

Research on Cultural Adaptation Mechanisms of the Duku Heritage Corridor Based on Heritage Ecosystems

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Abstract

The Duku Heritage Corridor is known as "China's Most Beautiful Highway", represents the the essence of the Tianshan World Heritage Scenic Byway. The 14th Five-Year cultural development Plan from China's central government emphasizes the importance of systematically protecting and utilizing historical and cultural heritage. Cultural adaptability plays an important role in achieving this balance by fostering harmony between cultural heritage and ecosystems. Through the creation of adaptive landscapes, integrating "ecological restoration - health restoration - cultural restoration - economic restoration", it is possible to ensure both preservation and sustainable use of heritage corridors. The Duku Heritage Corridor erves as a valuable case study for exploring how these principles can be implemented effectively. By analysing the "production space", "living space", and "ecological space" along the corridor, the research provides insights into how these spaces can coexist and support each other. The findings inform the development of a culturally adaptive management model that can guide route planning, infrastructure design, and conservation strategies. Ultimately, the proposed model offers a comprehensive framework for understanding the unique cultural and natural heritage of the Duku Heritage Corridor.

Keywords: Heritage ecosystems; Duku heritage corridors; multiple values; cultural adaptation mechanisms; digital management

1 Introduction

Since the promotion of the strategy of 'Tourism Development of Xinjiang' and the implementation of the project of 'Culture Runs Xinjiang', the regional government has made every effort to promote the development of Xinjiang's tourism industry. 2019, in order to promote the vigorous development of the new industry pattern of 'Transportation + Tourism In 2019, in order to promote the 'transport + tourism' new mode of vigorous development, the implementation of the regional party committee '1 + 3 + 3 + reform and opening up' for the precise poverty alleviation, rural revitalisation and vigorously develop the tourism industry deployment of the 'traffic and tourism exemplary project', in response to the traffic and transport In 2024, General Secretary Xi made an important instruction on tourism work, stressing that efforts should be made to improve the modern tourism system and accelerate the construction of a strong tourism country, promote the high-quality development of tourism to make a steady progress^[1], shape the tourism with the culture, highlight the culture with the tourism, and protect the cultural heritage and ecological resources. By promoting the construction of 'full-time' tourism along the Dokku route and driving the development of the regional economy, it will help multi-ethnic areas to fight poverty.



Fig. 1 The Duku Heritage Ecosystem

The Dushanzi-Kuche Highway starts in the Dushanzi district of Karamay City in the north and connects with the city of Kuche in the Aksu region in the south, crossing the Tianshan Mountains in the north and south, with a total length of 561 kilometres. More than half of this part of the road crosses high mountains and canyons, connecting many ethnic minority areas; snow-capped mountains, canyons, lakes and grasslands cover nearly all of Xinjiang's topographical features. The Duku Heritage Corridor, a landmark natural-cultural landscape route in Xinjiang, is taken as the object of study to address the practical issues of strengthening infrastructure construction along the route, upgrading the quality of services, enhancing regional cooperation in the heritage corridor, and focusing on the sustainable development of the heritage ecosystem.

Emphasis is placed on the construction of ecological protection zones and cultural heritage protection zones^[2], the use of big data, cloud computing, artificial intelligence and other modern information technologies to promote intelligent tourism, enhance the intelligent level of culturally-adapted management and services, strengthen tourism safety management, enhance security and emergency response systems, and undertake the mission of the times to promote the cultural adaptability of the Duku heritage ecosystem.(Fig. 1).

2 Related concepts

2.1 Adaptation of heritage ecosystems

In 2025, the Gunma Declaration introduced the concept of 'heritage ecosystems'^[3], which aims to deepen the understanding of heritage by emphasising the interconnections between tangible and intangible, cultural and natural heritage. Adaptive heritage ecosystems emphasise the ability to respond to environmental change and the ability of ecosystems to repair and renew themselves. Through the creation of adaptive landscapes, integrating 'ecological restoration - health restoration - cultural restoration - economic restoration', it is possible to ensure the conservation and sustainable use of heritage corridors. Cultural adaptation of heritage ecosystems plays an important role in achieving a balance between cultural heritage and ecosystems by fostering harmony between them. Cultural adaptation of heritage ecosystems emphasises the integration of cultural heritage into modern life and sustainable development in a dynamic and changing social environment through living heritage, community participation, value transformation and institutional innovation, while maintaining its originality.

Adaptability requires the integration of heritage into modern life to avoid becoming 'museum specimens', and emphasises the need to maintain the authenticity and original protection of core cultural values of heritage in the process of adaptation. Cultural adaptation relies on the subjective status of the heritage-holding community, such as community empowerment. The right to information, participation and benefit-sharing of indigenous people in heritage management is clarified. Holistic conservation and systematic management break through the single heritage ontology and focus on the synergy of cultural ecosystems, whose adaptability ultimately serves cultural continuity and identity construction. Therefore, the cultural adaptability of the heritage ecosystem is essentially the resilience of guarding the cultural genes in the midst of changes: it is necessary to abide by the bottom line of originality and innovate the inheritance path; it relies on the endogenous dynamics of the community as well as the exogenous support of the system and science and technology. The ultimate goal is to make cultural heritage a 'living tradition' through dynamic balancing, so as to continuously nourish the national spirit and modern civilisation.

2.2 Discriminating between resilience and adaptability

The Duku Highway Cultural Landscape Corridor is a major transport route connecting the north and south of the Tianshan Mountains, and its mode of protection should be resilience and sustainable management. The word 'resilience' (resilience), meaning 'recovery to the original state' is divided into three dimensions, namely: resistance (Resistance), recovery (Recovery) and evolution (Renewal). The main purpose of the project is to assess the cultural landscape of Duku. The main focus is on the adaptation of living conservation, the stabilisation of holistic conservation, and the promotion of regenerative conservation of the Duku cultural landscape corridor. Fabrizio Aimar explored the possibilities of cultural landscape resilience in his book *Cultural Landscape Resilience: a Perspective on UNESCO World Heritage Sites*, where the study emphasised the necessity of building an integrated management system and a heritage space that is more capable of responding to continuous change, and proposed the need to build an integrated management system and a heritage space that is more capable of responding to continuous change, as well as to build an integrated management system, and proposes a resilience management model with multidimensional synergistic enhancements^[4].

Therefore, in the context of the Doku Heritage Corridor, cultural adaptability is reflected in the 'adaptability' of communities and herders along the route to respond to external changes in the tourism economy brought about by the opening of the highway, and to take the initiative to adjust their economic models, such as the operation of B&Bs, service modes, or forms of cultural display; and cultural resilience emphasises the 'ability to maintain and rebuild' the ecological outlook of these communities after experiencing the impacts, Cultural resilience ^[5], on the other hand, emphasises the ability of these communities to maintain their core values such as ecological outlook, identity, traditional festivals or key rituals, and social structures to resist dissolution, maintain stability and achieve innovative inheritance after experiencing impacts. In short, adaptability is about 'how to change flexibly in order to adapt to new environments', while resilience is about 'how to protect and revitalise the core in the face of change'.

3 Adaptive mechanisms for the Doku Heritage Corridor

3.1 Mechanism for the Integration of Tourism

With the continuous promotion of the strategy of 'Tourism to Develop Xinjiang' and the in-depth implementation of the project of 'Culture to Run Xinjiang', the regional government is making every effort to promote the rapid development of tourism in Xinjiang. Since 2019, the regional party committee has put forward the '1+3+3+Reform and Opening Up' work deployment, aiming to promote poverty alleviation and rural revitalisation as well as the further development of tourism through the development of tourism. In order to implement this deployment and promote the development of the new industry of 'transport + tourism', the regional government has launched the 'Transport and Tourism Exemplary Project'. The project aims to respond to the support of transport to the development of culture and tourism ^[6], and at the same time expects the development of culture and tourism to feed back to transport, so as to achieve the positive interaction and common prosperity of the two. As an important corridor connecting the northern and southern parts of the Tianshan Mountains in Xinjiang, the Doku Heritage Corridor, with its unique geographical location and spectacular natural scenery, has become a typical example of the deep integration of transport and tourism. It has become a typical representative of promoting the deep integration of transport and tourism.

3.2 Mechanism of cultural and tourism integration

The cultural and tourism integration value of the Doku Heritage Corridor mainly consists of 'minority cultural value + tourism' and 'red cultural value + tourism', which fully embodies the functional value of guaranteeing ancient social and economic development, contemporary military defence and cultural exchange. The history of Doku Highway can be traced back to the ancient Mengkede Road at K625 Road Marker, as the predecessor of Ili section of the original Doku Highway, there are still traces of the national defence and war preparation highway that had been constructed in April 1964, when Chairman Mao issued the instruction of 'activating the Tianshan Mountain', and the road, which started from Dushanzi in the north and went to Kuche in the south, was completed and opened to traffic in September 1983, in order to communicate with the traffic along the north and south of the border. In order to communicate with the north and south of the border and increase the unity of the various ethnic groups along the route, during the many years of arduous road construction, 168 PLA soldiers were killed in avalanches ^[7], mudslides and other causes, and were buried in the Chorma Martyrs' Cemetery along the route, and a Dokoukou Highway Museum was built to commemorate this epic piece of road-building culture (Fig. 2).

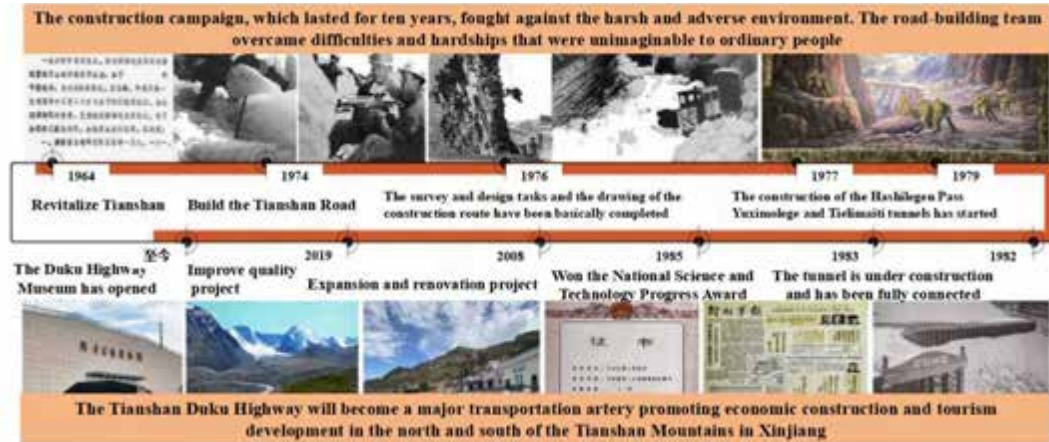


Fig. 2 History of the Duku Highway

In addition, Duku Cultural Landscape Corridor presents the most significant minority cultures as Donggui culture, Guzi culture, monuments, Ovoo, grottoes, murals and other cultural relics witnessing the diversity of roadside culture, while shouldering the responsibility of protecting, managing and demonstrating the use of the roadside cultural relics of the times.

3.3 Mechanism of production and tourism integration

The value of industry-tourism integration of the Duku Heritage Corridor lies in the sustainability of resource protection and management along the route, which improves the regeneration of the heritage sites, nature reserves, characteristic landscape nodes and parking spots in the road area, thus enhancing the effectiveness of the production space along the route. The translation value of its production and tourism integration value consists of the resource utilisation value and the socio-economic value brought by tourism, which can be broken down into the tourism resource value and the industrial resource value ^[8].

Duku Highway also has a very high value of tourism resources, and the natural and humanistic scenic spots along the way, such as Narathi Grassland Scenic Area, Jorma Scenic Area, Big and Small Dragon Pools, Bayinbruk Grassland and so on, have attracted many tourists from home and abroad for sightseeing and travelling, which brings the social and economic value and the popularity of the transport-tourism linkage. Duku Highway along the rich industrial resources, including tourism, including animal husbandry, mineral resources, water conservancy and hydropower resources, emerging industries and other industrial resources value, while the industry empowers the protective development of resources along the Duku Highway to promote the maximisation of socio-economic value, and together to create the 'Corridor Economy' of the value of the integration of the industry and tourism.(Fig. 3).

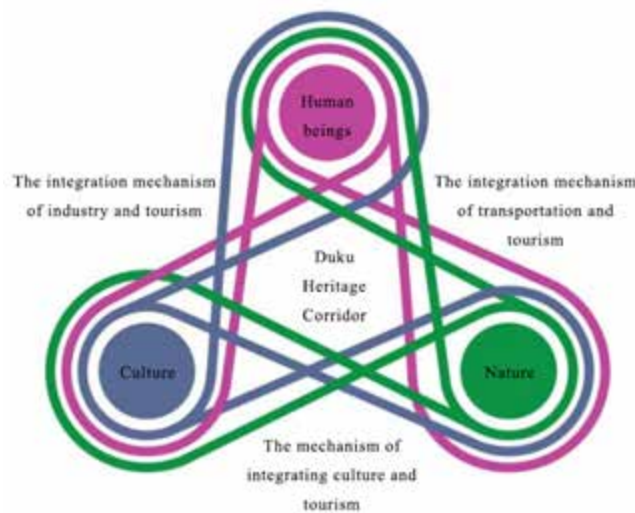


Fig. 3 Adaptive mechanisms for the Duku Heritage Corridor

4 Heritage Ecosystem Utilisation Pathways in the Duku Heritage Corridor

4.1 Zoning protection for ecological restoration-healthy recovery

The Duku Heritage Corridor Plan divides the Duku Highway into six regions based on the principles of resource similarity, cultural uniqueness, and regional coordination, including the Kuiduwu Area, the Qorma-Tangbra Area, the Nalati-Gongnaix Area, the Bayinbruk-Bayin Goleng Area, the Dalongchi -Yanshigou Area, and Baicheng County-Kuche County Area.

(1) Rational development of regional tourism resources

Tourism resources such as landforms, forests, scenic spots, water conservancy, humanities, wetlands, etc., should be reasonably developed and used, and all kinds of material and non-material resources with tourism and sightseeing value should be reasonably developed and utilised and perpetually used. Develop red tourism resources rich in local characteristics.

(2) Drive the tourism service industry, catering and accommodation industry, tourism equipment and other industries

Invest and operate in scenic spots, develop speciality tourism commodities, and turn local specialties into tourism commodities; use intangible cultural heritage as a carrier to develop a strong experience, entertainment and playability.

(3) Create a favourable atmosphere conducive to private tourism investment

Vigorously publicise national policies and the State Council's preferential policies and initiatives on encouraging, supporting and attracting the development of private capital, and vigorously promote and publicise the positive role and contribution of private capital in increasing the supply of tourism, meeting the needs of tourists, optimising the industrial structure, and enhancing the strength of economic development.

(4) Developing various types of tourism products along the route

Cultivate eco-tourism, forest tourism, trade tourism, study tourism and other tourism products according to local conditions, cultivate tourism products such as 'Nongjiale' and leisure farms, and actively cultivate leisure and tourism tourism products. Within the scope of the Duku Scenic Byway, except for the ecological conservation area, scenic restoration area and scenic excursion area, all other areas are the development control area. Within the development control area, the original land use pattern can be retained, and locally suitable tourism facilities and projects can be arranged for the orderly production, operation and management of the area; however, the scale and intensity of all facilities should be controlled, and be compatible with the environmental carrying capacity of the scenic area, and the three-level protection is implemented ^[9].

Wusu city in Xinjiang		H3 km	Geology Expo	Realising the integration of transport and tourism + cultural tourism
Nilka County		H2.26km	The Red Heritage	Realising the integration of transport and tourism + cultural tourism
Xinyuan county		H1.8km	natural landscape	Realising the integration of transport and tourism + agri- tourism
Hejing County		H2.25km	(Natural Landscape) Donggui Culture	Realising the integration of transport and tourism + agri- tourism
Baicheng County		H1.025km	Geology Expo	Realising the integration of transport and tourism + cultural tourism
Kucha City (end point)		H1.05km	(Geological Expo) Guzi Culture	Realising the integration of transport and tourism + cultural tourism

4.3 Multi-point enhancement of cultural and economic recovery

The Duku Highway connects many ethnic minority settlements and always puts the improvement of highway safety in the first place. In the near future, it mainly improves the safety and accessibility of the Duku Highway, and focuses on the treatment of road diseases that can be implemented at present and have an important impact on the improvement of the access conditions; it also strengthens the function of tourism services, and improves the sightseeing stops, signage systems, service areas, parking areas and other ancillary service facilities in suitable areas along the route; and it also improves the road appearance and the road environment to beautify the highway tourism environment. Improve the road appearance and road environment, and beautify the highway tourism environment. The medium- and long-term goals can be summarised as strengthening itself, promoting integration and leaving interfaces ^[10]. On the basis of guaranteeing the safe passage of highways and upgrading the quality of road surfaces, we will focus on the development of traffic+tourism integration into the industrial system, actively create the form of traffic+tourism industry, and build a high-quality highway for the integration

and development of 'traffic+tourism'.

5 Conclusions and Implications

5.1 Rationalisation of thematic mountain landscapes for travelling through the seasons

Due to the special climatic conditions and unique topography, four-season access to the Duku Highway is not yet possible. AI can process and analyse a large amount of environmental monitoring data, such as temperature, humidity, light, etc., so as to detect potential risk factors in time and prevent the risk of damage to the Duku Heritage Corridor. By analysing and monitoring data through machine learning algorithms, AI can predict the maintenance needs of heritage corridors and help managers plan maintenance work in advance to extend the life of the heritage. The term 'Digital Intelligent Conservation' ^[11] usually has two meanings: one is to make physical conservation more scientific through digital technology and intelligent management, such as better detection of diseases, more accurate identification of roadblocks and deformation of roadbeds, etc.; and the other refers to the fact that we use modern digital intelligence technology to digitise the heritage corridor itself and even the road environment and the view-scope landscape in a complete and holistic manner. Secondly, through modern digital intelligence technology, we can collect, reconstruct and present the heritage corridor itself and even the road environment and the landscape within the line of sight in a complete and full-fledged way, and save it as 'data' permanently. At the same time, the AI system can provide decision-making support for managers based on historical data and real-time conditions, such as emergency response strategies under extreme weather conditions, real-time broadcasting of the tour theme of the road section in front so as to make the heritage corridor culturally activated, on-site, and scenario, and thus promote the effective development of the construction of the 'all-time' tourist sites along the Duku Heritage Corridor.

The Duku Heritage Corridor is a 'full-time' tourist destination. With the development of modern science and technology, intelligent monitoring management system and computer network technology has been further optimised and improved. The construction of highways has also entered the era of intelligent transport, and intelligent service areas with higher service levels and more personalised functions have also emerged. Therefore, the digital intelligent management of heritage corridor is a systematic project covering many aspects, involving data collection, analysis and processing and application implementation. In concrete implementation, it is necessary to combine modern information technology, such as artificial intelligence, big data analysis, cloud computing and other technical means, to achieve effective protection and rational use of heritage corridors.

5.2 Systematic cognition of cultural landscape corridors of heritage world heritage sites

The core of the cultural landscape corridor as a world heritage site is to focus on the historical and human resources along the route, and the organisation of traditional festivals and events to bring economic benefits and brand economic benefits. With the development of artificial intelligence and machine learning technology, the accuracy of image recognition has increased dramatically, allowing for the automatic identification of past image data of the heritage corridor and its restoration. Using digital twin technology, panoramic 3D modelling and other technologies, the collected data can be transformed into virtual models, providing intuitive and accurate information support for management. Acquire high-precision images and 3D models of various types of natural-cultural heritage in the heritage corridor and accurately digitally record them, and provide support for the restoration of complex heritage corridor environments through the establishment of high-precision 3D models. To support this analysis, advanced methods such as digital footprint and user-generated content (UGC) from social media are utilized to capture and evaluate public interactions with the heritage corridor (Fig. 5).

The implementation of intelligent heritage and cultural corridor details and purposes can fully mobilise the enthusiasm of all stakeholders in the region along the route - including local government departments and other community groups of non-government organisations, increase the overall economic income of the region through the development of the regional economy of the road section, and enhance the attention and participation of all sectors of the community in the digital management of the heritage corridor. Enhance the community's interest and participation in the digital management of heritage corridors. Establish a digital archive of the heritage corridor for long-term preservation of heritage information to facilitate historical research and comparison of data for future restoration. Using the Internet platform, the results of the digital restoration will be shown to the public in the form of a virtual exhibition, so as to expand the dissemination of the culture of the Duku heritage corridor.(Fig. 6).



Fig. 5 The Duku heritage corridor is rich in multiculturalism



Fig. 6 The Cultural Inheritance Base of the Duku heritage corridor Area

5.3 Digital restoration of exemplary national parkways with Chinese characteristics

In addition to this, VR/AR technology is utilised to provide the public with an immersive experience of touring the heritage corridor, enhancing their knowledge and understanding of the cultural heritage. Introduce interactive technologies^[12], such as intelligent guide systems and interactive exhibitions, to bring the stories of the exhibits to life and enhance the visitors' experience. Carry out monitoring and big data analysis of important historical and cultural heritage sites, nature reserves, special viewpoints, parking spots, etc. in the road area to monitor the status of the heritage in real time and carry out preventive protection of the heritage corridor. Comprehensively improve the supporting service facilities such as sightseeing stops, signage systems, service areas, parking areas and other facilities at suitable locations along the Duku; intelligent car park management system, road safety monitoring system, cable broadcasting management system, road traffic signal transmission and guidance system, WiFi network hotspot coverage management system, and high-definition bayonet anti-evasion management system. Developing intelligent systems for automated diagnosis, comprehensively applying modern information technology means, starting from data collection, management, display, dissemination, research, monitoring and other aspects, automatically identifying damages and diseases in the natural-cultural heritage, and improving the relevance and efficiency of regular segmented restoration work, as well as using robots to fine tune restoration operations in high-risk or manpower-intractable areas, such as high-altitude tunnels, traffic site areas. It is also necessary to consider factors such as regulatory and policy support, financial and human resources protection, etc., to comprehensively improve the systematic protection and digital intelligent management level of the Duku Heritage Corridor, gradually realise the digital transformation of the whole road section and the whole network of heritage sites, to form a provincial intelligent heritage corridor system, to promote the development of an intelligent restoration management system of the heritage sites, to let the public understand the importance of digital restoration, and to enhance the public's cognition of the multifaceted value of heritage protection and the national Parkway construction participation.

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