

# Research on the Application Strategy and Sustainable Development of the Qinghai-Tibet Railway from the Perspective of World Heritage Sites

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## Abstract:

This article focuses on railways, and from the perspective of World Heritage sites, uses the Ovi Interactive Map to summarize the overview and construction difficulties along the Qinghai-Tibet Railway in China. We select railway linear heritage sites from around the world, conduct comparative research with the Qinghai-Tibet Railway in terms of geographical location, selection criteria, diversity and protection of natural and cultural landscapes along the line, and ultimately propose a sustainable development model for the Qinghai-Tibet Railway from the perspective of heritage tourism, and explore the possibility of applying for World Heritage on the Qinghai-Tibet Railway.

**Keywords:** Qinghai-Tibet Railway, Linear Heritage, Strategy of Applying for World Heritage, Sustainable Development

## 1. Introduction

The World Heritage refers to cultural and natural heritage of outstanding universal value, which is the most precious legacy left by nature and humanity, and the common wealth of all mankind [1]. Linear heritage, also known as linear cultural heritage, mainly refers to a linear or strip-shaped collection of culture and resources, covering both material and intangible cultural heritage, mainly divided into transportation routes, trade routes, and religious routes. Linear cultural heritage has characteristics such as scarcity in quantity, large scale in space, diversity in functions, and cultural integration [2]. It relies on complex geographical environments and accompanies specific historical and cultural forms, promoting economic and cultural exchanges along the linear heritage route and giving rise to diverse attributes such as geography, economy, ecology, and culture [2]. In the category of linear heritage, the number of railway heritage sites is small. In the World Heritage List, only four of them are listed, namely, the Mountain Railways of India; Semmering Railway; Trans-Iranian Railway; Rhaetian Railway in the Albula/Bernina Landscapes [18].

China's railways have a history of nearly a century and have developed rapidly in modern times, gradually transitioning from "Made in China" to "Created in China". China's railways have gradually entered the global perspective. As the first railway in the Tibet Autonomous Region,

the Qinghai-Tibet Railway is a milestone in changing the situation of inconvenient transportation in the region. The resolution of difficulties in the construction process and environmental protection also have important reference significance.

## 2. General situation

### 2.1 Overview of the research area

The Qinghai Tibet Railway, or Xining Lhasa Railway in China, has a total length of 1956 km and an average altitude of more than 4000 m. It connects Xining, Qinghai Province, China, to Lhasa, Xizang Tibetan Autonomous Region in a northeast southwest direction. It is the first railway to the hinterland of Xizang and also the plateau railway with the highest altitude, the longest line and extremely difficult natural conditions in the world. And the Golmud to Lhasa section relies on the Qinghai Tibet Plateau. The Qinghai Tibet Plateau is located between the Gondwana and Eurasian continents, and has undergone three stages of evolution[3]: the Indosinian, Yanshan, and Himalayan movements. During the Quaternary, the mantle tree rose[4], and the asthenosphere of the Qinghai Tibet Plateau was thermally uplifted, causing the lower crust to soften and a large amount of thermal material to accumulate in the middle and lower strata[3]. The balanced uplift of the Qinghai Tibet Plateau results in a sharp contraction in the horizontal direction and a sharp thickening in the

vertical direction[5], ultimately becoming the largest and highest plateau in China and the world, with a general altitude between 3000 and 5000 meters and an average altitude of over 4500 meters. Due to specific geographical and climatic conditions, it is widely developed with permafrost and seasonal permafrost, accompanied by complex glacial landforms. In addition, the Qinghai Tibet Plateau is characterized by well-developed tectonic movements, complex geological landforms, widespread faults and thrust events, and strong seismic activity.

The Qinghai Tibet Plateau has been plagued by long-term traffic congestion and poor logistics. The construction began in 1958 and was completed in 1984. Under the high attention and important instructions of the Central Committee of the Communist Party of China and the State Council of China, the Xining Golmud section of the first phase of the Qinghai Tibet Railway was completed and opened to traffic. Initially, it was a single track, with key projects including the Guanjiao Tunnel and the Salt Lake subgrade. The Golmud Lhasa section of the Qinghai Tibet Railway Phase II project began construction in 2001 and was put into operation in 2006. This section passes through permafrost area, natural origin of pestis, plateau alpine ecosystem and several nature reserves. Starting from 2007, the Xining Golmud section of the Qinghai Tibet Railway implemented the construction of an additional second line and electrification renovation project, and the New Guanjiao Tunnel was completed in 2014. The expansion and renovation project for the Golmud Lhasa section was carried out in 2015 and was fully completed in 2018[6].

The completion of the Qinghai Tibet Railway has broken the original closed traffic situation in the Xizang Autonomous Region, ended the history of no trains in the region, and is conducive to promoting the development of industry and tourism in the region, promoting economic benefits, and improving the industrial structure. In addition, Xizang is mainly a Tibetan autonomous region, and exchanges between Tibetan culture and other ethnic cultures have become more convenient with the completion of the Qinghai Tibet Railway, promoting national unity and common prosperity.

## 2.2 Difficulties of constructing the Qinghai Tibet Railway

The Qinghai Tibet Railway passes through a continuous permafrost area of about 550 km, with an average altitude of over 4500 m, and faces enormous challenges in terms of plateau, permafrost, and environmental protection[7][8]. The active layer of permafrost undergoes seasonal freeze-thaw changes every year, accompanied by adverse geological phenomena such as thawing settlement and frost

heave[9], and the possibility of damaging the balance of permafrost during construction, leading to the destruction of railway buildings[10]. Therefore, the use of stone air cooled embankment to change the embankment structure and change the heat transfer mode; Using hot rod technology to absorb the heat of frozen soil in cold seasons and transfer the cold energy back to the frozen soil. Using ventilation pipeline embankments, strengthening the ventilation of the roadbed through buried ventilation pipes. The impact of permafrost on railway construction has been addressed through various construction techniques, ensuring the stability of the operation of the Qinghai Tibet Railway. In addition, the climate conditions along the Qinghai Tibet Railway are severe, with the annual average temperature of  $-2\sim-6\text{ }^{\circ}\text{C}$ , the extreme maximum temperature of  $52\text{ }^{\circ}\text{C}$ , and the extreme minimum temperature of  $-45\text{ }^{\circ}\text{C}$ . The solar ultraviolet radiation is strong, and gales, sandstorms, thunderstorms, and hail occur occasionally, and it is located in the natural focus of pestis[6]; The route also passes through high-altitude and cold ecosystems such as deserts, grasslands, wetlands, as well as Kekexili and Sanjiangyuan National Nature Reserve. As a world natural heritage site, Kekexili in Qinghai has nurtured unique biodiversity based on its geographical and climatic conditions. More than one-third of its plant species and all herbivorous mammals are unique to the plateau and have a complete migration route of Tibetan antelopes. Therefore, establishing a comprehensive and comprehensive health security system covering the entire line, restoring high-altitude vegetation on the plateau, rebuilding wildlife migration channels, and other projects to ensure ecological stability along the Qinghai Tibet Railway[6].

## 2.3 Tourism resources along the Qinghai Tibet Railway

The development of tourism resources in Xizang can be divided into six major tourism sectors in terms of resource structure, including Lhasa, Shigatse, Naqu, Nyingchi, Changdu, Shannan, covering landscape tourism, mountaineering tourism, religious tourism, cultural tourism, scientific research tourism and other aspects. The Lhasa Sherton Festival, Qiangtang Horse Racing Festival and other festivals are diverse, rich and unique in tourism resources[11], with high tourism and experience value. Starting from Xining, the Qinghai Tibet Railway goes deep into the hinterland of Xizang, passing through the Kunlun Mountains, Tanggula Mountains, Nianqinggula Mountains, and crossing the Qaidam Inland River, the Yangtze River, the Yarlung Zangbo Inland River, the Nu River and other water systems. In addition, relying on the Qinghai Tibet Railway, natural landscapes and world heritage sites such as Chaka Salt Lake, Bangongcuo, Ramlac-

uo, Yuzhu Peak, Kekexili, and Sanjiangyuan Nature Reserve are all connected. Along the route and surrounding vast areas, there are also numerous rich cultural heritages created by ethnic minorities in the Qinghai Tibet Plateau. In the national intangible cultural heritage list, there are 88 items in Qinghai Province and 105 items in Xizang Autonomous Region. In addition, in 2009, the epic of Gesar, Qinghai Regong art, and Tibetan opera were included in the World Representative List of Intangible Cultural Heritage of Humanity, and in 2018, the Chinese Tibetan Medicine Bathing Method was also included. (According to the UNESCO World Heritage Center <https://whc.unesco.org>) The Qinghai Tibet Railway has extremely high natural and cultural heritage values along its route.

### 3. Comparative Study on World Railway Heritage and Qinghai Tibet Railway

#### 3.1 Comparison between Qinghai Tibet Railway and Railways in World Linear Heritage Sites

Comparing the Qinghai Tibet Railway with the railways listed in the World Linear Heritage List, they are: 1) Qinghai Tibet Railway; 2) Mountain Railways of India; 3) Semmering Railway; 4) Trans Iranian Railway; 5) Rhaetian Railway in the Alberta/Bernina Landscapes. The geographical location of these four linear heritage sites and the Qinghai Tibet Railway is shown in Figure 1.



*Figure 1. Comparison of geographical location between Qinghai-Tibet Railway and related World Heritage sites*

The Qinghai Tibet Railway is the highest altitude and longest plateau railway in the world. Relying on the Qinghai Tibet Plateau, it has harsh construction conditions and a complex geological environment. After years of permafrost and fragile ecological areas, the construction of the Qinghai Tibet Railway is extremely difficult. In addition, its average altitude is above 4500 meters, and the highest point on the entire line is 5072 meters. The complex geographical environment also makes the Qinghai Tibet

Railway a unique natural and cultural environment. The Hoh Xil and the Three Rivers Source Nature Reserves are distributed along the railway. Kunlun Mountain and Tanggula Mountain can be seen. Through Chaka Salt Lake, the Yarlung Zangbo River, etc., there are rich ethnic minority cultures along the railway and surrounding areas. The Gesar epic, Qinghai Regong art, and Tibetan opera are all included in the World Intangible Cultural Heritage of Humanity Representative List.

The Mountain Railways of India consists of three railways: the Darjeeling Himalayan Railway, the Nilgiri Mountain Railway, and the Kalka Shimla Railway, all of which are outstanding examples of mountain railways. The innovative design of the Darjeeling Himalayan Railway includes six zigzag reversals and three control loops with a slope of 1:31. The Nilgiri Mountain Railway is a meter line monorail, with an elevation rising from 326 meters to 2203 meters, representing the latest technology at the time. The Kalka Shimla Railway has the world's highest multi arch corridor bridge and the longest tunnel. The Mountain Railways of India have extremely high integrity, despite systematic maintenance and repair, the overall infrastructure of the line today is very close to its original characteristics.

The Semmering Railway was built between 1848 and 1854, spanning 41 km of high mountains, and is one of the greatest civil engineering feats in the pioneering stage of railway construction. This railway line is set against a spectacular mountain landscape, and due to the quality of its tunnels, overpasses, and other engineering, it is still in use today, with many entertainment buildings built along its tracks. In terms of integrity, the railway line itself and civil engineering have been operating continuously since 1854.

The Trans Iranian Railway connects the Caspian Sea in the north with the Persian Gulf in southern Iran, with a total length of 1394 kilometers. It combines the spectacular mountainous environment with the continuous steep slopes, and surges along the main engineering structures along the way. It created a new Persian Western mixed architectural style that influenced Iranian architecture at that time. All components of the Trans Iranian Railway (including railway routes, tunnels, bridges, train stations, buildings, and other attachments) have maintained their authenticity in terms of location, environment, form, design, materials, use, and functionality, even if certain elements have been upgraded or replaced. Some parts of the original railway line have been expanded or slightly modified.

The Rhaetian Railway in the Alberta/Bernina Landscapes represents a model railway development that emerged in the early 20th century as the Central Alps were liberated.

The railway has a significant and lasting impact on the lives of residents along the line, the exchange of human and cultural values, and the changes in the relationship between Westerners and nature. The total length of the Rhaetian railway is about 128 km, with a total of 196 ele-

vated bridges and 55 tunnels. It provides various technical solutions for building railways in harsh mountainous conditions. In addition, the infrastructure along the railway line is particularly harmonious with the Alpine landscape it passes through.

**Table 1. Comparison of the Qinghai-Tibet Railway and related World Heritage**

Name	Country	Selection time	Criteria	Geographic coordinates	Area of region	Feature
Qinghai-Tibet Railway	China	—	—	—	—	The total length of the Qinghai Tibet Railway is 1956 km. It is the first railway leading to the hinterland of Xizang and also the plateau railway with the highest altitude and the longest line in the world.
Mountain Railways of India	India	1995, 2005, 2008	(ii)(iv)	11°30' 37.008"N, 76°56' 8.988"E	Core area:88.99ha; Buffer area:644.88ha;	The Indian Mountain Railway is an outstanding example of mountain railways, built between 1891 and 1908, and is an innovative transportation system established on difficult terrain.
Semmering Railway	Austria	1998	(ii)(iv)	47°38' 55.6"N, 15°49' 40.7"E	Core area:156.18ha; Buffer area:8581.21ha;	The Semelin Railway was built between 1848 and 1854, with a total length of 41km. It is one of the greatest civil engineering projects, echoing the spectacular mountain landscape.
Trans-Iranian Railway	Iran	2021	(ii)(iv)	35°39' 29.9"N,51°23' 54"E	Core area:5784ha; Buffer area:32775ha;	The Iranian Trans Railway was fully opened in 1938, with a total length of 1394km. Combined with the spectacular mountainous environment and continuous steep slopes, it created a new Persian Western mixed architectural style.
Rhaetian Railway in the Albula/Bernina Landscapes	Switzerland, Italy	2008	(ii)(iv)	46°29' 54"N,9°50' 47"E	Core area:152.42ha; Buffer area:109385.9ha;	The Letane Railway in the Albula Bernina landscape has a total length of 67km, and its railway infrastructure harmoniously integrates with the Alpine landscape it passes through.

*Note: The data is sourced from the UNESCO World Heritage Center.*

*Note: The railways in mountainous India are divided into the Darjeeling Himalayan Railway; Nilgiri Mountain*

*Railway, Kalka Shimla Railway*

Based on the selection criteria in Table 1, a comprehensive comparative study has concluded that the construction process of the Qinghai Tibet Railway and the natural and cultural landscapes along the line have significant advantages in terms of quantity and variety compared to the

other four linear world heritage sites in the table.

### 3.2 Comparison of protective regulations

Table 2 shows a comparison of relevant regulations and measures for the protection of World Natural Heritage sites.

**Table 2. Comparison of protection laws and regulations of Qinghai-Tibet Railway and related World Heritage**

Name	Country	Year of implementation	Regulations for management, protection and development
Qinghai-Tibet Railway	China	1990 2004 2007 2021 2022	<i>Railway Law of the People's Republic of China</i> <i>Railway Transport Safety Protection Regulations</i> <i>Law of the People's Republic of China on the Protection of Cultural Relics</i> <i>Qinghai Province Railway Safety Management Measures</i> <i>Measures of the Xizang Autonomous Region for Railway Safety Management</i>
Mountain Railways of India	India	1971 1989	<i>the Public Premises Act</i> <i>the Railway Act</i>
Semmering Railway	Austria	1923	<i>Austrian Monument Protection Act</i>
Trans-Iranian Railway	Iran	1996	<i>the Constitution of the Islamic Republic of Iran</i> <i>the Act of Conservation and Optimization of the Environment</i> <i>the Criminal Islamic Law for Destruction of Natural Heritage</i> <i>Book Five of the Islamic Penal Code</i>
Rhaetian Railway in the Albula/Bernina Landscapes	Switzerland,Italy	1957	<i>the Federal Constitution Law</i>

*Note: The data is sourced from the UNESCO World Heritage Center.*

It is not difficult to see from Table 2 that countries around the world have relatively complete legal protection for their railway heritage, involving both the protection of the railway itself and the natural environment along the railway. The protection laws of the Qinghai Tibet Railway are more detailed, not only in terms of natural heritage protection, but also in terms of cultural heritage in the areas along the line, which has significant advantages.

## 4. Sustainable development of the Qinghai Tibet Railway

### 4.1 Research on the Strategy of Applying for World Heritage

The recognition of the outstanding universal value of railway heritage is mainly based on the six standards of cultural heritage in the Operational Guidelines, namely c (i)

creative value, c (ii) exchange value, c (iii) witness value, c (iv) type exemplar value, c (v) environmental value, and c (vi) related value[12]. In order to more accurately reflect the type attribute value of railway heritage, ICOMOS proposed four targeted standards in the thematic research of World Railway Heritage Sites[13]: first, “creative engineering value”, specifically referring to the display of elite or collective wisdom in the field of engineering; Secondly, “technological innovation and exchange value” specifically refers to technological innovation and dissemination in the fields of engineering and architecture; Thirdly, the exemplary value of “typical cases” includes two situations: the outstanding value that existed when the railway was built, and the few cases that were once ordinary but have survived in social changes; Fourthly, “the witnessing value of the socio-economic development process” specifically refers to the degree to which railways promote the evolution of urban spatial form, economic development, and industrialization.

According to Table 1, it can be seen that the four railways listed as World Heritage sites all meet the c (ii) and c (iv) standards, all of which have technological innovation and dissemination in the fields of architecture and engineering. With the completion of the railways, the local and surrounding areas have far-reaching economic, cultural, and political impacts.

The Qinghai Tibet Railway is different from the four, and is not included in the mountain railway, but in the plateau railway that connects the Qinghai Tibet Plateau. The Qinghai Tibet Railway has a total length of 1956 kilometers, with an average altitude of over 4000 meters and a maximum altitude of 5072 meters. It is the highest altitude and longest plateau railway in the world. In addition, due to the complex geological landforms, special climatic conditions, and rich ecological environment of the Qinghai Tibet Plateau, the Qinghai Tibet Railway has achieved extremely high technological breakthroughs and innovations in the construction process. From 2017 to 2023, a total of 46 invention patents were applied for. For example, in solving the problem of construction on the permafrost area with the widest distribution and largest thickness in the mid latitude zone, the Qinghai Tibet Railway adopts a “wing type heat pipe active heating anti freezing device and its roadbed” to absorb and utilize solar energy and transfer its converted heat energy to the interior of the roadbed, in order to reduce the temperature of the permafrost below the roadbed, maintain the shape of the permafrost, prevent the problem of thermal thawing settlement of the permafrost foundation, and adopts a block stone roadbed structure and gravel slope protection to cool and stabilize the roadbed. The Qinghai Tibet Railway has a significant promoting and innovative role in establishing a technical system for plateau railways and engineering construction in permafrost areas on the plateau.

In addition, as the first railway to penetrate into the hinterland of Xizang, the Qinghai Tibet Railway is of great significance in changing the traffic blocking situation in the region and promoting the economic development of the region. Secondly, the Qinghai Tibet Railway passes through the world heritage site Qinghai Hoh Xil Nature Reserve, as well as numerous mountain ranges, lakes, meadows, wetlands, permafrost and other landforms such as Kunlun Mountains and Chaka Salt Lake. The scenery is beautiful and unique, and the ecological environment is diverse. Along its route and surrounding areas, there are numerous cultural heritages created by unique ethnic minorities in the Qinghai Tibet region. Among them, the epic Gesar, Qinghai Regong art, Tibetan opera, and Chinese Tibetan medicine bathing methods have all been included in the Representative List of Intangible Cultural Heritage of Humanity. Therefore, the Qinghai Tibet Railway has

extremely high tourism value along its route.

After the above argumentation, the Qinghai Tibet Railway meets the c (ii) and c (iv) standards in the Operational Guidelines for the Implementation of the World Heritage Convention, and has great World Heritage value and a possibility of successful application.

## 4.2 Integration Strategy of Xizang Tourism

With the completion of the Qinghai Tibet Railway, the inherent tourism pattern in Xizang will change, and its tourism development needs to be repositioned. Adopting a regional integration model and developing comprehensively from a macro perspective[17]. We should properly handle the development of new resources and the redevelopment of old products, handle the competition and cooperation between old and new tourist destinations[14], strengthen the synergy between the Qinghai Tibet Railway and other transportation through the construction of a comprehensive transportation hub, promote the communication and connection between Xizang and major tourist distribution centers such as Chengdu, Lanzhou, Xining, and Xi'an, so as to form an organic whole of the plateau transportation system. By building a big market strategy, we will promote the rapid and healthy development of Xizang's regional economy, and on this basis, drive the coordinated development of surrounding industries and regions, so as to achieve “one main body and two wings”.

## 4.3 Development of boutique tourism

Attention should be paid to improving and innovating tourism products, while also strengthening the construction of high-quality brands within the tourism industry. We aim to enhance cooperation between Lhasa and major cities in the Trans-Himalayan region, the Greater Shanggri-La region, the Xizang Autonomous Region, as well as cities along the Tea Horse Ancient Road and the Tang Tibet Ancient Road[15]. To achieve this, we will strengthen brand building, adopt joint marketing, plan diversified cultural heritage tourism products, and appropriately highlight the characteristics of the cultural heritage tourism product portfolio to meet the diverse needs of tourists[16]. Simultaneously, in conjunction with the integration strategy, strengthen connections with neighbouring tourist cities to showcase Tibet's distinctive religious history, culture, and diverse ethnic customs.

## 4.4 Protective and sustainable development

Tourism development along the Qinghai Tibet Railway is bound to face significant challenges in ecological protection due to the unique and fragile ecological environment of the Qinghai Tibet Plateau. Therefore, we should adopt the guiding ideology of people-oriented and scientific development, attach great importance to environmental

protection, adhere to the coordination and unity of practical and long-term interests[15], develop based on protection, and promote the improvement of protection through development, so that the two complement each other. We place significant emphasis on the value of the natural environment and resources. To achieve this, we aim to improve the legal management of the tourism industry and strengthen the legal protection and constraints of resource development. Additionally, we prioritize and enhance publicity and education efforts to eliminate external factors that pollute and damage the environment and resources of tourist areas[15]. Our ultimate goal is to promote the sustainable development of the tourism industry along the Qinghai Tibet Railway.

## 5. Conclusion

The Qinghai Tibet Railway is the first railway in China to reach the hinterland of Xizang. It is also the plateau railway with the highest altitude and longest line in the world. The railway is significant in terms of technological innovation and economic and social effects. The surrounding areas of the Qinghai Tibet Railway have unique natural and cultural heritage, making it an excellent destination for heritage tourism. By utilizing their natural and cultural heritage, the existing world natural heritage and intangible cultural heritage of humanity can be combined to create a unique tourism model along the Qinghai Tibet Railway. If the Qinghai Tibet Railway is added to the World Heritage List, it will become China's first railway world cultural heritage.

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