

# The Ecosystem Protection and Promotion of Mogao Grottoes

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**Abstract.** The cultural heritage of the Dunhuang Mogao Caves is a valuable asset for China, but the site is located in Gansu Province in northern China, where the ecological environment is fragile, the environmental space is relatively small and the environmental carrying capacity is limited. In the process of accelerating the tourism development and construction of Mogao Caves cultural heritage, the ecological balance of the environment has been upset and problems have emerged. This paper investigates the ecological and environmental management and enhancement of the site, as well as the conservation and protection of the non-renewable resources of the Mogao Caves cultural heritage.

The pristine ecological balance of the Mogao Caves cultural site has been disrupted by the over-exploitation of tourism resources, along with the tourism development project, which would have been quite The burden on the fragile ecosystem is getting heavier. "China's heritage site management departments often have the dual attributes of being an institution and a business unit, which makes it difficult for them to handle the The latter is often preferred in terms of social and economic benefits. Using the concept and policy of economic development zones to develop and exploit protected socially beneficial heritage sites inevitably leads to the misplacement of landscape heritage sites Development and over development, resulting in the artificialization, commercialization and urbanization of natural cultural heritage sites, causing serious damage to scenic heritage sites ." [1] For the tourism development of Mogao Caves cultural sites should deal with the development of a balance between commercial development and the retention of cultural sites, in the dissemination of Cultural classic charm, explore the economic benefits without forgetting its ecological protection.

## 1 Ecological and environmental management of Mogao Caves cultural sites

Due to its uniqueness and scarcity, the Dunhuang Mogao Caves have been developed as a popular tourist attraction to showcase cultural treasures. However, as it went to market in pursuit of economic efficiency, the environment and ecology were severely disturbed, and the Mogao caves in the northwest were fragile. The environmental carrying capacity of the ecosystem of the tourist environment has increased in the destruction of tourism development and the influx of tourists, and the tourist environment ecosystem. The loss of balance

overloads the original historical landscape and its internal and external ecological environment gradually deteriorated over time.

### 1.1 Ecological problems and governance within the Mogao caves

#### 1.1.1 Ecological problems within caves

Since the discovery and opening of Dunhuang Mogao Caves in the last century, the original internal ecology has been altered, accelerating the deterioration of the cultural heritage. The murals, architecture, and painted sculptures have been subjected to varying degrees of foaming, armor, and alkali.

When Mogao Caves' cultural heritage was exploited for tourism on a large scale, the limited space within the cave reached its maximum capacity for tourism, and a large number of tourists flocked to the cave. The interior space of the Mogao Caves is altered by high volumes of visitors exhaling humidity-laden gases, carbon dioxide, and heat from the cave's interior space and the Temperature, exacerbating the weathering of the cave wall stone and discoloration of the mural painting; lint and dust carried by visitors as they walk through the cave's interior spaces It is easy to have chemical reaction with the wall pigment and change the color, or change the adhesion of color, intensify the color of the The rate at which the saturation is reduced or the color is peeling off, when cleaning up these clings of dust on the surface of the mural, can easily lead to dissolution of pigment or Pigments mixed in the dust fall off, injuring the mural images, and the integrity of cultural heritage is gradually compromised. "Researchers at the Dunhuang Research Institute have estimated that the half-life of air temperature, relative humidity and carbon dioxide concentration in the Mogao Caves are respectively 0.25 hours, 1 hour and 3 hours, due to poor air exchange

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inside and outside the cave, and water vapour from people breathing in the cave. After leaving the cave, 67% of the exhaled carbon dioxide and 52.3% of the exhaled carbon dioxide remain in the cave, and the 'three gases' emitted by the human body in the cave are still in the cave. ' (heat, moisture, and exhaust gases) can severely damage the cave's microenvironment, causing sodium chloride to accumulate at the base of the cliffs and murals, catalyzing the Mural foaming, puffed up nail alkali, etc., thus trapping the cave in a state of 'environmental fatigue' and causing the cave's 'physical deterioration.'" [2] With prolonged erosion, the wall attached to the picture weathered, and the color of the picture gradually darkened until it slowly blurred and disappeared. The contradiction between the development of tourism and the limits of carrying capacity has exacerbated the spatial environmental problems within Dunhuang Mogao Caves.

### *1.1.2 Cave internal ecological management*

Visitor flow restriction relieves the ecological pressure in the cave. People flow is one of the important factors of environmental stress and problems in the cave, the scientific design of a reasonable flow of tourists is an important channel for the management of its environmental problems, to minimize the "three airs" of tourists and people driven air flow on the internal environment of the cave ecological balance; build a tourist season and off-season tourist balance mechanism, not overload the average daily balance of the number of visitors to achieve the maximum cultural dissemination and economic benefits.

Open cave spaces on a rotating basis. For a period of time, Mogao Cave Yuan Dynasty Cave 3 is closed to avoid contact with air, to prevent weathering and oxidation of the cave, to avoid space The flow of the paint causes the paint to peel off from the image. This was the inspiration for constructing a mechanism to open the caves of Dunhuang Mogao Caves in rotation, so that the cultural heritage of the caves could be extended and the caves could be opened in rotation. Medium protective restoration.

Increased monitoring of the cave interior environment. Increase investment in modern monitoring systems for the internal environment of caves to monitor the internal ecology of open caves from time to time and to ensure that the cave environment is protected once it has been restored. If the environmental monitoring indicators exceed the specified values, the cave can be closed for rest and treatment, and then the cave can be rehabilitated after its environment and ecology have returned to normal. Open to the public.

Modern technology systematically treats the cave's internal air environment. Dunhuang is prone to short-term rainstorms during the summer, during which the relative humidity of the caves increases dramatically; at the same time, tourists' The "three airs" contribute to the poor air quality of the cave's interior environment. In order to create a good ecological environment inside the cave and to mitigate the negative effects of humidity

inside the cave and the visitor's "three airs" on the artifacts, it is necessary to The use of modern technology to intelligently regulate and intelligently control the air in the internal space environment of the cave with the environmental parameters appropriate for the survival of cultural relics. Treatment and absorption of natural and human-induced damage to the Mogao Caves' interior environment. An experimental exploration of the use of modern mechanized technology to treat the internal air environment of the Mogao Caves. "The 'System' equipment was sized and installed on site in Mogao Cave Cave 328, using tracer gas testing for natural ventilation and mechanical and electrical ventilation. Cave air exchange rate, cave CO<sub>2</sub> drop time, air age and air velocity at typical cave measurement points under ventilation.

By comparing the parameters, the effectiveness of the system in maintaining the air quality and the non-disturbance of the air in the cave was fully verified, as well as the effectiveness of the system in maintaining the air quality and the non-disturbance of the air in the cave. Engineering guidance and successful experience are provided for the design of artificial environmental control systems for the internal physical environment of single-sided opening sites in the desert climate of severe cold regions." [3] This provides the theoretical guidance and practical basis for the use of modern intelligent technology for environmental management inside the cave.

## **1.2 Mogao Caves external ecological problems and governance**

### *1.2.1 The external ecological problems of the caves*

Since its discovery, the resources of the Mogao Caves cultural site have been subjected to dust, wind erosion, earthquakes, sun exposure, mountain fissures, and rain erosion. The double oppression of natural disasters and excess tourism carrying capacity. Affected by the natural ecological environment of the northwest, the external ecological environment of the Mogao Caves is mainly reflected in the lack of water resources, desertification, desertification, and the loss of natural resources. Expansion, vegetation cover is not high in several aspects. "In recent years, the total amount of water resources has been decreasing due to the influence of the wider environment in the Dunhuang area. The brackish and freshwater lakes within the oasis have almost dried up, the wetlands around the oasis are constantly shrinking and degrading, and biodiversity is decreasing." [4] In addition, as the economic development and population of the Dunhuang area continues to grow, people's water consumption is increasing, which has serious consequences for the area around Mogao Caves. of ecological problems." [5] Along with the increase in projects such as the extension of the tourism chain, festival celebrations, and summer tourism, it has brought to the surrounding ecology of the Mogao Caves cultural site Negative impact. Frequent sandstorms and dusty

weather make the conservation of Mogao Caves murals a serious threat.

### **1.2.2 Management of the external ecological problems of caves**

Establishing a recyclable water use method. The Mogao Caves cultural site is located in the westernmost part of the northwest, surrounded by the Gobi, with low annual precipitation and high evaporation, which is a serious drought in China. Water-scarce areas, 410,000 acres of arable land in Dunhuang city mainly rely on the Dang River water resources for irrigation. "Water is the basis for the existence of the desert oasis, since liberation, due to the increasing agricultural, social and economic water use in the Dang River basin, water resources The conflict between supply and demand is exacerbated by the serious over-extraction of groundwater in the basin, the massive crowding out of ecological water for domestic and productive use, and the discharge of water from rivers into the lower basin. The amount of ecological water is decreasing." [6] The water resources available at Dunhuang are used to sustain the Mogao Caves cultural site, in addition to supporting normal domestic water use and irrigation of farmland. Normal functioning. Due to the development of Mogao Caves tourism resources, water consumption has increased and water supply is weak.

The construction of the Mogao Caves and even buildings within the city limits of Dunhuang can be completed using green buildings. Rainwater, air-conditioning water and domestic wastewater are collected through green buildings. "Growing social and economic trends are also creating drivers to the endorsement of sustainable technologies, as the general public begins to adapt to the thought of sustainable living. This is a growing public concerns on environmental issues, therefore it can be predicted that the need for more sustainable buildings will become a priority in the future." [7] According to different water quality using water systems for treatment in the use. At the same time, the implementation of the scenic area of domestic waste water discharge treatment project, the cave area through biodegradation of waste water for environmental water conservation and greening water. or special equipment and technology, and transformed into a reactive water source that complies with environmental discharge standards for reuse. Adequate water supply for ecological nourishment in the cave.

Cave area greening project construction. Dunhuang drought, less rain, sand and other natural climate, coupled with the Mogao Caves cultural sites excavated in the foothills of the Mingsha cliffs, the top of the The flat Gobi Desert, backed by the Mingsha Mountains, is heavily desertified. A hundred years ago, there were only a few trees scattered across the Gobi Desert, and when the wind blew, sand would fall in great quantities on the Mogao Caves. The ground outside the cave. After the Dunhuang Research Institute to carry out sand control engineering attempts, planting sand forest, improve the

wind environment in the Mogao Caves cave area, to alleviate the sand in Mogao Caves Erosion conditions. As the vegetation cover in the cave area is not high, the number of anti-desertification forests still needs to be strengthened, and the construction of supporting greening projects is urgent. "Increasing the area of forest land, pasture land and parkland, and increasing the planting of protective forests can prevent the increase of land desertification, especially by expanding the The area of protected forest is very useful to counteract the ecological damage caused by the specific climatic conditions of the region." [8] Improving the severe desertification of the land surrounding the Mogao Caves cultural site and strengthening the forest, green areas and wetlands can effectively Improve vegetation cover to mitigate the negative impact of extreme weather conditions, such as wind erosion and sand movement, on the ecological environment of cultural heritage. A vegetation protection zone should be established to protect artificially planted vegetation from destruction, and a sand grid should be adopted to effectively prevent the flow of sediment and to reduce the risk of damage to cultural heritage. The expansion of desertification and the erosion of woodlands and greenery; drought-resistant, cold-resistant and high-temperature resistant tree species such as Poplar, salix, sea buckthorn, etc. are planted in large numbers, and trees are planted to fix sand and conserve water sources. The external environment of the Mogao Caves is constantly being improved in tandem with the greening of the various cave areas.

## **2 Strategies for enhancing the ecological environment of Mogao Cave Cultural Sites**

### **2.1 Raising tourists' awareness of ecological protection**

Mogao Caves cultural heritage ecological environment enhancement and development, based on the reasonable control of the flow of tourists, the tourist behavior of tourists proposed higher It is required to raise the visitors' awareness of ecological and environmental protection and the preservation of cultural heritage. The visiting tourists are both the breakers of the ecological balance of the Mogao Caves cultural site and the participants of the ecological environment construction. "The proposal of ecotourism can greatly improve people's awareness of environmental protection and play a role in China's concept of green and sustainable development. good publicity." [9] The shift of tourists from the identity of ecological equilibrium-breakers to that of construction participants is the result of the ecological shift of the Mogao Caves cultural site to a The key to the positive direction is that tourists take on the multiple roles of builders, watchdogs and leaders as tourists.

Visitors are required to read and learn about the Mogao Caves Cultural Heritage Site's Code of Conduct and

Rules for Visitors online before entering the site. Then a mock tour test, which recreates the cave's frescoes, sculptures and other scenery and tests whether the tour operator will touch, photograph and The cave's exterior and the surrounding ecology of the cultural site are simulated to test whether visitors are exposed to environmental pollution and damage during their travels. Environmental vandalism. To be online mock tour test visitors who meet the standards, online signed a civilized tourism electronic commitment, photographed to generate their own avatar of the a QR code for Mogao Caves cultural heritage protectors, with which visitors can enter the park for a tour. The aim of this strategy is to raise awareness of environmental protection and turn visitors into learners and protectors of Mogao Cave's cultural heritage. It also enables civilizational and scientific tourism to slow down the aging of Mogao Caves' cultural heritage resources.

## 2.2 Development of digital tours for visitor streaming

"For the permanent preservation and sustainable use of the Dunhuang Caves, the Dunhuang Academy began digital exploration in the early 1990s." [10] Use modern information technology to develop digital tour platform, digital, three-dimensional form of Mogao Caves cultural heritage resources, to guide tourists Online tours to divert visitors and relieve the load on offline field trips to Mogao Caves, with lower admissions relative to online tours. The price eases the financial pressure on some culture lovers. "The Dunhuang Grottoes are digitized using advanced digital technology." [11] At the same time to save time resources consumed by long-distance travel for offline tours. Relying on modern digital technology, virtual reality technology, augmented reality technology, 5G communication channels to enhance the experience and awareness of online tours This will help to increase the number of people willing to visit online, divert more offline visitors and reduce the impact of Mogao's offline visitors on the cave and its surroundings. Stress

## 2.3 Scientific treatment of tourism waste

With the promotion of the development of the Mogao Caves Cultural Site, more and more visitors are coming to the site, and with it comes the The amount of waste from tourism is increasing, and the upgrading of tourism waste at Mogao Caves cultural sites has become an ecological development for the region. The focus of the work. "The threat of tourism solid waste to tourist attractions is a worldwide problem, and the situation is particularly acute in China." [12] Dunhuang Mogao Caves is a treasure of splendid culture and art in China and the world, with profound connotations, brilliant art and extremely Highly visible, attracting thousands of domestic and foreign tourists each year, the number of tourists continues to grow, and the threat of waste to the environment is very high. The level of waste treatment should be improved by applying internationally advanced waste treatment equipment or technologies to

minimize the environmental impact of waste. Damage to the Mogao Caves cave paintings is avoided by avoiding harmful fumes from the disposal of waste.

## 3 Conclusion

The cultural heritage of Dunhuang Mogao Caves is a valuable treasure in China, and the ecological management and enhancement of its site is the culmination of the cultural heritage. The value of sexual conservation is even more far-reaching. The cultural heritage resources of the Mogao Caves are non-renewable and should be exploited with conservation in mind. The basis for continued protection, and how to govern and enhance its environmental ecology, is the subject of our ongoing research.

## References

1. G.R Zhang, X.A Wei, D.Q Liu, Social Science Literature Publishing House, 32(2005)
2. Y. Zhang, L.D.Kong, Thought Front, 123-128 (2006)
3. J.L Wang, Xi'an University of Architecture and Technology, 16(2016).
4. H. L, Seeking the truth magazine, **11**, 14-16(2008).
5. Y.Q Mu, R. Mi, Journal of China Academy of Environmental Management Cadre, 38-41(2019).
6. X.W Chai, Tsinghua University, 23(2017).
7. Andrew Hand, J. Zuo, B Xia, X.H Jin, P. Wu, *Proceedings of the 19th International Symposium on Advancement of Construction Management and Real Estate*, 291-301(2015).
8. F. Wu, X.Y Guo, Agricultural Network Information, 75-77(2017).
9. Q.H Li, Tourism Review, 186-187(2019).
10. J.S Fan, Dunhuang Research, 3(2004).
11. T.X Yu, J. Wu, L. Zhao, X.H Ding, Q. Ye, Dunhuang Research, 120-130(2020).
12. J.S Fa, Dunhuang Research, 1-3(2005).