatively late, it shows a positive development trend, primarily used in historical and cultural displays and virtual experience scenarios. However, in the process of digital technology empowering the green and low-carbon development of rural cultural tourism, there exist issues such as uneven levels of digital application, the need for enhanced awareness of green and low-carbon concepts, insufficient depth in the integration of technology and industry, and incomplete coordination mechanisms. These problems, to some extent, affect the progress of green and low-carbon development of rural cultural tourism resources.

Practical pathways for digital technology empowering the green and low-carbon transition of rural cultural tourism in Hebei

Based on the aforementioned mechanism analysis and current status assessment, the pathways for achieving the green and low-carbon transition of rural cultural tourism in Hebei Province can focus

on three core directions: platform-based integration, intelligent upgrading, and green development.

Deepening platform-based integration

There is an urgent need to construct a unified comprehensive service platform for rural cultural tourism [10]. This platform should integrate functions for tourist services (attraction inquiry, route planning, online booking, payment, feedback and evaluation, personalized recommendations), business management (product listing, order processing, customer service, data analysis), and government oversight (data statistics, quality monitoring, environmental monitoring, policy release) to provide integrated technical support for the industry's green and low-carbon transition.

The key to realizing the platform's effectiveness lies in establishing a system for holistic data sharing. This requires formulating unified data coding standards and exchange protocols to break down data barriers between departments, regions, and enterprises. By integrating government data (from culture and tourism, environmental protection, transportation, meteorology, etc.), market entity operational data, and social data (from social media, academic research, user reviews), it provides a comprehensive data foundation for precise decision-making and coordinated management.

Ensuring the platform's long-term operation necessitates innovative institutional design. Establish a model guided by the government, led by enterprises, and operated by market forces. Constructing a multi-stakeholder governance structure (involving government, enterprises, academic institutions, and social organizations) to ensure impartiality. Explore diversified revenue models (service fees, advertising, data services) to guarantee financial sustainability. Simultaneously, establishing a dedicated technical team responsible for system iteration and security maintenance to continuously enhance the platform's technical resilience and service efficacy.

Advancing intelligent upgrading

Intelligent facility transformation constitutes the foundational carrier for improving energy efficiency and optimizing experiences [11]. In the accommodation sector, promoting smart room systems to achieve intelligent regulation of the environment (temperature, humidity, lighting, air conditioning) for higher energy efficiency. In the catering sector, applying intelligent kitchen systems to optimize ingredient procurement, processing procedures, and waste handling, reducing food waste. In the transportation sector, deploying intelligent transportation systems to optimize vehicle dispatch, route planning, and parking management, alleviating congestion and reducing emissions.

The full-journey digital service model is the core engine for upgrading tourist experiences. In the pre-trip phase, generating personalized itineraries based on tourist profiles and spatiotemporal big data. During the trip, utilizing artificial intelligence to provide real-time services such as smart guides, voice assistants, and real-time translation. In the post-trip phase, facilitating experience sharing and evaluation through social media platforms, forming a closed loop.

A provincial-level intelligent management hub is the critical infrastructure for green and low-carbon governance. The system should include an intelligent resource allocation module (optimizing the allocation of human, financial, and material resources), an intelligent environmental monitoring module (real-time monitoring of air, water quality, noise, and other indicators), an intelligent safety and security module (safeguarding tourists, facilities, and data), and an intelligent quality evaluation module (scientifically assessing service, product, and management quality), thereby achieving comprehensive, precise, and efficient management of the industry.

Strengthening green development

A multi-level green standard system provides institutional guarantees for the transition [12]. Hebei Province should further formulate standards and norms tailored to local conditions and specific times, covering environmental protection (air, water, soil, and noise pollution prevention and control

standards), resource utilization (energy, water, land use efficiency standards), carbon emission control (total volume, intensity, and neutrality targets), and ecological restoration (ecosystem restoration, biodiversity conservation, and landscape ecology construction standards).

The integrated application of green technologies forms the core driver for emission reduction. In clean energy, it actively promotes the application of solar, wind, and biomass energy in cultural and tourism facilities. In energy conservation and emission reduction, popularizing high-efficiency energy-saving equipment and technologies such as LED lighting, inverter air conditioners, and intelligent control systems. In the circular economy, we promote technologies like waste recycling, reclaimed water reuse, and organic waste composting to realize resource recycling.

A full-cycle green evaluation mechanism ensures sustainable development. Constructing a multi-dimensional comprehensive evaluation system covering environmental, economic, and social benefits. Employing evaluation methods that combine quantitative and qualitative analyses, and integrate expert and public input. Linking evaluation results with policy support, financial assistance, market access, etc., to form a result application mechanism that balances incentives and constraints, guiding enterprises and projects to proactively practice green development.

Conclusion

This study focuses on the green and low-carbon transition of the rural cultural tourism industry in Hebei Province under the impetus of digital technology. Through an in-depth analysis of the industry's current status, it constructs a "technology empowerment - industry integration - green transition" theoretical framework, systematically elucidates the internal mechanisms of the transition, and proposes targeted implementation pathways and strategies to address existing challenges.

The main conclusions are as follows:

First, digital technology serves as the core driving force for promoting the green and low-carbon transition of the rural cultural tourism industry. The application of big data, artificial intelligence, the Internet of Things, and other technologies enables precise resource allocation, intelligent management, and green development, effectively reducing carbon emission intensity and enhancing resource utilization efficiency.

Second, technology empowerment provides foundational support for the transition through data-driven decision-making, intelligent resource allocation, and platform-facilitated collaboration; industry integration promotes industrial structure optimization and upgrading through cross-boundary innovation, value chain reconstruction, and ecosystem synergy; green transition ultimately achieves sustainable development goals by improving resource efficiency, strengthening environmental monitoring and protection, and implementing refined carbon emission management. These three elements are interconnected and function in a progressive, layered manner.

Third, platform-based integration, intelligent upgrading, and green development represent three effective pathways for Hebei Province to realize the green and low-carbon transition of its rural cultural tourism. Platform-based integration emphasizes resource coordination and synergy; intelligent upgrading focuses on efficiency enhancement and experience optimization; green development targets environmental protection and sustainability. These three pathways are mutually reinforcing and together constitute a systematic approach for driving the industry's transformation and upgrading.

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Conflicts of Interest

The authors declare no conflict of interest.

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