Research on Sustainable Conservation of Ancient Villages by Utilizing Digital Technologies

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Abstract: With the coming of the 5G era, it has become a crucial international trend to conserve ancient villages and the sustainability by utilizing multiple digital technologies. The recognition of landscape and culture is a momentous step in the sustainable conservation of ancient villages’ study, as well as the extended application and management approach of data should be considered seriously. In the pages that follow, it tries to provide a conservation method systematically in which emphasizes the integration utilization of digital technologies by taking the Taoping Qiang Stockade Village in Sichuan as a case study. Moreover, this article proposes that the conservation should be carried out at three steps: landscape recognition, establish the data chain and cultural inheritance and dissemination. In general, this essay seeks to explore the utilization of digital technologies and provide a systematic perspective and methodology for the sustainable conservation of ancient villages.

1. Introduction

The blending of various ethnic cultures has strongly influenced Chinese culture, resulting in a vast number of ancient settlements with distinct ethnic characteristics which are unfortunately being ruined at an alarming pace as a result of the fierce conflict between traditional society and modern civilization. With the continuous acceleration of industrialization and urbanization, civilizations are undergoing several invasions, which, more specifically, resulted in the loss of 80 to 100 ancient villages every day on average in the decade years[1]. Thankfully, the conservation of ancient villages began in the 1980s and the country's defense strategy was presented in 2012 in China[2]. Since then, a considerable literature has grown up around the theme of ancient villages conservation. Nevertheless, compared with the concept of conservation, sustainable conservation of ancient villages which is defined as a balanced management concept of recognises the inheritance of the past, benefits for the present and the legacy for the future should be taken in account[3].

At present, digital technologies have played a crucial role in the sustainable conservation of ancient villages with the development of modern technology. It is now well established from a variety of studies that numerous technologies applied in architecture and ancient village measurement, such as terrestrial digital photogrammetry (TDP), terrestrial laser scanning (TLS), unmanned aerial vehicle digital photogrammetry (UAVDP), which could provide abundant accurate data for the study[4]. Besides, it has been demonstrated that a dynamic information platform of cultural landscape heritage could be established by utilizing the geographic information system (GIS) technology with supplement of text and multimedia databases[5]. Australia Ballarat has been digitizing its historic landscape and establishing the "Ballarat Historic Landscape Network" and the "Ballarat Visual Geo information Database" as open data for its heritage archives, which may serve as a model for the establishing of
In terms of inheritance and culture communication, virtual reality technology and the Internet are predominantly used, allowing for the creation of a virtual roaming infrastructure and the availability of a range of man-machine interface methods[7].

With the coming of the 5G era, although the application of digital technologies in sustainable conservation of ancient villages’ research has become an essential trend, there are many gaps which are heavily affected by diverse ethnic cultures. It was highlighted that the recognition of representative landscape elements and the utilization of integration technologies were lacking in village conservation[8]. Besides, the data management system based on GIS technology is not conducive to synchronous link of culture and culture visualization. Furthermore, public participation could speed up the updating of village information, though government and professionals have done very well. Generally speaking, there is still a long way to go in the field of data application and data analysis in village conservation. This paper aims to present an approach by using digital technologies on sustainable conservation of ancient villages systematically, which includes crucial landscape elements recognition, data collection, data application, data management, and culture propagation and transmission.

2. Research area
Taoping Qiang Stockade Village is located 40 kilometers east of Lixian County, Sichuan Province, along the Zagunao River in Taoping Town. It is also known as the ‘Mysterious Oriental Castle’, and has a history of over 2,100 years. Unfortunately, Taoping Qiang Stockade Village suffered damage in the Wenchuan earthquake, though most of the unique elements and architecture survived. The rescue and conservation of the Qiang watchtower and village project began with the assistance of the government, and a great deal of money was spent in the reconstruction and rehabilitation of it. Although the modern village is well-planned, the ancient village is completely irreplaceable in terms of cultural and landscape. Therefore, the ancient stockade village (hereafter Taoping) with a land area of 106 acres was taken as the research case (Figure 1).
3. Exploration of Taoping sustainable conservation approaches utilizing digital technologies

3.1 Landscape recognition

There are multiple influences which contributed to Taoping's distinct features, including the peculiar geographical environment of the Western Sichuan Plateau, the roots of Tibetan and Qiang, wars, and so on. Other than the unusual architecture and space characteristics, there are plenty of unique significance in the scenes of religious, agriculture and production. Thus, in the first stage of a digital technologies-based research, it is critical to recognize systematically the information of landscape, architecture and so on, which will begin with the three aspects described below.

3.1.1. Location. It could be dated back to the Han Dynasty in 111 BC when the Qiang ancestors migrated southward to survive the battles, which decided to settle isolated in the considerably high mountains and valleys in the upper reaches of the Minjiang River. Taoping is located by a first-level tributary that takes the Minjiang River Valley as its axis and several tributary valleys as the expansion to create a dendritic structure, and the intersection with the main stream becomes the only way to communicate with the primary river[9]. Consequently, each tributary created a comparatively closed inner space, and the culture and settlement grown there. Furthermore, the soil is thin and the cultivated land is limited, which is located in the alluvial fan of the river. Due to the harsh climate, the Taoping villagers had to survive by agriculture and fighting for available resources all year. Taoping was built halfway up the mountain, layer by layer, to prevent occupying arable land to the full extent possible. Gradually, a village with a three-level platform, an 18-meter height gap and a heavily defensive feature appeared[10].

3.1.2. Landscape. One of the vital reasons why Taoping is priceless is that it is full of unique landscape characteristics, which could be described by the following three aspects: architecture, space and landscape elements.

Architecture. The types of architecture in Taoping could be classified as three categories: stone dwelling, watchtower dwelling and modern brick building. The stone dwellings vary in the height from one to three floors, with areas ranging from a few dozen square meters to several hundred square meters, among which the Yang’s has the largest area with four stories. A watchtower dwelling is constructed as a hybrid of a watchtower and a stone dwelling. Nowadays, there are 3 watchtower dwellings in Taoping. Among them, Chen’s is the most centrally located, with a clear and perfect view of the entire village. Furthermore, craftsmen used their own hands to build stone dwellings and watchtower dwellings which were built one layer per year, taking local stones and clay as the construction materials. Besides, the funnel-like windows (Figure 2) were designed to fulfill the demands of illumination and defense[10].

Figure 2. The view sight through the special window.

Figure 3. The roof platforms that could support entertainment activities.
**Space.** Under the multiple influences of geography and history, Taoping has a three-dimensional spatial form with three networks, the ground, roof, and underground. Gradually, there was a layout which took the watchtower as the center of the settlement in order to avoid frequent invasions. And as the population boomed, there has been an expansion service of closely adjacent buildings to construct the arcade, which is the reason that enabled the buildings to stick together tightly as well. With the increasing number of arcades, multiple dark alleyways and the ground road network appeared. Secondly, since dwellings are constantly extruded, the ground space is not enough to meet the demands, so the roof platforms of the architecture were used for undertaking the production and recreation activities, such as sun-drying and neighborhood meeting (Figure 3). Gradually, the wooden ladders are interconnected as a network of aerial roads. Moreover, the villagers use the village's elevation gap to draw water from the snow mountain. The inexhaustible snow water was transported to each building in the village by many channels, during which several open and dark canals were built up to form a comprehensive underground water supply system that could be regarded as a special communication approach when facing invasions.

**Landscape elements.** Taoping has a diverse range of natural and man-made landscape elements. Rocks and water are major natural landscape features of Taoping, all of which have a momentous impact on the vision and function. The rock is the vital construction material, and the water works as a peculiar scene with delightful sound and essential function. Besides, Taoping is abundant with cultivating and living elements. For instance, there are stone bridges, water intakes, as well as arcades which serviced as the place where food and sundry housing and women's everyday leisure activities taking place in the past. Moreover, fruit trees survive in the village as both landscape and harvesting components. The villagers still maintain the tradition of the sheep worship, nature worship, totem worship, and white stone worship as well. Hence, there are a considerable number of spiritual and cultural elements, including a sheep totem, a white stone pile, a stone daredevil, and a stone dog.

3.1.3. **Scene.** Firstly, harvesting and daily life scenes, which are the essential landscape elements of Taoping are full of aesthetic and functional characteristics, as well as distinct expressions. Almost all the harvest scenes were happened in the roof platforms and outdoors in Taoping, such as grain sun-drying and clothes handicraft. The reasons for this are the constant invasion and nearly thorough occupation of the limited land. When it comes to culture scenes, the representative ones in Taoping are the abundant festivals which are cultural activities that convey religious beliefs and customs passed down from generation to generation. The noteworthy festivals are the Qiang Calendar Year, which occurs on the first day of the tenth lunar month and originated from the celebration of a good harvest, and Mountain Worship Festival[11]. Mountain worship is a festival for Qiang People paying tribute to the mountain to express their high esteem and also praying to Mubita for a prosperous harvest in the coming year. The only plaza in Taoping serves as the celebration place as well, where villagers would dress up and dance passionately with upbeat music, which is known as the Rrmea Salengw culture and the Qiang people's mother culture[12].

3.2. **Establish the data chain**
The vital step of sustainable conservation of ancient villages based on digital technologies is to obtain as much data as possible. A considerable amount of literature has been published on the digital technologies’ application in measurement, which indicates a need to understand the various perceptions of data application. The aim of this essay is to build a data chain on the study of sustainable conservation of ancient villages, which involves collecting data by measuring, data analyzing, and supplementing with analysis results.

3.2.1. **Collecting data by measuring.** Accurate data collection on scenes, topography, and space is a crucial phase in sustainable conservation of ancient villages’ research. With the rapid development of digital technology, we can take suitable measurement techniques and make reasonable mapping plans.
based on the topography and other landscape features of Taoping, by using terrestrial laser scanning (TLS), unmanned aerial vehicle digital photogrammetry (UAVDP) and other technologies.

3.2.2. Broad application and supplementing. To achieve the deep excavation of space characteristics, the quantitative analysis study would start from settlement, alleyway, and human viewpoint by using the multivariate analysis approaches comprehensively and the village data obtained by measurement.

Settlement scale. The comparative study of typical settlements is beneficial in addressing the essential characteristics of settlements. The existing quantitative studies have effectively broadened the techniques and horizons of settlement morphology analysis, but the survey is limited to the settlement's layout. Generally, topographic studies rely on qualitative research method to describe and summarize the ancient villages’ features, except the quantitative comparative study of Miao settlement morphology in Qiandongnan, which attempted to achieve comparison study by a combination of three-dimensional quantification and factor clustering[13]. Taoping, which has uncommon characteristics and three-dimensional features compared with the plain region, is built along the terrain. Thus, this research proposes to analyze the three-dimensional morphology, as well as to examine the settlement boundary morphology, space, and geographic features in order to provide a new perspective for Taoping’s conservation.

Alleyway scale. One of the most widely used research methods in the study of space characteristics is space syntax theory. Bill Hillier of the University of London's School of Architecture proposed space syntax theory for the first time in 1970, which emphasized the research on connectivity, integration, depth and so on. Some researchers already used the space syntax theory to study the ground road network’s form of Taoping[14-15]. Nevertheless, owing to the low accuracy of the data, the results of the ground road network study should be validated, as well as the village's aerial road network still needs to be explored. Meanwhile, the axis of the road network could be isolated by the software Cloud Compare Semi-automatically, which could be applied in spatial analysis.

Human scale. It was found that Taoping is very mysterious and disorienting, which would bring unique experiences to those who stepped in it. Up to now, far too little attention has been paid to discuss the individuals’ understanding of the space or their behavioral preferences, though there is extensive research has been carried out. With the growth of technologies, virtual reality (VR) and its derivatives augmented reality (AR) and mixed reality (MR) are widely used in heritage interpretation and display, which can be regarded not only as ‘the information dissemination medium’ or an alternative to conventional heritage information displays[16], but also as a tool to communicate and interact the audience with the exhibit[17]. Furthermore, research has indicated that VR-based technologies have major technological benefits of reconstructing historical and damaged heritages, as well as that participants can learn about their information and history more easily and visibly and increase the interest in learning[18]. It is foreseeable that the application of VR-like technologies would open a host of new prospects and possibilities in the field of sustainable conservation of ancient villages. Therefore, this research proposes to create a VR platform using a realistic model of Taoping in order to achieve a realistic panoramic record of Taoping's multiple scenes, and probably to complete the study of the human behavioral performance characteristics of various groups. With the aid of the system's real-time recording capabilities, the Taoping VR platform can be utilized to store the movement trajectory and real-time position, and help the study of individual spatial cognition.

3.2.3. Data management. The reason for the slow growth in ancient villages’ sustainable conservation based on digital technologies is the lack of data management platform, which results in data waste as well. Several authors have considered that the only method to manage and visualize the various sources of data is to establish a database primarily based on GIS technology. However, it is difficult to realize the linkage of culture characteristics in that system on the research of sustainable conservation of ancient villages. It is indispensable to combine the excavation and analysis of the intrinsic culture characteristics (the spiritual part) and the management and recreating of landscape elements (the material part). Besides, the public could provide different perspectives of reservation and accelerate the speed of data updates.
Therefore, the study on the creation of the public-accessible management platform would play a significant role as well.

3.3. Cultural inheritance and dissemination
The recognition and dissemination of village landscape and culture are unavoidably issues in sustainable conservation research. Therefore, this study proposes the extensive use of digital technologies, like VR, internet and new media, in sustainable conservation research to realize the Taoping’s cultural inheritance and to innovate the research method, which could boost the efficiency and quality of dissemination, diversify the display form and so on. Higher accuracy data of Taoping may offer more convincing research assistance, including in-depth excavation of the settlements' culture and general identification of the settlements' landscape, all of which can be considered as the essential content for heritage research. Making full use of online and off-line channels, such as digital media, off-line exhibition halls, could achieve the dissemination of the settlement's high-quality culture.

4. Discussion

4.1. Integration utilization of digital technologies
In recent years, scholars from various countries continually argued for the application of various new digital technologies to the study of landscape architecture disciplines in order to facilitate the advancement of the disciplines and the growth of society. However, the research tends to concentrate on either one or two types of technologies, such as measuring with 3D laser scanning or experimenting with VR scenario improvements. In fact, the research process of ancient villages preservation by digital methods should include data collection, data implementation, and data management, which means a series of digital technologies should be utilized in research. Besides, there are diverse drawbacks in different technologies, while the integration utilization could broaden viewpoint and compensate for shortcomings.

4.2. The extended application of data
At present, it is relatively inadequate in application of village data collected by numerous researchers at considerable cost. While the landscape architecture academics have achieved a lot of outcomes in terms of basic research, the research of the extended application of data is still in shortage. Indeed, technical barriers have been broken down. Meanwhile, the key to keep ancient villages alive is continuously exploring the extended applications of data in various fields. As an attempt, space characteristics research is proposed in this research, which focuses on three different scales of settlements and has improved the perspective of space characteristics research to some extent, though this is merely a fundamental extension review and further research is needed.

4.3. The data management
In terms of sustainable conservation study based on digital methods, it has achieved valuable results for data management study. As mentioned in the literature review, the multi-source data management platform based on GIS technologies would bring multiple benefits and immense potential. However, the unique and profound cultural characteristics of ancient villages couldn’t be displayed simultaneously. Furthermore, the sustainable conservation of ancient villages should not merely be accomplished by governments and professionals. It would be a worthwhile study to produce a data co-construction mechanism by establishing a public-accessible management that will instantly update and correct data and compensate for the shortcomings.

5. Conclusion
Rapid urbanization threatens the viability of ancient villages, making sustainable conservation critical. The exponential evolution of technology has historical and functional implications for conservation, heritage, and sustainable development. However, related to the cultural specificity and terrain
sophistication of ancient villages, the application of technologies also necessitates extensive research. Each technology has its own combination of advantages and disadvantages, and integrating them for broader use and forming a technical approach will address the shortcomings. In general, further research should be undertaken to deepen our recognition and comprehension of minority culture through digital technologies and enhance the effectiveness of ancient villages’ data management.

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