

Research on the Sustainable Development of the Dujiangyan Irrigation System from a World Heritage Perspective

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Abstract

It has been 2280 years since the construction of water conservancy projects in Dujiang Dam, and the water conservancy projects in Dujiang Dam have been running continuously for more than 2000 years. It is not only a miracle in Chinese history, but also a unique pearl in the history of water conservancy projects in the world. The purpose of this paper is to study the Dujiang Dam of water conservancy projects in the world cultural heritage, and to deeply excavate the various values of the cultural heritage of modern Dujiang Dam. Summarize the relevant valuable cultural connotations and immortal spirit, and refer to excellent cases. In view of the current situation of Dujiang Dam protection, management and development, the remaining problems were solved. Today, with the rapid development of science and technology, new technologies have also brought Dujiang Dam new opportunities for the modernization of water conservancy projects. Both protection management and development should actively seek both offline and online. We should make every effort to carry forward the connotation and spirit of the deep culture of Dujiang Dam, base ourselves on the present and look forward to the future. It not only finds a new way for the development of water conservancy projects in Dujiang Dam, but also provides reference value for the sustainable development of other cultural heritages of water conservancy projects.

Keywords

Dujiangyan; Conservation and restoration; Cultural tourism; Sustainable development.

1. INTRODUCTION

Water conservancy projects are complex and difficult projects. They use some technologies to control and regulate surface water and groundwater in nature to achieve the effect of eliminating harm and promoting benefits [1]. The Dujiangyan Irrigation System was built in 256 BC. Its initial construction concept was to control the Minjiang River and prevent floods. Its builder, Li Bing, led the people on both sides of the Minjiang River to cleverly use the method of damless water diversion to achieve both flood control and irrigation of the Chengdu Plain without changing the natural flow direction of the Minjiang River [2]. Thousands of years later, the Dujiangyan Irrigation System has become the only water conservancy project in the world that is still in use. As a manifestation of the wisdom of the ancient Chinese working people, the Dujiangyan Irrigation System contains rich connotations, spanning disciplines such as agriculture, environment, culture, and architecture, and carries the unique water culture and

the spirit of water management of the Chinese nation [3]. Its own advantages are unmatched by other scenic spots, attracting tourists from all over the world to visit.

Today, to maintain the sustainable development of Dujiangyan, we should adopt a holistic approach, maintaining and updating it from different perspectives. This will allow the Dujiangyan water conservancy project to keep pace with the new era's promotion of cultural confidence and pursue new development opportunities. As the world's largest water conservancy project, Dujiangyan's development in the new era can also provide a reference for global water conservancy cultural heritage, helping these projects to be repaired, protected, and developed. This will ensure that water conservancy cultural heritage receives more attention and importance, preventing it from disappearing into the tides of history.

2. RESEARCH BACKGROUND

Research into the essence of the Dujiangyan Irrigation System and subsequent studies on its sustainable development are intrinsically linked to its construction context. One of the primary motivations for its creation was to regulate the Min River. As a tributary of the upper Yangtze River, the Min River flows with exceptional turbulence due to its topography. Throughout ancient China, it frequently caused devastating floods, leaving the people living along its banks on the Chengdu Plain suffering from crop failures year after year. To alleviate these hardships, the construction of a water management system became imperative, leading to the creation of Dujiangyan. The project ingeniously harnessed the local topography and hydrological characteristics, employing an innovative damless water diversion method. This approach not only achieved flood control and disaster mitigation but also cleverly utilised natural resources, thereby securing the Dujiangyan Irrigation System's enduring renown throughout the land [4].

2.1. Background Information on the Min River

The Minjiang River is one of the important tributaries of the upper reaches of the Yangtze River. Based on the geographical characteristics of the main stream, the section upstream of Dujiangyan City is considered the upper reaches, the section from Dujiangyan City to Leshan is the middle reaches, and the section from Leshan to Yibin is the lower reaches. The Minjiang River is a vital water resource for the Chengdu Plain. Historically, the Minjiang River has been prone to natural disasters, but our ancestors never gave up on controlling this raging river. The most famous example is the Dujiangyan Irrigation System, built by Li Bing, the governor of Shu County during the reign of King Zhaoxiang of Qin, leading the people on both banks of the Minjiang River. Its construction has created the "Land of Abundance" we know today. Since the completion of Dujiangyan, natural disasters on the Minjiang River have decreased dramatically. Today, the Zouma River and Baitiao River, which are diverted by Dujiangyan, eventually merge with the Xuyan River into the Fu River, becoming the mother river of Chengdu. In the long history of Minjiang River management, in addition to the magnificent water management project, unique folk customs have been nurtured, water management legends, water management stories, water management spirit and many activities to commemorate water management. These customs are precious intangible cultural heritage, which together with material culture constitute the rich Minjiang River water management culture of the Chinese nation [5].

2.2. Introduction to the Dujiangyan Irrigation System

The Dujiangyan Irrigation System is located in the western part of the Chengdu Plain, at the junction of the Sichuan Basin and the Qinghai-Tibet Plateau, in the middle reaches of the Minjiang River. It is an ecological engineering feat that was first built in the Qin Dynasty around 256 BC and was called "Jiayuan" in ancient times. The Dujiangyan area belongs to the Central China subtropical humid region with an average annual temperature of 15.2 degrees Celsius.

The area has a small diurnal temperature range, a rainfall of about 1200 mm, and fertile soil, which is suitable for agricultural development [6]. As shown in Figure 1, Dujiangyan divides the Minjiang River into the inner river and the outer river, which can not only effectively solve the problem of floods, but also realize water diversion for irrigation. The Dujiangyan irrigation system was repaired and expanded to different degrees in the Tang, Song, Yuan and Ming dynasties. It made full use of the natural topography of the Chengdu Plain and the hydrological characteristics of the Minjiang River, and realized multiple functions such as agricultural water diversion for irrigation, silt removal, flood control and flow regulation under dam-free conditions. It coordinates flood control, farmland irrigation and ecological protection, fully reflecting the wisdom of ancient Chinese people to live in harmony with nature [5]. In 2000, the Dujiangyan Irrigation System was listed in the World Heritage List along with Mount Qingcheng. In 2006, it was listed in the World Natural Heritage List as part of the Sichuan Giant Panda Habitat. In 2018, the Dujiangyan Irrigation System was officially listed in the World Irrigation Engineering Heritage List, becoming China's first "three heritages" cultural heritage [7].



Figure 1. Map of the Dujiangyan Irrigation System

3. HERITAGE LANDSCAPE TYPES AND VALUES OF THE DUJIANGYAN IRRIGATION SYSTEM

The Dujiangyan Irrigation System contains a wealth of heritage types and diverse values. At the beginning of the construction of the Dujiangyan Irrigation System, in addition to the engineering, many buildings were also built. Over time, these buildings have become unique historical architectural landscapes. Together with the natural environment landscape and the artificial landscapes built later to promote the Dujiangyan water culture, they constitute the complete Dujiangyan Scenic Area. The diverse landscape types and the cultural and spiritual connotations accumulated over the years have endowed Dujiangyan with multiple values. In addition to the functional value of Dujiangyan itself, it has also extended to various values at the social and cultural levels in the new era. The value of Dujiangyan today is very different from that of 2,000 years ago. It integrates water conservancy projects, cultural construction, and tourism development, and has greatly promoted the development of culture, economy, and society in the Chengdu area [8].

3.1. Heritage Landscape Types of the Dujiangyan Irrigation System

Today, Dujiangyan is a World Cultural Heritage, Natural Heritage and Irrigation Engineering Heritage, so the types of heritage are also rich and diverse. First, according to the form, it can be divided into material cultural heritage, intangible cultural heritage and spiritual heritage. The historical buildings and historical projects in the Dujiangyan Scenic Area are all material cultural heritage; the corresponding sacrificial activities, the Erwang Temple Fair and the Dujiangyan Water Release Festival are intangible cultural heritage; in addition, the spiritual heritage of Dujiangyan cannot be ignored. For example, Li Yuan of the Qing Dynasty summarized

"Li Bing's eight methods of water management", the six-character stele inscribed with the water management essence of "deepening the beach and lowering the weir", the idea of taking advantage of the situation and adapting to the times, etc [9].

The tangible cultural heritage can be further subdivided into the following four types: First, natural landscapes, consisting of river views such as the inner and outer rivers and mountain views such as the Nanmu Forest; second, historical sites, such as the Erwang Temple and Anlan Suspension Bridge; third, the Dujiangyan Irrigation System, such as the Feisha Weir, the Renzi Embankment, and the Baopingkou; and finally, modern commemorative buildings, such as the Li Bing Memorial Hall and the Natural and Cultural Exhibition Hall.

3.2. The Value of the Dujiangyan Irrigation System

The modern Dujiangyan irrigation system possesses multifaceted functions, manifesting not only in agricultural and ecological spheres but more broadly across cultural and spiritual dimensions. Today, Dujiangyan transcends its role as a mere hydraulic facility, evolving into a cultural emblem of China's water heritage. Consequently, the value system embodied by Dujiangyan has expanded beyond purely agricultural significance to encompass six dimensions: historical value, cultural value, economic value, educational value, and social value.

3.2.1. Historical Value

Dujiangyan has immense historical value. The Dujiangyan Irrigation Project was first built during the reign of King Zhaoxiang of Qin in the Qin Dynasty, and it had a decisive impact on the unification of Qin and the development of the ancient Chengdu Plain. Through detailed research on ancient books and the Dujiangyan project, it has been found that the construction of Dujiangyan was precisely a strategic need for Qin to unify China. For example, the Records of the Grand Historian states: "The governor of Shu, Bing, carved the Lidu River to avoid the harm of the Mo River and dug the two rivers through Chengdu. These canals are all navigable, and any surplus is used for irrigation, and the people enjoy its benefits. Along the way, the water was often diverted to irrigate the fields, numbering in the trillions, yet still countless." This shows that the construction of Dujiangyan was initially for navigation needs, and then to meet agricultural irrigation needs, and its role greatly enhanced the material foundation of the Qin state [10, 11]. In addition, Dujiangyan can also make significant contributions to the study of the scientific and technological wisdom of the ancients and other historical events, especially for the study of ancient Chinese water conservancy projects, which has unique historical value.

3.2.2. Cultural Value

Water culture is a brilliant gem in the Chinese cultural heritage database, encompassing the material and spiritual achievements accumulated by mankind in the process of interacting with water resources [12]. Shu water culture has a profound impact on the development of Chengdu, Sichuan, while the construction of Dujiangyan laid the foundation for Shu water culture. From "fearing water" to "being close to water", the local people used the Minjiang River to irrigate farmland and meet their daily water needs, gradually moving towards social stability and economic prosperity. Over the long term, activities centred on water have steadily increased. As illustrated in Figure 2, the Dujiangyan Water Release Festival exemplifies how Shu water culture has flourished, fostering a cultural ethos characterised by 'prosperity and beauty derived from water' [13].



Figure 2. Schematic Diagram of the Dujiangyan Water Release Festival

3.2.3. Economic Value

Dujiangyan, as an irrigation project, has been operating for more than 2,000 years and has played a key role in the agricultural development of the Chengdu Plain. The Dujiangyan irrigation area covers 23,000 square kilometers and benefits 7 cities (prefectures) and 38 counties (cities, districts). As of 2021, the actual irrigated area has reached 726,670 hectares [14], and the agricultural economic value it brings is immeasurable. In addition to the Dujiangyan irrigation area, the Dujiangyan Scenic Area, as a national scenic spot and a national 5A-level scenic spot, has received an average of about 5 million tourists per year in the past 10 years, making a great contribution to the cultural tourism economy of Dujiangyan City.

3.2.4. Ecological Value

The Dujiangyan Irrigation System adopts a "damless water diversion" method and cleverly integrates artificial engineering with the surrounding environment. This makes Dujiangyan not a simple water conservancy project from the beginning, but an ecological-engineering system that is highly coordinated with the environment [15]. Moreover, the construction and annual maintenance of Dujiangyan mostly use local renewable resources, such as using weirs to block the river and cut off the flow. Most of the materials required are sourced locally, which is conducive to protecting the local ecological harmony [6]. In addition, in order to adapt to the surrounding environment, the fish mouth diversion dike built by the Dujiangyan project divides the Minjiang River into the inner river and the outer river, which greatly improves the ecological environment of the Chengdu Plain, avoids flood disasters, saves the local ecosystem, and protects biodiversity.

In addition, in order to solve the problem of insufficient strength caused by the fact that all the materials used in Dujiangyan are natural materials, an annual maintenance system was established. The annual maintenance system allows the Dujiangyan project to adapt to changes in the environment and protect the surrounding ecological environment as always.

3.2.5. Educational Value

As China's first water conservancy project, operating continuously for thousands of years, Dujiangyan embodies the technology and wisdom of the ancients. The project itself provides a continuous source of inspiration for modern water conservancy projects. The management and protection systems derived from it are also treasures of world water conservancy history, worthy of ongoing study. Furthermore, within the Dujiangyan scenic area, newly built buildings such as the Natural and Cultural Exhibition Hall and the Li Bing Memorial Hall serve as cultural education bases. Through teaching and research activities, they promote Chinese water management culture and concepts, allowing the public to participate in the inheritance and

promotion of water culture and to understand and learn about the profoundness of traditional Chinese culture.

3.2.6. Social Value

The social value of Dujiangyan is specifically reflected in its rich spiritual connotations. Upholding cultural confidence is one of the fundamental principles of the development of the Chinese nation in the new era. The spiritual connotations embodied by the Dujiangyan water conservancy project are: a tenacious and wise spirit of water management; a spirit of dedication and conscientious responsibility; a spirit of harmony between humanity and nature; and a pioneering spirit of continuous research and innovation. These spirits are the backbone of the Chinese nation, and passing them down from generation to generation helps the public enhance their national pride and sense of identity.

4. EXISTING PROBLEMS IN THE SUSTAINABLE DEVELOPMENT OF THE DUJIANGYAN IRRIGATION SYSTEM

As a still-functioning tangible cultural heritage site, the Dujiangyan Irrigation System faces unprecedented challenges in its protection, management, and future development due to its complexity and unique characteristics. Although the state and government attach great importance to the sustainable development of Dujiangyan and strive to extend its lifespan, with a recent focus on the protection and inheritance of cultural heritage, unavoidable natural disasters and unpredictable chain reactions still severely impact its protection. Protection and management are the foundation for future sustainable development; finding a better path between prioritizing protection, rational development, and ecological balance warrants careful consideration.

4.1. Protection Level Issues

Protection and restoration are key to the sustainable development of the Dujiangyan Irrigation System. As a project with a history of more than 2,000 years, Dujiangyan has suffered from multiple major natural disasters, both in terms of its main structure and its affiliated historical buildings. Due to its location in an active earthquake zone, Dujiangyan has been the most frequently and severely affected by earthquakes. The Diexi earthquake in 1933 caused flooding and severely damaged Dujiangyan. The Wenchuan earthquake in 2008 caused unprecedented damage to the historical building complex, such as Fulong Temple, in the Dujiangyan scenic area, which is located in the earthquake zone. The damage caused by natural disasters is irreversible and can only be partially recovered through subsequent restoration. However, the restoration methods are extremely complex. Engineering technology, material selection, the lack of original drawings or ancient books, and incomplete survey data all add difficulty to the actual operation [16]. In addition, given the large number of cultural heritages, the government and the public did not have a strong awareness of protection in the early stages. They did not realize that Dujiangyan, located in an earthquake zone, should be surveyed and archived as early as possible to prevent sudden damage. This resulted in the loss of a large amount of data on ancient buildings in Dujiangyan, making it impossible to refer to and restore them during restoration, and the difficulty of restoration increased sharply.

In addition, the protection of Dujiangyan is closely related to the ecological environment, so the damage caused by human intervention in the ecological environment cannot be ignored. In recent years, hydropower stations and reservoirs have been built in the Dujiangyan irrigation area. As of 2020, more than 500 sluice gates, 3 large reservoirs and 15 medium-sized reservoirs have been built in the main canal system of the irrigation area [12]. Although such facilities have improved the irrigation guarantee capacity, they have also weakened the natural water diversion capacity of the upper reaches of the Minjiang River to a certain extent. For example,

the blocking of water for power generation by hydropower stations in the upper reaches of the Minjiang River has caused difficulties in water diversion for irrigation in the irrigation area. Similarly, the construction and use of the Zipingpu Reservoir, which is located in the upper reaches, has also caused serious damage to the ecology. Moreover, urban expansion and transportation construction have also led to the cutting of ecological corridors and the destruction of landscape structure, all of which have weakened the overall ecological resilience [17]. If the protection of the ecological environment is not taken seriously, the water conservancy function of Dujiangyan will be seriously damaged, and its characteristics and qualifications as a World Irrigation Engineering Heritage will be exhausted.

4.2. Management-level Issues

The Dujiangyan Irrigation System covers a vast area and contains a variety of cultural heritage categories, with diverse and complex management institutions. Currently, the irrigation portion of Dujiangyan is managed by the Sichuan Provincial Dujiangyan Administration Bureau, while the tourist area portion is managed by the Qingcheng Mountain-Dujiangyan Scenic Area (Tourist Area) Administration Bureau. Although this functional division of management helps to refine responsibilities and improve management efficiency, in the long run, it will lead to a fragmentation of Dujiangyan's cultural connotations and weaken its overall integrity as a system integrating water conservancy, ecology, and culture [18].

The Qingcheng Mountain-Dujiangyan Scenic Area (Tourist Area) Administration also manages seven scenic areas within the Qingcheng Mountain-Dujiangyan Scenic Area. Among them, the Dujiangyan Scenic Area covers an area of 10.05 km², with 7 scenic clusters and 56 scenic spots; the Qingcheng Front Mountain Scenic Area covers an area of 9.08 km², with 1 scenic cluster and 34 scenic spots; and the Qingcheng Back Mountain Scenic Area covers an area of 25.44 km², with 5 scenic clusters and 51 scenic spots [19]. Given the large number of scenic areas and their wide geographical distribution, it is inevitable that the management department will have oversights in coordination and monitoring. The Dujiangyan cultural heritage involves multiple departments such as cultural relics, water conservancy, and ecology, covering many fields. Management requires the cooperation of various departments. According to Su's research, in actual management, due to the complex division of responsibilities and the imperfect emergency response mechanism, decision-making efficiency is often reduced [20]. Although the local government regularly revises the "Regulations on the Management of Dujiangyan Irrigation Project in Sichuan Province" to ensure the legalization of Dujiangyan's management, the regulations and methods still need to be flexibly adjusted according to the overall changes in Dujiangyan, and there are still shortcomings that need to be improved.

4.3. Issues at the Publicity Level

Nowadays, tourists' travel methods and travel goals have undergone significant changes. Traditional scenic spots have been particularly impacted, experiencing a sharp decline, while emerging micro-vacation models such as weekend getaways, rural tours, surrounding tours, and suburban tours are rapidly emerging. As one of the traditional scenic spots in Sichuan Province, Dujiangyan Scenic Area has seen a decline in tourist attention. Although the scenic area's promotion methods have been reformed and digital promotion output has been introduced, the overall execution is insufficient, and a systematic and differentiated digital communication strategy has not yet been formed. Studies show that tourists' true perception of heritage sites is closely related to their willingness to revisit, and the creation of authentic experiences is an important foundation for the sustainable promotion of cultural heritage sites [21]. Currently, many traditional scenic spots have promoted themselves by creating culturally distinctive IP images. For example, the Sanxingdui Museum created the urban super IP "Sanxingdui: Awakening of Glory" in 2022, which quickly garnered a lot of attention and

popularity. Although Dujiangyan has proposed digital and IP-based development in its planning, it is still in the initial conceptual stage, which has led to Dujiangyan lagging significantly in new media communication and cultural identity shaping, affecting its competitiveness in the cultural tourism market [22].

In recent years, in order to increase economic benefits, Dujiangyan City has successfully held events such as the Dual Heritage Marathon, the Giant Panda International Eco-tourism Festival, and the Chengdu International Sister City Music Festival. Although these events have boosted the popularity and economic benefits of the scenic area in the short term, they lack cultural recognition and are difficult to form a sustainable attraction.

5. SUSTAINABLE DEVELOPMENT STRATEGIES FOR THE DUJIANGYAN IRRIGATION SYSTEM

To address the existing problems affecting the sustainable development of the Dujiangyan Irrigation System, corresponding strategies should be proposed from different levels, drawing on the advanced experiences of excellent examples both domestically and internationally. On the basis of strengthening protection and improving management, further development should be considered more rigorously to ensure the Dujiangyan Irrigation System truly achieves sustainable economic, social, and cultural development.

5.1. Utilize Advanced Technologies to Establish a Scientific Guarantee Mechanism

The development of modern technology has provided new means for the protection of cultural heritage. The international heritage protection field has widely applied GIS and remote sensing technologies, which have significantly improved the accuracy of cultural heritage surveying and risk warning [23]. The use of modern 3S technologies (i.e. RS, GIS, GPS) has accelerated the surveying and registration of ancient buildings and projects in Dujiangyan, and classified and managed various types of information to form an online and offline restoration and protection system. A platform has been established to systematically manage and collect data information, prevent data loss, and record protection and restoration measures to provide reference for subsequent research. At the same time, an online joint office platform has been established to promote real-time collaboration among multiple departments such as water conservancy, architecture, and cultural relics. In view of the special characteristics of Dujiangyan, information sharing and emergency response can be achieved through a digital sharing platform, which can improve work efficiency and response efficiency and minimize losses. This heritage management model with digital technology as the core has been proven to significantly improve the risk management level of architectural heritage [24].

5.2. Improve Protection and Management Systems and Regulations to Comprehensively Enhance Standardized Management Levels

The relevant protection and management system inherited from ancient times should be combined with the modern concept of heritage protection. All institutions and departments should study and formulate a new era of annual maintenance system for Dujiangyan based on its current situation to ensure regular assessment and restoration work. At present, the management regulations related to the Dujiangyan water conservancy project are not perfect and the legal system needs to be strengthened. The protection and management framework should be improved through legislation to provide clear responsibilities for departments at all levels and prevent dereliction of duty and abuse of power. In addition, there are many departments or institutions involved in the management functions of the Dujiangyan scenic area or irrigation area. The management system should be optimized, the responsibilities and subordinate relationships of the institutions should be straightened out, and inefficiency in coordination should be avoided. Based on the current situation of Dujiangyan, the

responsibilities and functions that need to be performed should be analyzed. Based on the management system and the subordinate relationship between superiors and subordinates, the functions should be redistributed, unnecessary institutions should be eliminated, the management structure should be clarified, and responsibilities should be assigned to units and departments. International experience shows that establishing a cross-departmental collaborative mechanism and institutionalized governance framework in the management of water conservancy heritage is a key path to ensure the dual sustainability of culture and ecology [25].

5.3. Strengthen Talent Cultivation and Improve Talent Incentive Mechanisms

Talent is the core resource for the sustainable development of Dujiangyan. To ensure the sustainable development of the Dujiangyan water conservancy project, it is necessary to build a composite talent team. The relevant units in Dujiangyan are mainly professional and technical positions, with few management positions and little room for promotion, so it is difficult to attract management talents [26]. Moreover, to ensure the sustainable development of Dujiangyan, it is necessary to cultivate composite talents who understand both engineering and cultural heritage protection, and to conduct regular training and knowledge updates for existing technical personnel, and to formulate a long-term talent training plan. In addition, it is also very important to improve the talent incentive mechanism. A flexible and fair distribution method can retain talents, promote healthy competition among talents, and promote common progress in technical research.

5.4. Prevent Over-Development and Transformation, And Adhere to The Concept of "Harmony Between Man and Nature"

The Dujiangyan Irrigation System and the surrounding ecological environment complement each other. Any change in one side will have an unknown and irreversible serious impact on the other side. In recent years, the concept of "harmony between man and nature" has been proposed, which is a further reflection of human beings on the current state of the natural environment and ecosystem. Nowadays, the way to measure the level and degree of ecological civilization is to consider whether the behavior of people in society and its results have achieved a dynamic balance and a virtuous cycle with nature and the ecological environment [27]. Due to the needs of social development, the area of the Dujiangyan irrigation area is gradually expanding. In order to meet the needs of the irrigation area for water demand and water consumption, the number of modern water conservancy projects has also increased. However, this measure will inevitably break the ecological harmony that has been maintained for many years, and some water conservancy projects will have a negative impact on the ecological environment, leading to new ecological problems and water resource problems. Water conservancy projects focus on "water benefit". As the most important water conservancy project on the Minjiang River, Dujiangyan has followed the principle of adapting to nature, respecting nature and changing nature to the minimum extent since ancient times. Therefore, the construction of modern water conservancy projects should also follow the same principle and strive to maintain the harmonious coexistence between the project and the ecosystem. Scientific and careful evaluation of the construction of the project, adherence to the principle of ecological, economic and social benefits, prevention of over-development, and cautious repair or expansion of Dujiangyan and its related facilities, reduce the negative impact on the ecological environment of the Minjiang River and avoid a series of irreversible environmental damages. This indirectly ensures the sustainable development of Dujiangyan.

5.5. Adapting to the Changing Times and Creating Distinctive Cultural Brands

To enhance government and public awareness of the sustainable development of Dujiangyan and strengthen the protection of the Dujiangyan Irrigation System, a World Heritage Site, it is

essential to increase public attention to Dujiangyan. Cultural tourism promotion, as a primary means, needs to adapt to changing times. With the rise of local and leisure travel, the Dujiangyan Tourism Development Zone can leverage the unique features of its irrigation system to develop agriculture + tourism, meeting the needs of 71% of tourists from within the province and ensuring a steady flow of visitors from within the province. Furthermore, keeping pace with emerging trends, technological innovation should be applied to cultural tourism promotion, accelerating online marketing and digitalization. Utilizing digital modeling, digital animation, and virtual reality technologies, a pioneering Chinese water culture IP can be created to effectively attract tourists from outside the region. Implementing these two planning measures can ensure the sustainable development of Dujiangyan as a cultural heritage site and tourism resource while simultaneously enhancing its economic benefits. As a World Heritage Site rich in cultural connotations, Dujiangyan possesses unique characteristics and development advantages that other scenic spots cannot replicate. The promotion of Dujiangyan should be closely integrated with its cultural characteristics and spiritual connotations, defining its development positioning and strategies, and creating a unique brand. In addition to holding cultural promotion activities, it is also possible to develop sketching bases and water culture education bases. If we blindly pursue the short-term benefits brought by modern and popular activities, the cultural and spiritual connotations inherent in Dujiangyan will be gradually forgotten, and its sustainable development will be in jeopardy.

6. CONCLUSION

The Dujiangyan Irrigation System is a treasure of the Chinese nation and a living heritage shared by all mankind. Therefore, its sustainable development is of great significance. As a super-large-scale water conservancy system, Dujiangyan spans the Minjiang, Tuojiang, and Fujiang river basins and remains a key element in the development of the Chengdu Plain. It controls the lifeline of agriculture and ecological development within the Dujiangyan irrigation area and is the foundation of Sichuan Province's economic development and social stability. As a carrier of traditional Chinese culture and spirit, Dujiangyan's sustainable development is conducive to upholding cultural confidence, enhancing public cultural pride and sense of belonging, and inheriting and promoting traditional Chinese culture. As a World Cultural Heritage site, Dujiangyan's sustainable development aligns with international standards, integrating its own effective experiences with outstanding international cases, summarizing sustainable development strategies, and ensuring its own sustainable development while providing a reference for other water conservancy heritage projects worldwide. The sustainable development of the Dujiangyan Irrigation System must adhere to the concept of "harmony between man and nature." Based on this, protection, management, and publicity work should be carried out: learn to use high-tech methods to repair and protect ancient projects and buildings; improve management regulations and systems to enhance the level of standardized management throughout the project; recruit and cultivate talents with multiple skills to participate in related work; and finally, create a distinctive cultural brand to enhance influence and ensure that the unique culture and spiritual connotation are passed down from generation to generation.

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