SHRIMAYI KUMAR

URBAN AND RURAL TOURISM STRATEGIES IN SUSTAINABILITY

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4/21B, First Floor, E-Block,
Model Town-II,
New Delhi-110009, India

Urban and Rural Tourism Strategies in Sustainability
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ISBN: 978-93-5590-984-8

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Prediction of Urban and Rural Tourism Economic Forecast Based on Machine Learning

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Academic Editor: Bai Yuan Ding

With the rapid development of tourism, tourism revenue, as one of the important indicators to measure the development of the tourism economy, has high research value. The quasi-prediction of tourism revenue can drive the development of a series of related industries and accelerate the development of the domestic economy. When forecasting tourism income, it is necessary to examine the causal relationship between tourism income and local economic development. The traditional cointegration analysis method is to extract the promotion characteristics of tourism income to the local economy and construct a tourism income prediction model, but it cannot accurately describe the causal relationship between tourism income and local economic development and cannot accurately predict tourism income. We propose an optimized forecasting method of tourism revenue based on time series. This method first conducts a cointegration test on the time series data of the relationship between tourism income and local economic development, constructs a two-variable autoregressive model of tourism income and local economy, and uses the swarm intelligence method to test the causal relationship and the relationship between tourism income and local economic development, calculate the proportion of tourism industry, define the calculation result as the direct influence factor of tourism industry on the local economy, calculate the relevant effect of local tourism development and economic income, and construct tourism income optimization forecast model. The simulation results show that the model used can accurately predict tourism revenue.

1. Introduction

Tourism economic forecasting [1–3] serves tourism economic decision-making and planning management. It is the premise of scientific decision-making and planning management and directly affects the accuracy and reliability of tourism economic decision-making [4, 5] and planning management [6, 7]. It is impossible to make an optimized tourism decision and planning without a tourism economic forecast that conforms to the objective reality. Tourism economic forecast participates in tourism economic decision-making and planning management and affects decision-making and planning. This important role is mainly reflected in the following aspects: first, through forecasting, reveal the changing trend of tourism economic development in the future [8], for the purpose of formulating tourism economic development. The strategy provides a reliable basis. The formulation of a tourism economic development strategy is the most important tourism economic decision, and every link and every factor that constitutes a tourism economic development strategy, including development goals [9], implementation steps [10], and measures, cannot be separated from the prediction of future trends. To formulate a tourism economic development strategy, first of all, it is necessary to predict and make reasonable predictions about a series of unknowns, such as the overall development of the national economy [11, 12], changes in economic structure, changes in national policies, and changes in population quantity and quality, in order to grasp the possibility of the development of the tourism economy of the country and propose feasible development goals; secondly, it is necessary to predict the changes in the market within a certain period of time, the changes in the industrial structure of the tourism economy, the changes in the

product structure, and the changes in reception capacity. Only by making scientific predictions on the status and level of tourism economic development can we accurately divide the development stages and strategic steps [13] and determine the approximate execution sequence and time range for related work; again, the flow direction and flow of the future tourism market [14] and the tourism economy [15] must be determined. Only by predicting the changing trends of the quality and abundance of regional resources can we reasonably formulate the strategic layout of tourism economic development and complete the optimal spatial configuration of tourism productivity [16, 17]. Obviously, leaving the basis of tourism economic forecasting, the entire tourism economic development strategy has become a castle in the sky. Second, through forecasting, reveal the various situations that may occur in the development of the tourism economy: mainstream and tributary [18], favorable and unfavorable factors [19], opportunities and risks [20], and achievements and problems [21], so as to be confident and avoid blindness and one-sidedness in decision-making [22–24]. For example, in 1982, Hong Kong's tourism industry still maintained a momentum of development despite the global economic downturn, and all walks of life were deeply affected. One of the important reasons is that the Hong Kong tourism authority [25] predicted the trend of the world economic downturn and made corresponding preparations in advance. Third, predicting the economic benefits of a number of alternative tourism development programs can provide a practical basis for choosing the best program. In other words, the tourism economy forecast not only proposes a variety of ways and plans for the development of the tourism economy but also analyzes and analyzes the possible losses and benefits of each plan and the possible consequences and impacts of each proposed tourism policy. Demonstration is to make a decision on the premise of comprehensively weighing the pros and cons. Fourth, the role of forecasting not only is limited to speculating on the economic process specified by tourism economic decision-making and planning management but also includes foreseeing the changes and prospects of the external environment related to it. Planning management provides more ambitious information in order to make tourism economic decision-making and planning management more comprehensive. The external environment mentioned here mainly refers to various external noneconomic factors that may have an impact on the development of the tourism economy, such as the trend of global climate warming, the peaceful trend of the international political environment, and the negative impact of the SARS epidemic. Forecasting the changes and prospects of the external environment of tourism is particularly important for macro decision-making.

In order to effectively play the role of tourism economic forecasting, machine learning algorithms [26] have played a big role. The application of machine learning in the economic field mainly includes helping scholars obtain data that was difficult to obtain in the past, exploring the correlation between variables and making predictions, predicting counterfactuals, and then identifying cause and effect. From the perspective of predictive ability, machine learning is a predictive method with strong applicability, good accuracy, and high efficiency. First of all, machine learning [27] is not limited to "interpretability"; it can flexibly choose functional forms to fit data, study highly nonlinear, unexplainable models, and make out-of-sample predictions. Its predictive power surpasses traditional econometric methods [28]. Although mainstream empirical methods mostly use econometric models based on causality, these models have strict application conditions. Even with the support of the correct economic theory, they are often unusable in research, or even though they can be used, they end up in failure. Secondly, machine learning can make full use of the value of big data, directly mining the relationship between data and "discovering nontrivial knowledge that is of interest to specific users from the database." Finally, when the machine classifies, almost no human judgment is added, so the objectivity is high.

The contribution of this paper is to study the effectiveness of machine learning methods, promote the application of machine learning methods in financial forecasting, and provide ideas and references for the intelligent and digital transformation of tourism economic forecasting. The research results of this article prove that machine learning is an accurate, simple, and objective forecasting tool suitable for listed companies in my country, and different models have their own strengths in tourism economic forecasting. As a forecasting tool that "advances with the times," machine learning can be self-optimized with the continuous enrichment of future tourism economic data so that the forecasting method can be constructed "once and forever" and "excellent" in terms of results. Therefore, machine learning can help companies discover financial problems in time to take remedial measures; provide investors, corporate partners, and other stakeholders with more financial information to optimize investment decisions; and provide effective methods for regulators to reduce human and material costs and improve market supervision.

2. Related Works

Machine learning methods have improved the economics research paradigm [29], and the academic results of applying them to financial forecasting have become increasingly abundant. Scholars at home and abroad have done more research on financial distress forecasting, but there are few results involving performance explosions. On the whole, machine learning provides ideas and methods for the prevention and discovery of financial problems of listed companies [30], and the predictive model trained by it provides an effective practical reference for the stakeholders of listed companies [31]. Chen et al. [32] used data from listed companies in Taiwan and found that the closer to the time point of financial distress, the higher the prediction accuracy of the prediction data and the accuracy of the neural network model is higher than that of the machine learning (clustering) model. Sun et al. [33] used Chinese ST companies as samples and used regression trees (CART)

[34], support vector machines (SVM) [35], K-nearest neighbors (KNN) [36], multiple discriminant analysis (MDA) [37], logistic regression [38], and other methods to make predictions. The results showed the prediction effect of the CART model. Sun et al. [33] also used Chinese ST companies as cases of financial distress, single-factor testing (SAT) [39], and decision trees as weak learners, and used the AdaBoost method [40] to integrate weak learners to predict the company's financial distress situation; combined with separate decision tree models, SVM is compared; and it is found that the AdaBoost method, which uses SAT as a weak learner, has the highest prediction accuracy. Sun and Lie [33] took Chinese listed companies as a sample and defined financial distress as two consecutive years of loss or the loss of the most recent year exceeding the registered capital, constructed a dynamic financial distress prediction model, and used minority oversampling technology (SMOTE) to solve the problem of sample imbalance. Financial fraud forecasts: there are also many research results in this area. Given the limited resources, it is unlikely to find all financial frauds, and the possibility of exploring causality is limited. The use of machine learning to predict is practical. Nasir et al. [41] used the support vector machine model to detect the financial fraud of listed companies. After adding a specific "core" to the model, the model worked well. Al-Hashedi et al. [42] summarized and compared the technologies and methods of financial fraud detection and found that there are applicable technologies and methods for different types of fraud.

In terms of predictors, scientific and complete data are necessary conditions for the success of machine learning models. The data of listed companies is relatively rich, and there are many variables that can be collected. Therefore, the selection of predictors has become a research topic. Liengaard et al. [43] believed that there are generally two methods for selecting predictor variables: one is to select variables based on financial accounting theory and the other is to select variables based on machine learning. They studied the financial distress prediction problem [44, 45] of listed companies in mainland China (using ST as the standard) and found that the selection of predictive variables based on data mining models has the same effect as the selection based on expert financial accounting knowledge, and ROA is the best predictor variables.

3. Methodology

In the process of forecasting tourism income, first, calculate the regional tourism income and tourism income growth rate indicators, obtain the promotion characteristics of tourism income to the local economy, describe the law of change between tourism income and economic growth, and build a tourism income prediction model. The specific steps are described in detail as follows: assuming that N_p represents the tourism output value, C_{cs} represents the connection between the tourism industry and other industries, and DW represents the elastic value of tourism income, then use equations (1) and (2) to calculate regional tourism income and tourism income growth rate:

$$Q_{JP} = \frac{D_{DS} \times w}{C_{cs}} \times \mathrm{TES} \times N_p \mathrm{DW}, \tag{1}$$

$$W^* = \frac{D_{DS} \times w}{C_{cs}} \times \frac{\mathrm{TES} \times N_p Q_{JP}}{\mathrm{DW}}. \tag{2}$$

Here, N_p represents the added value of tourism, w" represents the final demand for tourism in the place, and TES represents the income effect of the tourism economy.

Assuming that X represents the degree of dependence of tourism on other industries, formula (3) is used to obtain the promotion characteristics of tourism income to the local economy:

$$\phi''' = \left(Q_{JP} \times W^*\right) \times \frac{\varphi \times \kappa}{(H \cdot \chi)} \times \varsigma. \tag{3}$$

In the formula, φ represents the balanced relationship between tourism income and tourism growth, κ represents the income effect of tourism, H represents the factors influencing the development of tourism, χ represents the comprehensive employment coefficient of tourism to other industries, and W^* represents tourism income and the lag structure between the two variables of economic growth. The tourism income forecast model is shown in the following:

$$\mathrm{NA} = \frac{\nu\gamma \times \phi'''}{W^*} \otimes Q_{JP} \cdot \mathrm{DW}. \tag{4}$$

In the formula, VR represents the law of change between the two variables of tourism income and economic growth. However, traditional methods cannot accurately describe the causal relationship between tourism revenue and local economic development and cannot accurately predict tourism revenue. This paper proposes an optimized forecasting method of tourism income based on time series.

In the process of modeling and modeling of tourism revenue optimization forecast, obtain time-series data of tourism revenue and local economic growth, conduct cointegration test on tourism revenue and economic development time-series data, and build a vector autoregressive model of tourism revenue and economic development variables. To test the causal relationship between the models, the specific steps are described in detail as follows: Before the cointegration test on tourism income and economic development time-series data, the stability of tourism income and economic development time series data should be tested, respectively. Its function is to avoid false regressions with high $R2$ values between tourism income and economic development time series variables. Assuming that B represents the criterion for judging regional economic growth, use equation (5) to calculate the economic growth level of a tourist area:

$$p_\alpha(X, A) = \frac{B \cdot \Omega}{\mu_n \cdot R2} \times \frac{\varsigma^\gamma \cdot U_n}{M^{\nexists}}. \tag{5}$$

In the formula, Ω represents the total tourism income, μn represents the dynamic impact of random disturbances on the variable system, ς^γ represents the impact of economic lagging variable in the economic region on the current

Table 1: Index system of influencing factors of tourism income.

Explained variable	First level indicator	Secondary indicators
Domestic tourism income	Socioeconomic factors	Added-value of tertiary industry
		Regional per capita production value
	Residents' living standards	Per capita disposable income of urban residents
		Per capita consumption expenditure of urban residents
		The total retail sales of social consumer goods
	Traffic convenience	Passenger turnover
		Passenger volume
		Kilometers, railway density
	Tourism resources and services	Number of star-rated hotels
		Number of travel agencies
		Number of A-level and above sceneries
	Environmental quality factors	Green area rate of built-up area
		Harmless treatment rate of domestic garbage
	Regional demographic factors	Permanent population at the end of the year
		Number of students in the university

variables, U_n represents the availability of variable data, and $M^{\nexists}$ represents the tourism order of the time series of income and economic growth.

Assuming that the tourism income time series represented by ξ is a first-order single integer and l represents the second-order difference sequence of the economic growth data series, then use equation (6) to obtain stable tourism income and economic development time series variable data:

$$p\left(\frac{\gamma}{\eta_1}\right) = \frac{\xi\left[\sum_{i=1}^{k}\eta_{1i}\right]}{\Gamma(\eta_{1i})}\gamma(\eta_{1i}-1). \tag{6}$$

In the formula, n_{1i} represents the cointegration relationship between tourism income and regional GDP, Γ represents the random disturbance term, Υ represents the n-dimensional endogenous variable, and k represents the lag period of economic growth:

$$P^L = \frac{\mu_{1n}-\mu_{jn}}{t_{ES}\times P(\gamma/\eta_1)}\cdot P_{\propto}(X,A). \tag{7}$$

The income effect of tourism is defined as the impact of tourism on domestic per capita income. Since the expenses spent by tourists on tourism in tourist destinations will directly become the income of local enterprises, tourism income will gradually be based on the correlation of its related industries. Infiltrate the local economic system, thereby driving the improvement of the overall local economy. The tourism effect of a place can be expressed as the direct and indirect impact of the tourism industry on the local economy. Obtain the causal relationship between local tourism revenue and economic growth as a basis, calculate the proportion of tourism industry, define the result of the calculation as the direct influence factor of tourism on the local economy, integrate the related effects of the local tourism industry, and establish the model of tourism revenue optimization forecast.

4. Experiment and Results

In order to prove the effectiveness of the proposed time-series-based tourism revenue optimization forecasting modeling method, an experiment is needed. The experiment takes Yan'n from 2009 to 2019 as an example to empirically demonstrate the relationship between tourism income and economic growth in Xi'an. The simulation tool for the experiment is python.

In view of the complexity of the tourism system, there are two internal and external systems for its impact factors. Taking into account the availability and quantification of data, an indicator system is constructed from the internal system of domestic tourism revenue impact factors. Table 1 shows the selected indicators.

According to the method proposed in the third part, Table 2 shows the prediction results of this method, including the original value, predicted value, error, relative error, and level error.

It can be seen from Figure 1 that the average relative error is 0.073923, the average grade ratio deviation is 0.1148, both are less than 0.2, and the posterior difference ratio C value is 0.021 less than 0.35, which means that the model accuracy meets the requirements. The combined effect is good, and the model can be used for prediction.

In order to reflect the superiority of our algorithm, we use the algorithm of this paper, SVM, and Naive Bayes algorithm to construct tourism revenue optimization forecasting models and compare different algorithm models to optimize tourism revenue forecast accuracy. The comparison results are shown in Figure 2.

It can be seen from Figure 2 that the accuracy of using the algorithm model in this paper for different algorithm models to optimize tourism revenue is better than the accuracy of the SVM algorithm model for time series testing. This is mainly because the algorithm is used to establish the model first. The time-series data of tourism income and local economy are tested for cointegration, which guarantees the accuracy of the algorithm in this paper to optimize the forecast of tourism income by using different algorithm models.

The algorithm of this paper, SVM algorithm, and Naive Bayes algorithm is used to construct tourism revenue optimization forecasting model, and the error rate (%), stability (%), and time efficiency (%) of tourism revenue optimization forecasting models of three different algorithms are

Table 2: The predicted value of our proposed method.

Year	Original value	Predictive value	Error	Relative error	Step ratio deviation
2009	53.1	53.1	0	0	53.1
2010	67.3	51.177	16.123	0.23957	67.3
2011	83.81	75.115	8.695	0.10375	83.81
2012	103.39	100.532	2.858	0.02764	103.39
2013	126.55	127.521	−0.971	−0.0077	126.55
2014	141.56	156.179	−14.619	−0.1033	141.56
2015	160.01	186.609	−26.599	−0.1662	160.01
2016	207.33	218.919	−11.589	−0.0559	207.33
2017	275.22	253.288	21.932	0.07969	275.22
2018	291.9	289.658	2.242	0.00768	291.9
2019	335.56	328.34	7.22	0.02152	335.56

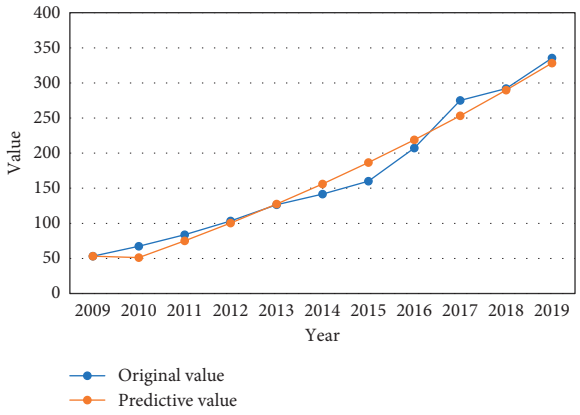

Figure 1: Comparison of predicted value with the original value.

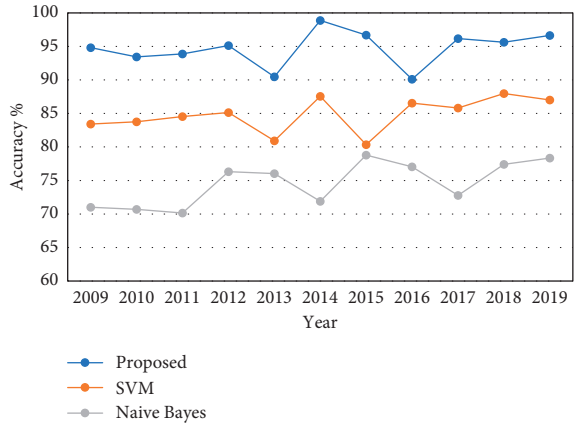

Figure 2: Comparison of prediction accuracy of three algorithms.

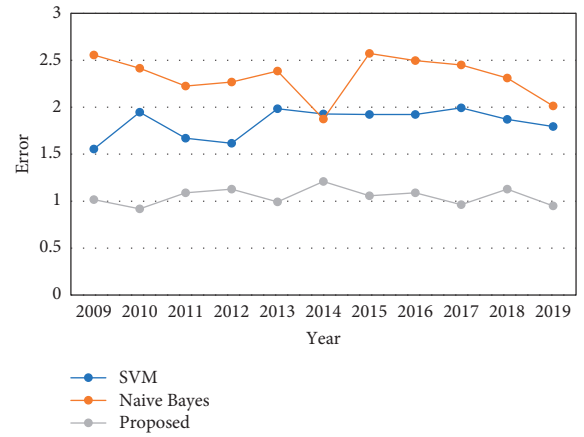

Figure 3: Comparison of modeling error rates of different algorithms.

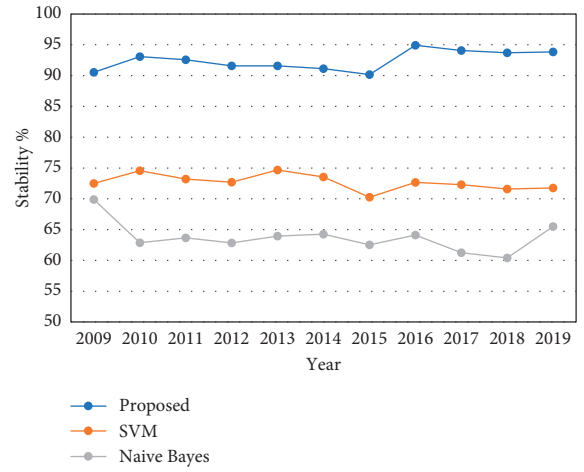

Figure 4: Comparison of stability of different algorithms.

compared. The results of the comparison measure the comprehensive effectiveness of the two different algorithms to establish the tourism revenue optimization forecast model. The results of the comparison are shown in Figures 3, 4, and 5.

From the analysis in Figures 3–5, it can be concluded that the comprehensive effectiveness of the establishment of the tourism revenue optimization forecast model established by the algorithm of this paper is better than the effectiveness of the SVM algorithm and the Naive Bayesian model. This is because when using the algorithm in this paper to establish a tourism revenue optimization forecast accuracy model, a vector autoregressive model based on tourism revenue and local economy two variables is constructed, and the relationship between the two variables is tested by the Granger method, and the proportion of tourism industry is calculated. On this basis, the correlation effect of local tourism income is calculated, and a tourism income optimization forecast accuracy model is established.

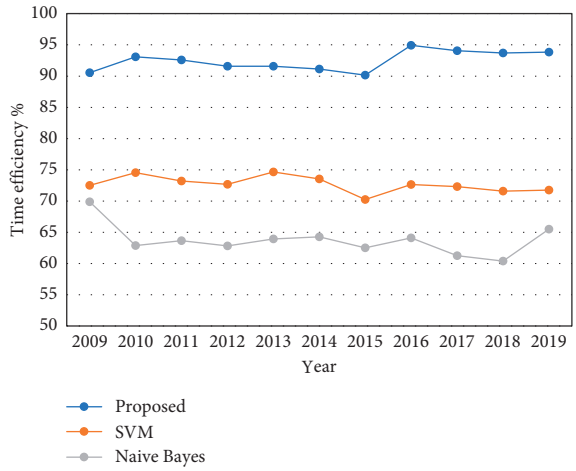

Figure 5: Comparison of time efficiency of different algorithms.

5. Conclusion

The development of modern tourism is closely related to the development of modern transportation. Transportation construction is an important condition for the development of tourism resources and the construction of tourist destinations. Related research shows that areas with obvious advantages in transportation accessibility have a relatively high level of regional tourism economic development. It is necessary to grasp the geographical position of the northwestern region to the east, seize the opportunity of the "Belt and Road" and the construction of the economic belt along the Yellow River, improve transportation services, speed up the construction of transportation networks, and continuously improve transportation accessibility. The development and construction of tourism resources are very important to the development of the tourism economy. In the development process, we must pay attention to the investigation of the tourist attraction radius of the scenic spot and the excavation of the characteristics of the scenic spot, avoid the appearance of homogeneous scenic spots, and establish a unique tourism brand image system. Furthermore, due to the low location and environmental carrying capacity of arid and semiarid areas, the stereotype that tourism is equal to a "smoke-free industry" must be changed, and the coupled and coordinated development of the environment and tourism must be emphasized to create a good environment for cultural tourism and natural tourism. The tourism service industry is a related industry generated by tourism activities. The more mature it is, the more prosperous the tourism economy will be. In order to promote the maturity of the tourism service industry, it is first necessary to establish a multichannel financing mechanism, increase capital investment in the tourism industry, and improve supporting service facilities; secondly, it is necessary to regulate the order of the tourism market and strengthen the supervision of the quality of tourism services; and finally, it is necessary to transform tourism services. The business philosophy is to establish a professional team of talents, pay attention to feedback from tourists, and advocate "refined" and "individualized" services.

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Temporal Differences of Urban-Rural Human Biometeorological Factors for Planning and Tourism in Szeged, Hungary

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Academic Editor: Panagiotis Nastos

Heat load and cold stress can provoke annoyance and even health issues. These climatic situations should be avoided by tourists and locals to prevent negative experiences. Thermal comfort indices are required, as they combine meteorological and thermophysiological parameters. The Physiologically Equivalent Temperature (PET) is easy to understand and interpret also for nonexperts like tourists or decision-makers. The Hungarian Meteorological Service and the University of Szeged run an urban and a rural weather station close to Szeged, which build the basis for the human biometeorological analysis for a twelve-year period between 2000 and 2011. The maximum, mean, and minimum air temperature of both stations were compared to detect the differences of thermal dynamics. Heat and cold stress are quantified by analyzing the PET frequencies at 14 CET. The air temperature of urban areas is on average 1.0°C warmer than rural areas (11.4°C). Heat stress is more frequent in urbanized areas (6.3%) during summer months at 14 CET, while thermal acceptance is more frequent for surrounding rural areas (5.9%) in the same period. The Climate-Tourism/Transfer-Information-Scheme is a possibility to present the meteorological and human biometeorological data which is interesting for decision-making and tourism in a well-arranged way.

1. Introduction

Tourism is an important economic sector in Hungary representing 11% of the Hungarian GDP [1]. In 2011 about 9.8% of the total employments were directly or indirectly related to the tourism sector. The tourism potential of a region arises from several influencing criteria, such as landscape, flora, fauna, geographical position, topography, culture, leisure opportunities, weather, and climate [2, 3]. One of the crucial factors for tourists choosing a certain holiday destination is the climatic conditions, followed by scenery and nature [4].

The climatic conditions vary between urbanized and rural districts and therefore have to be investigated separately. The urban climate is altered through the construction of artificial structures and surfaces [5]. Every city has individual thermal dynamics, which form a very heterogeneous microclimate, depending on surface structure, height of the buildings, street width, and numerous other factors. One of the most important effects is the increased heat storage of buildings, which can cause heat stress for human beings during summer as well as a negative impact on recreation and well-being. The heat wave in Europe 2003 recorded predominant human deaths of about 14 802 in France, 2 045 in the United Kingdom, and 2 099 in Portugal [6]. The knowledge of climate information is required for a better tourism planning and for tourism industries. It should help travellers to prepare and adapt to the climatic situation, and it will protect tourists from negative climatic effects like heat stress [7, 8]. Therefore it is crucial to ascertain the temporal distribution of heat stress situations. Both city-planning and tourism derive advantage from investigations of the urban and rural climatic conditions [9]. It must be pointed out that it is insufficient to evaluate the climatic variables separately. The thermal sensation of humans is a combination of air temperature, wind velocity, water vapour, and radiation fluxes [10–12]. There are applicable human-biometeorological indices which combine not only these meteorological parameters but also several personal parameters [13–15]. In this study,

the biometeorological conditions of a mid-sized city in the south of Hungary and its rural surroundings are analyzed in terms of urban planning and vacation issues. The mean, minimum, and maximum air temperature for urban and rural areas around Szeged are presented. In order to quantify thermal stress conditions, the frequencies of PET classes, as well as the precipitation conditions, for each ten-day interval of the year were analyzed. The Climate-Tourism/Transfer-Information-Scheme gives a clearly arranged overview of the most important meteorological and human-biometeorological factors which influence tourism potential and recreation. This paper offers a bioclimatic information scheme developed for tourism purposes for the medium-sized Hungarian city of Szeged that could be used also for urban planning. It compares thermal and climatic differences between the city and its surroundings. Meteorological data comes from one urban and one rural station and covers the period from 2000 to 2011.

2. Materials and Methods

In this study, meteorological and human-biometeorological conditions of Szeged were analyzed. The city is located in the south of Hungary in a huge plain, the so-called Carpathian/Pannonian basin (Figure 1). Szeged is a mid-sized city with 170 000 inhabitants and has a circuit street system. The data for the period 2000–2011 is provided by the Hungarian Meteorological Service and the University of Szeged and has a time resolution of one hour [16, 17]. The rural synoptic weather station is surrounded by grassland and is located in the west of the city center of Szeged (Figure 1(c)). The climate station in the heavily built-up city center is separated; some measurement tools are located on the top of the roof of a university building, while the Stevenson screen is situated on a lawn beneath the roof station, in order to conform to international regulations.

Evaluating the influence of meteorological parameters on human beings, various thermal indices have been established, which can be classified into three categories: elementary, bioclimatic, and combined indices. Elementary indices usually attach single parameters such as air temperature, sunshine duration, and precipitation. The required synthetic values do not have any thermophysiological relevance and are mostly unproven [7]. Bioclimatic and combined indices, such as the Tourism Climate Index (TCI) or the Physiologically Equivalent Temperature (PET), take account of several climatological parameters and also combine their effects. The TCI developed by Mieczkowski [19] includes seven climatological factors: two of them are in a bioclimatic combination (Daytime comfort index and Daily comfort index) and three are independent (precipitation, sunshine, and wind velocity). The weak point of this index is that it does not rely on the human energy balance. Recognising this weakness, Kovács and Unger [20, 21] have aimed and presented methods to replace the air temperature and relative humidity values as the basis of Daytime and Daily comfort indices of the TCI with the human-biometeorological index PET. In addition to TCI, there are indices which include the effects of short- and longwave radiation fluxes on the human body, such as Predicted Mean Vote (PMV) [22], Standard Effective Temperature (SET*) [23], Universal Thermal Climate Index (UTCI) [24], or Physiologically Equivalent Temperature (PET) [25–27]. The parameter used in this study is PET, which is defined as the assessed air temperature under complex outdoor conditions, at which the human energy budget is balanced at typical indoor conditions. In order to calculate PET, several parameters such as air temperature, wind velocity, relative humidity, or vapour pressure and global radiation are needed. PET is an indicator for thermophysiological stress and its values are given in °C, which makes it easy to interpret and understand also for nonexperts (Table 1) [26]. The calculations for PET have been done by the use of RayMan model [28, 29]. For analyzing the annual distribution, a PET frequency diagram at 14 CET (Central European Time) for the urban station was made for 10-day periods, as this time span comes very close to the mean vacation duration [30, 31]. In addition, the average maximum, mean, and minimum air temperature in urbanized and rural areas were analyzed.

Table 1: Threshold values of Physiologically Equivalent Temperature (PET) for thermal sensation and the physiological stress level of human beings [18].

PET (°C)	Thermal sensation	Physiological stress level
	Very cold	Extreme cold stress
4		
	Cold	Strong cold stress
8		
	Cool	Moderate cold stress
13		
	Slightly cool	Slight cold stress
18		
	Comfortable	No thermal stress
23		
	Slightly warm	Slight heat stress
29		
	Warm	Moderate heat stress
35		
	Hot	Strong heat stress
41		
	Very hot	Extreme heat stress

More detailed information about tourism relevant to climatological and bioclimatological parameters can be illustrated in the Climate-Tourism/Transfer-Information-Scheme (CTIS). The threshold for the included thermal, aesthetic, and physical facets is chosen as follows [30, 32, 33]:

Thermal Facet

(i) thermal acceptance (18.0°C < PET < 29.0°C),

(ii) heat stress (PET > 35.0°C),

(iii) cold stress (PET < 4.0°C).

Aesthetic Facet

(i) cloudiness (cloud cover < 4),

(ii) fog (relative humidity > 93%).

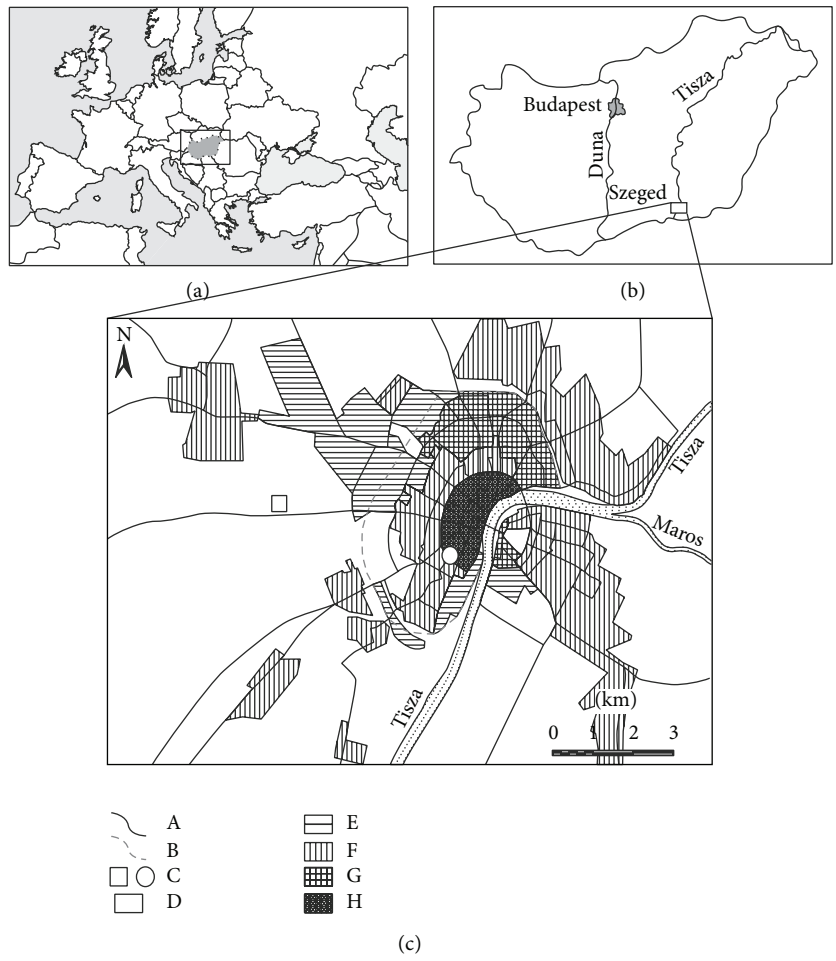

Figure 1: Geographical location of Hungary in Europe (a) and of Szeged in Hungary (b) and characteristic land-use types and road network of Szeged (c); A: road; B: circle dike; C: measuring point in the city centre (○) and in the rural area (□); D: agricultural area; E: industrial area; F: 1-2-storey detached houses; G: 5–11-storey apartment buildings; H: historical city core with 3–5-storey buildings (modified after [36]).

Physical Facet

(i) sultriness (vapour pressure > 18 hPa),

(ii) windy (wind velocity > 8 m/s),

(iii) dry days (precipitation < 1 mm),

(iv) wet days (precipitation > 5 mm).

In CTIS, the absolute frequencies and probabilities of these factors are given in 10-day intervals. To make the information easier to understand for tourists and the tourism industry, each factor given in CTIS can be ranked as positive or negative and will be categorized in seven classes from "very poor" to "ideal." As heat stress, cold stress, fog, sultriness, windy, and wet days are not favourable for tourism, these factors are ranked as negative. On the other hand, thermal acceptance, cloudiness, and dry days are presumed to be beneficial for tourism. This means that a high probability of heat stress is categorized as "very poor," whereas a high probability of thermal acceptance is evaluated as "ideal."

3. Results

3.1. Annual Course of the Maximum, Mean, and Minimum Air Temperature. The annual courses of the maximum, mean, and minimum air temperature in rural and urbanized areas are shown in Figure 2 for each ten-day interval of the year. Rural areas show marginal lower air temperature than urban areas from November until May and become higher from June to October. In the city of Szeged, $T_{a,\max}$ is up to 0.8°C higher in April and up to 0.5°C lower in September and October compared to its surroundings. In general, $T_{a,\max}$ of urban areas ranges from 2.5°C to 29.1°C and in rural areas ranges from 2.1°C to 29.3°C. The lowest $T_{a,\max}$ occurs in December and January, and the highest $T_{a,\max}$ occurs in July. The annual mean air temperature of urban areas is 12.4°C, while rural areas in the region of Szeged are 1.0°C cooler. The coldest period of the urban and rural areas is the first ten-day interval of January with 0.1°C and −0.8°C, and the warmest period occurs in the second ten-day interval of July with 23.9°C and 22.9°C, respectively. In the winter months (December to February), the urban areas have an average

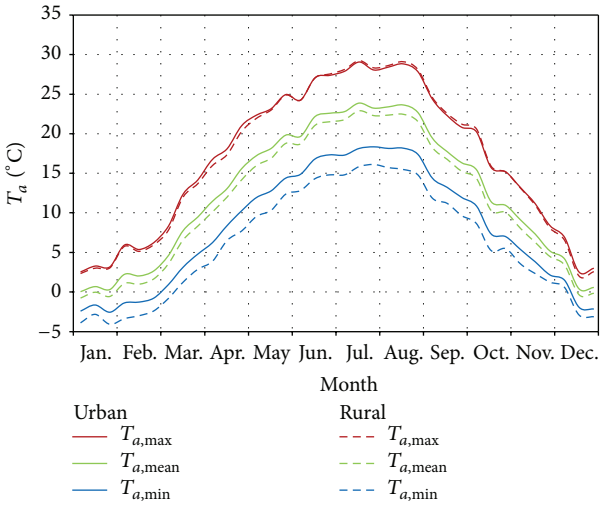

Figure 2: Mean annual course of the maximum, mean, and minimum air temperature for urban and rural areas of Szeged.

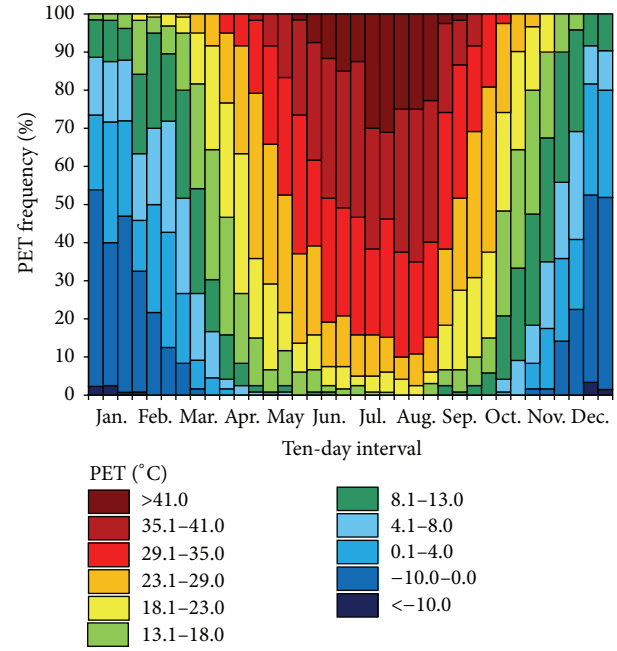

Figure 3: Frequency diagram of PET at 14 CET based on ten-day intervals for urban areas.

$T_{a,mean}$ of 1.5°C, which is about 0.9°C warmer than in rural areas. In summer (June to August), it is even 1.1°C warmer, with an average $T_{a,mean}$ of 22.7°C. The highest differences of $T_{a,mean}$ between urban and rural areas occur during summer and add up to 1.4°C. The average minimum air temperature of rural areas compared to the city of Szeged is 1.5°C lower in winter and 2.6°C lower in summer. It varies from −2.5°C to 18.5°C in urban areas and for rural areas $T_{a,min}$ varies from −4.1°C to 16.0°C. The lowest values of $T_{a,min}$ occur in January and the highest values occur in July for both areas.

3.2. Physiologically Equivalent Temperature for Urban Areas at 14 CET. The values of PET in the urbanized areas at 14 CET are grouped into the classes of thermal sensation and physiological stress level (Figure 3). The class frequencies are shown for each ten-day interval of the year. Due to this well-arranged diagram, it is easy to detect the occurrence and probability of thermal comfort, heat, and cold stress. In the urbanized area the mean annual PET is 19.3°C, with maximum values up to 48.9°C and minimum values up to −15.8°C. The range of PET values for the rural surroundings ranges from −20.5°C up to 50.6°C, with an average of 17.8°C. Expressed in the thermal sensation scale, the meteorological conditions in Szeged and its outer conurbation area go from "very cold" to "very hot," which are the upper extremes of the scale.

Between the first ten-day interval of November and the first ten-day interval of May, cold stress (PET < 4.0°C) can occur. The probability of cold stress increases rapidly from 8.3% in the first ten-day interval of November to 35.8% in the third ten-day interval of November. In December the occurrence triples and up to four of five days show PET values < 4.0°C. In winter (December until February) cold stress dominates at almost two-thirds of the days. In December and January the PET values do not exceed 18.0°C, whereas in February the first comfortable days (18.0°C < PET < 29.0°C) can occur. During winter months the urbanized areas of Szeged have an average PET value of 2.4°C at 14 CET. While in February thermal acceptance has a probability of 1.9%, which is about one day every second year: it increases during spring (March until May) with at least 40% of the days. The second ten-day interval of April shows the highest probability of thermal acceptance (65.0%) and neither cold nor heat stress occurs. At an average of 18 days in April thermal acceptance is expected and the probability of heat and cold stress is less than 1%. In March, there is still a slight chance of cold stress, while in May almost every fifth day produces heat stress. In spring the mean PET at 14 CET is thermally comfortable in general, with an average of 20.5°C.

Heat stress (PET > 35.0°C) may occur between the third ten-day interval of April and the third ten-day interval of August. During summer months (June until August) heat stress occurs on average every second day (54.8%), while there is a minor chance of thermal acceptance (16.0%). The average value of PET at 14 CET during summer is 34.9°C. The highest risk of heat stress is given in August with an average of 62.4% and accordingly about 19 days, while there are only 3 days which are thermally comfortable. In autumn (September until November) the number of comfortable days increases rapidly. Thermal acceptance already dominates in September with 45.3% compared to 15.8% of heat stress. Neither heat stress nor cold stress occurs in October and every second day (50.3%) is expected to be thermally comfortable. Per year there are about 67 days of cold stress and 61 days of heat stress in the city of Szeged, while at least 84 days are thermally comfortable. The majority of the comfortable days are detected in spring and autumn. The frequencies of PET classes are very similar for rural areas and therefore not shown in a figure separately. In general, cold stress is more frequent (78 days per year) and heat stress occurs less

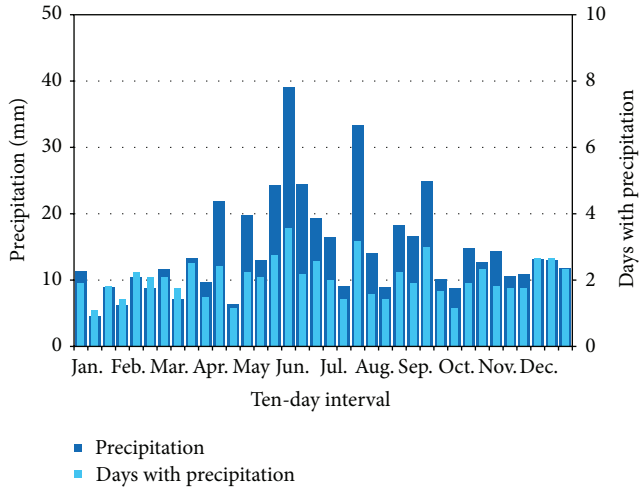

FIGURE 4: Total amount of precipitation and amount of days with precipitation (RR > 1 mm) per ten-day interval at the urban station.

frequently (53 days per year), while there is no difference for thermally comfortable days between urban and rural areas.

3.3. Precipitation in Szeged. In Szeged there are on average 73 days with precipitation per year at a total amount of 520 mm. Most of the precipitation falls during summer, with a maximum of 82 mm in June falling within 8 days (Figure 4). Compared to 25 mm within 5 days in January, the winter precipitation events are less intensive than during summer. Between May and July precipitation events occur during 24% of the days. There are only marginal differences of precipitation between the urban and the rural station, due to the relatively short horizontal distance between the stations and the homogeneous area.

3.4. Climate-Tourism/Transfer-Information-Scheme. In Figure 5, the probability of thermal acceptance, heat and cold stress, cloudiness, fog, sultriness, wind, and dry and wet days at the urban station are shown for 14 CET for each ten-day interval. In April and October, up to 70% of the days are thermally comfortable, while during summer there are only on average 5 days per month with high thermal comfort. Regarding the difference between the urban and the rural station (Figure 6), it is noticeable that during spring and autumn the probability of thermal acceptance is up to 20% lower in the city than at the rural station, but there is a higher chance during summer months.

Heat stress is possible from May until September, with the highest probabilities in July and August, when PET exceeds 29.0°C for almost two-thirds of the days. In rural areas heat stress occurs less frequently than in urban areas. Between October and April cold stress might occur; in the second ten-day interval of December 84% of the days cause cold stress. In general, two out of three days show a PET below 4.0°C during winter months. At the rural station, the possibility of cold stress is slightly higher than at the urban station (Figure 6).

Mean annual cloud cover of Szeged is 5 octas, with small differences between the seasons. During summer it is up to 40% less cloudy than during winter months. Sultriness can occur in May and October, with the highest probability of 30% in July and August. Wind and fog seem to have almost no impact on the human well-being in the region of Szeged, as they hardly exceed the given threshold values.

Generally eight out of ten days are presumed to be dry days, with less than 1 mm of precipitation per day. About 33 days of the year are wet days with more than 5 mm of precipitation. There are only little annual differences in the amount of dry and wet days.

4. Discussion

The differences of the air temperature and PET between the urban and the rural area are a result of the anthropogenic urban structures. The energy balance in urbanized areas is influenced by the composition, degree of sealing, surface roughness, street orientation, and thermal characteristics. Due to the alteration of land surfaces in cities, the materials absorb and accumulate short-wave radiation, which will be emitted as heat radiation. Weak wind conditions in cities facilitate the development of the UHI, which occurs especially in winter and summer during nighttime [34]. Therefore the mean annual air temperature at the urban station is about 1.0°C higher than at the rural station. Regarding PET, the rural station shows a mean value of 8.1°C and the urban station shows a mean value of 9.8°C.

The urban and rural human-biometeorological conditions of Szeged were compared by using the Thermohygrometric Index THI, the Relative Strain Index RSI, and the number of beer garden days for a 3-year period [35]. On the scale of THI, 6% of the year was "hot" in urban areas, while in rural areas it was only 1%. Cold conditions occurred for 54% and 66% in urban and rural areas, respectively. Beer garden days occur almost twice as often as in urban areas between May and October. Gulyás et al. [36] and Gulyás and Unger [37] made further studies about the human-biometeorological situation in Szeged, using hourly PET frequencies over a 10-year period from 1999 until 2008. The mean annual PET value for urban areas is 2.9°C higher than for rural areas. While the maximum PET values are insignificantly higher (0.9°C), the minimum PET values are 10.6°C higher in urban areas compared to rural areas. Thermal acceptance occurs almost twice as often in urban areas. Findings were that rural areas have a higher frequency of extreme cold and extreme heat stress. The heat wave of 2003 was investigated separately [17]. The examined period was March until November 2003, concluding that extreme heat stress occurs more frequently in rural areas due to direct radiation, which decreases in urbanized areas. Even though the average annual PET value is 14% higher in urban areas, thermal acceptance occurs twice as often. The difference in PET is the highest after sunset, when the urban areas are 7-8°C warmer due to the decreased cooling effect. These studies coincide with our results.

The human thermal differences in Budapest, Hungary, expressed with the PET were investigated by comparing

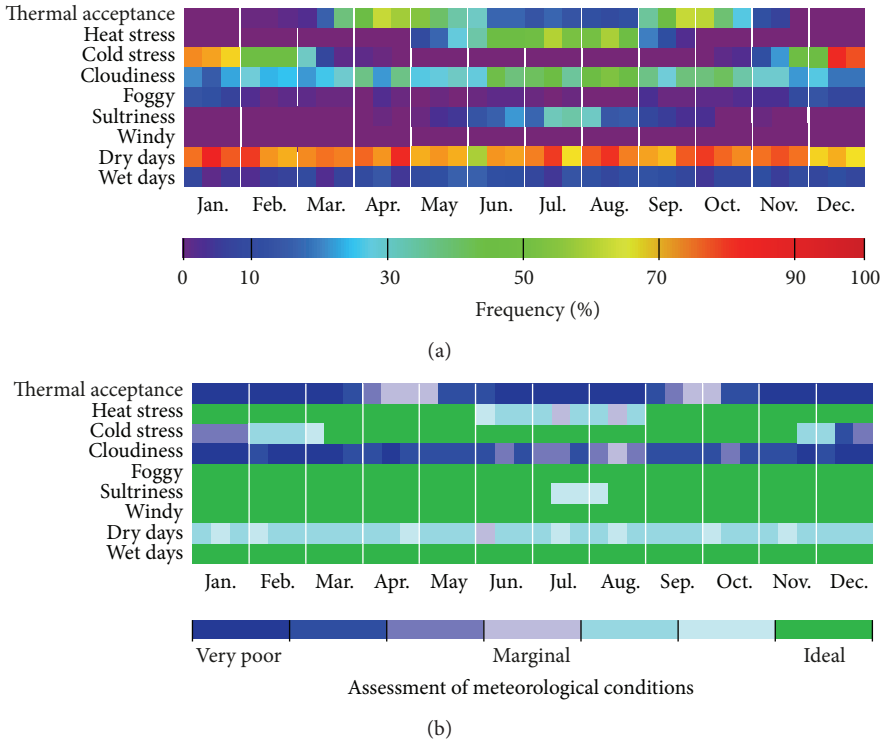

Figure 5: Climate-Tourism/Transfer-Information-Scheme (CTIS) for the urban station at 14 CET shown in relative frequencies (a) and as evaluated parameters (b).

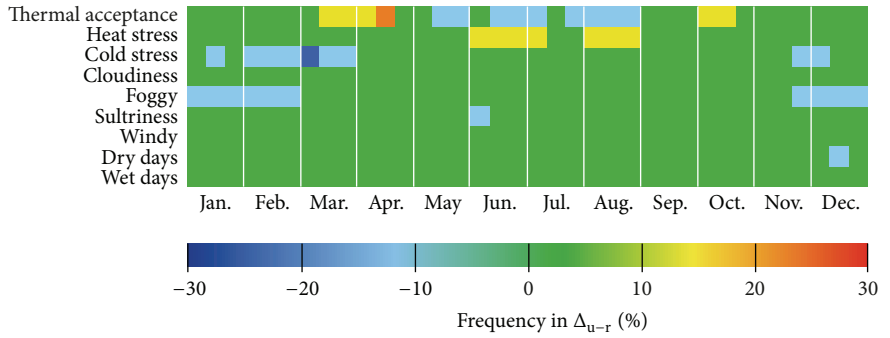

Figure 6: Difference of frequency between the urban and the rural station at 14 CET.

measurements of weather stations situated in the central and the suburban area [38]. They found that the PET differences are the same in all characteristic diurnal observation times (0, 6, 12, and 18 UTC) in the periods 1961–1990 and 1981–2010: the heat load is stronger and the cold stress level is less in the city centre than in the suburbs. During the period from 2001 until 2010 the average PET value is higher by 3°C in the city centre. The maximum PET is only slightly higher (0.9°C) here, but the difference in the minimum value is much higher, about 5°C. The tendencies are similar to those in Gulyás et al. [36] and Gulyás and Unger [37].

The biometeorological comfort of rural urban and urban forest in Erzurum, Turkey, were determined by using the THI [39]. Erzurum has a continental climate and a population of about 361 235. Unlike this study, they stated that the urban area is most advantageous for human comfort, followed by the urban forest and rural area. It has to be considered that the THI is based only on air temperature and relative humidity. The cooling effect of wind is not involved, which is usually higher in rural areas than in urban areas, due to urban structures. The differences of urban, suburban, and rural districts over Greater Cairo in Egypt, which has a subtropical climate, were investigated [40]. As well as Balogun et al. [41], Robaa [40] ascertained that the urban areas are in general warmer than its surroundings.

In our study a more complex system was used; hence, it is of higher significance. Not only the difference of air temperature between urban and rural areas but also PET was compared. We analyzed the mean, maximum, and minimum air temperature, the frequency of PET classes

at 14 CET, and arranged the most important meteorological information for planning and tourism in a Climate-Tourism-Information-Scheme. Tourists can easily ascertain favourable and unfavourable conditions to plan their vacation for their individual needs. Zaninović and Matzarakis [31] designed a bioclimate leaflet, which includes climatological and bioclimatological information of a city or region for tourists. It is an application to assist the tourism industry and stakeholders in decision-making, as well as tourists themselves. The information which is contained could help tourist planners in order to extend the tourist season, and it could help tourists to find the best individual period for their vacation. The design of the leaflet is easy to understand and gives a broad and compact overview of the climatological conditions of the destination.

5. Conclusion

In this study, meteorological and human-biometeorological parameters of urban and rural areas of Szeged were analyzed and the temporal differences of thermal conditions were discovered. There are differences for PET values during the day, as in summer heat stress occurs more frequently in urban areas at 14 CET, and thermal acceptance is more probable in the rural surroundings. On the contrary, cold stress is more frequent in rural areas during winter, due to the absence of heat storage of buildings and low wind speed. Based on the little horizontal distance between the urban and the rural station, there are marginal differences of precipitation.

Single weather parameters, usually presented on a monthly basis, are not appropriate for planning in tourism and urban structures. The Climate-Tourism-Information-Scheme visualizes the most important weather and climate information which is useful for tourism and recreation. It might be helpful for planning a vacation and to know more about the climatic conditions than the usually given meteorological forecast. Information about biometeorological conditions can detect the risk of heat or cold stress whereby the tourists can adapt. The CTIS is user-friendly and easy to understand also for nonexperts like tourists and it gives an overview about the most important climatic and biometeorological parameters.

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Sustainable Development of Tourism under the Background of Low-Carbon and Green Economy

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Academic Editor: Song Jiang

The development of tourism industry not only promotes social and economic progress and the improvement of people's happiness index but also causes resource damage and environmental pollution, which not only affects our living environment but also directly threatens the survival and development of mankind. Therefore, how tourism will develop in the context of low-carbon green economy has become the main problem of tourism development. Based on the above background, in order to solve the development problem of tourism in the future under the low-carbon green economy, based on the research results at home and abroad, starting from the starting point of sustainable development of tourism, this paper introduces the concept of "tourism consumption separation rate" and uses Kaya traditional accounting method. The structural decomposition analysis method and cointegration relationship test method are used to calculate, analyze, and test the tourism carbon emissions and influencing factors at the overall level of China and the middle, western, and eastern regions. Through this method, the accuracy of the calculation results is improved by 30%, which increases the accuracy of the experimental data and is more practical.

1. Introduction

With the continuous development of human society and economy, the actual problems caused by carbon emissions to people all over the world are gradually increasing. The frequent occurrence of extreme weather and natural disasters caused by carbon emissions has brought great losses to the survival and life of people all over the world, as well as the shortage of energy supply. China's economic development is very dependent on energy. The extensive use of primary energy will eventually lead to insufficient energy supply and an energy crisis, which will affect China's economic and social development. Sustainable environmental development will be challenged. Extensive economic growth mode has destroyed forests and caused serious air pollution. Therefore, to find out the key factors affecting China's carbon emissions is an inevitable choice for China's social and economic sustainable development, it is of theoretical and practical significance to study the carbon emission factor and its mechanism. Therefore, how to reduce the impact of human activities on global climate change has become an important task to achieve sustainable development in the future.

Due to the importance of low-carbon and green economy to the future development strategy of tourism, many research teams have begun to study this and achieved good results. For example, tourism is one of the sources of carbon dioxide emissions, and tourism activities will cause pressure on the ecological environment. Zha et al. research constructs the evaluation framework of tourism direct and indirect carbon dioxide emissions and puts the carbon dioxide emission factors into the efficiency evaluation framework based on the SBM bad model. On this basis, taking Hubei Province as an example, this paper evaluates the tourism carbon dioxide emission as a case study, measures the development efficiency and dynamic fluctuation of the low-carbon tourism economy in various cities from 2007 to 2013, and makes analysis [1]. Wu et al. pointed out that the

calculation of tourism carbon dioxide emissions is a prerequisite for the formulation of energy-saving emission reduction targets in some regions of our country, and it is essential for the sustainable development of tourism in certain regions [2]. Shuxin w established a new method to analyze the characteristics and influencing factors of EETT in China from 1994 to 2013. Shuxin w found that the CO_2 emission per unit person time (CETTU) increased from 26.07 kg in 1994 to 14.01 kg in 2013. The decline of energy intensity, scale effect, and policy promotion is the key factor affecting energy consumption. Although the research results are relatively rich, there are still many deficiencies, which are mainly reflected in the fact that the above research results are more focused on a certain aspect of research and are not systematic and comprehensive [2].

In the calculation and research of tourism carbon dioxide emissions, tourism consumption stripping coefficient and Kaya traditional accounting method are good methods, which can solve the problem of large deviation in the calculation data of tourism carbon emissions in the past. Therefore, it is used in the calculation and analysis of tourism carbon dioxide emissions in China. The calculation of tourism carbon dioxide emissions is the premise of formulating energy conservation and emission reduction targets in some regions of China. It is also important for the sustainable development of tourism in some areas. Based on the concept of "tourism consumption stripping coefficient," Wu et al. proposed the calculation method of tourism emissions in Beijing, Shandong, Zhejiang, Hubei, and Hainan. The results show that, from 2009 to 2011, the total tourism emissions of the five provinces and cities increased continuously, and the per capita tourism emissions decreased from 56.569 kg to 54.088 kg. During this period, Hainan's tourism emissions are still the lowest. Hubei's tourism emissions soared from the third place in 2009 to the first in 2011. Beijing is the only downward trend that has not been disturbed. Hainan has the lowest total emissions, but the highest per capita emissions. Only Beijing and Hainan's per capita emissions continued to decline in 2009 and 2011 [3]. The emission of the tourism industry in Zhejiang Province shows an inverted U-shaped trend, while that of Shandong and Hubei Province shows a U-shaped trend. In the future, China should promote energy conservation and emission reduction by formulating action programs, innovating energy-saving technologies, strengthening environmental awareness, and developing regional tourism cooperation.

In order to solve the future development of tourism in the low-carbon green economy, this paper introduces the separation rate of tourism consumption and takes Kaya traditional accounting method as the first step, structural decomposition analysis method as the second step, and cointegration relationship test method as the third step to establish an analysis model to study how to develop a low-carbon economy and low-carbon tourism in response to global climate change, so as to achieve the goal of saving energy. Under the common requirement of environmental responsibility, we are actively promoting the construction of a green economy and the development of low-carbon tourism and exploring the future route of low-carbon tourism, which is also one of the hotspots of future research [4, 5]. How to develop tourism in the future is a comprehensive problem, including the transformation of social, economic, resource, and environmental values. There is little research on carbon tourism in China. At present, low-carbon tourism is only at the level of theoretical discussion and strategic positioning. Based on the classification of relevant research results at home and abroad, according to the relevant theories, such as the theory of sustainable development and the stripping coefficient of tourism consumption, this paper makes an in-depth and multi-faceted evaluation and empirical analysis on the carbon dioxide emissions of tourism cities. The research results have certain practical significance and guiding practical value.

Sustainable development can protect the ecological environment and is a key issue that needs to be considered in the development of tourism.

2. Sustainable Development Strategy of Tourism under Low-Carbon and Green Economy

2.1. Tourism Consumption Separation Rate. It means "separation rate of tourist consumption" [6–8]. It is the added value of tourist consumption deducted from tourism related industries. The original intention is to refer to the percentage of tourism consumption in the added value provided by service sectors including tourism consumption. As the products of tourism industry only account for a part of the products of tourism consumption, it is necessary to deduct a certain proportion of its growth value. The idea of calculating this ratio is to convert the total value of market production, supply, transportation, and other industries into total tourism income with added value according to the percentage of the added value of tourism related industries and calculate the passenger consumption separation rate based on industry value-added words [9–11].

According to this calculation method, the calculation formula is set as follows:

$$E_N = \frac{V_N}{C_N}. \tag{1}$$

In formula (1), E_N represents the separation rate of tourism consumption of n industry, V_N represents the growth number of n industry; and C_N represents the tourism growth number of n industry, multiplying the growth rate of n industry by the tourism revenue of n industry, where the growth rate of n industry is the ratio of the growth number of n industry to the total revenue of n industry [12, 13].

2.2. Kaya Traditional Accounting Method. In order to clarify the contribution efficiency of China's overall and regional tourism carbon emission influencing factors, this paper adopts the Kaya traditional accounting method, namely, Kaya's accounting identity, which is used to analyze the key

factors affecting the change of national carbon emissions [14, 15].

The expression is as follows:

$$C = \frac{C}{R} \times \frac{R}{\text{GDP}} \times \frac{\text{GDP}}{\text{POP}} \times \text{POP}. \quad (2)$$

In formula (2), W is carbon emission, R is energy consumption, GDP is GDP, and pop is household population (100 million). W/R is the energy structure, representing the carbon emissions per unit of energy consumption; w/GDP is the energy intensity, representing the energy consumption per unit of GDP; and GDP/Pop is the per capita GDP [16].

2.3. Structural Decomposition Analysis Method. The method of structural decomposition analysis (IDA) is used to analyze the changes of energy intensity, structure, economic scale, and industrial structure of national and cross-city structures based on industry data [17, 18]. In a word, IDA methods can be divided into two types: Divisia exponential decomposition analysis (Dida) and Laspeyres exponential decomposition analysis (Lida). This method can be divided into two types: arithmetic mean divisor index (AMDI) and logarithmic average divisor index (LMDI). The former model was weighted by arithmetic mean. The deduction process is relatively easy, but the residual value is too large to be calculated when the value is zero [19, 20]. The latter model uses logarithms instead of arithmetic based on the weight ratio and performs zeroing using analysis constraints. Avoid situations that cannot be calculated.

2.4. Cointegration Test Method. It is necessary to investigate whether there is a stable long-term relationship between various influencing factors before empirical research is carried out to ensure that the database is more stable. Therefore, it is inevitable to use the cointegration relationship test method to verify the periodic time series data. Whether there is a stable long-term relationship [21]. At present, there are two common cointegration testing methods: one Engle Granger (EG), mainly based on the stationarity test of regression residuals, followed by the j-j test.

Johansen Juselius mainly uses vector autoregression and VaR to verify the cointegration relationship. Before conducting an empirical study on the overall level and responsible regions of the influencing factors of carbon emissions in tourism industry, this paper examines whether there is a long-term cointegration relationship between the influencing factors on the basis of the *JJ* likelihood ratio test. In order to ensure that individual factors are taken into account, it is meaningful to analyze the decomposition of the influencing factors later [22, 23].

The expression of the *j-j* likelihood ratio test is as follows:

$$T_Y = \alpha + \prod_1 q_{t-1} + \cdots + \prod_k y_{k-1} + \mu = \alpha + \sum_{j=1}^{k} \prod_j y_{t-j} + \mu_t. \quad (3)$$

However, the best method to analyze the fragmentation of index has not been established. Among the many IDA methods mentioned above, this article analyzed the theoretical basis, applicability, and functionality of the index decomposition analysis (IDA) in the existing literature and pointed out that the log average degradation index (IDA) LMDI method can eliminate the residual duration, so it is more applicable [24, 25].

3. Research Design

3.1. Accounting Scope of Tourism Carbon Emission. Tourism industry has the characteristics of a long industrial chain and high business relationship, which leads to the complexity and diversity of energy consumption and carbon dioxide emission measurement indicators. In addition, due to the lack of tourism statistics and the unclear definition of the scope of tourism carbon emission accounting, the measurement of tourism energy consumption and carbon emission has become a recognized problem. Before calculating the carbon dioxide emissions of tourism, it is necessary to determine the accounting scope of carbon dioxide emissions of tourism. Although China has incorporated the tourism industry into the carbon emission system, the five links of "eating, traveling, shopping, and entertainment" in the tourism industry have not been directly reflected. If the carbon emission of tourism is calculated according to this statistical classification, it is actually only a part of the carbon emission in the accommodation process of tourism and tourism service industry, resulting in the formation of "quantity leakage," because other situations are not taken into account. Therefore, domestic researchers believe that the statistical coverage of tourism should include economy, catering, communication and transportation, post and telecommunications, and social services, as well as accommodation and catering industry. They should be put forward independently of each other. Tourism revenue and tourism added value are considered from six aspects of transportation, post and telecommunications, trade, catering and accommodation, and social services.

3.2. Carbon Emission Research Design. In this paper, the "separation rate of tourism consumption" is used to calculate the "separation rate of tourism consumption," and the energy consumption of tourism industry is separated from tourism related industries.

The calculation formula of "tourism consumption separation rate" and the proportion of energy consumption in tourism related industries are as follows:

$$\text{TVN}_K \equiv \text{TE}_K \times \text{VAE}_K = \text{TE}_K \times \frac{\text{VN}_K}{\text{TPV}_K}. \quad (4)$$

In formula (4), TVN_K is the tourism growth value of tourism related industry K, TE_K is the tourism revenue of tourism related industry K, WAE_K is the growth value of tourism related industry K, TE_K is the growth value of tourism related industry K, and WAE_K is the total revenue of tourism related industry K, where $k = 1, 2, 3, 4$ represent "transport, "transport, and post and telecommunications," "wholesale and retail," "catering and accommodation," and "social service industry."

Based on the statistics of energy consumption of tourism related industries, this paper investigates and calculates the overall level of carbon emission of tourism industry in eastern, central, and western regions of China in accordance with the "reference method" proposed in IPCC "guidelines for greenhouse gas emission inventory." The expression is as follows:

$$k^e = \sum_q k_q^e = \sum_j k_j^e = \sum_j k_{jq}^e = \sum_j \mathrm{DR}_{jqv}^e \times \beta_v. \quad (5)$$

In formula (5), k^e is China's overall tourism carbon emission in e year; k_q^e is tourism carbon emission in q region in e year; k_j^e is tourism carbon emission in e year of J province; k_{jq}^e is tourism carbon emission of tourism related industry q in e year of j province; DR_{jqv}^e is energy consumption of tourism related industry q in e year of J province; and β_v is carbon emission coefficient of energy source v. Among them, $e = 1, 2, 3$ denote eastern, central, and western and $v = 1, 2, 3, \ldots$.

4. Analysis of Simulation Results of Tourism Carbon Emissions in China

4.1. Carbon Emission Algorithm Analysis. According to the calculation formulas (1) and (2) and based on the research data of added value and total revenue of tourism related industries, this paper calculates the transport; post and telecommunications; wholesale and retail; and the east, central, and western regions of China from 2010 to 2019. The "tourism consumption stripping coefficient" of the four tourism related sectors of social services is shown in Table 1. On the basis of calculating the "tourism consumption stripping coefficient" of each industry, according to the calculation formulas (4) and (5) and the energy consumption data of tourism related industries, we can separately calculate the overall level of China and its eastern, central, and western tourism carbon emissions, as shown in Table 1.

As shown in Figure 1, in terms of regions, in the past 10 years, the tourism carbon emission intensity of the industries in the west, the middle, and the east is limited by the energy utilization efficiency, energy consumption composition, management efficiency level, policy regulation environment, and energy conservation and emission reduction technology, which shows a different numerical distribution. On the whole, however, the intensity of tourism carbon emission in the west, middle, and east always shows "catering and acceptance > transport, post, and telecommunications > wholesale and retail > social service industry."

4.2. Analysis on the Results of China's Tourism Carbon Emissions. As shown in Figure 2 and Table 2, the measurement results of tourism carbon emissions of China as a whole and its eastern, central, and western regions show that there are two significant characteristics of China's tourism carbon emissions from 2010 to 2019: (1) the tourism carbon emissions show an upward trend year by year, but the rising range gradually tends to be gentle. In terms of increase, China's overall tourism carbon emissions increased from 48.9114 million tons in 2010 to 198.646 million tons in 2019, an increase of 149734600 tons. From the perspective of the increase rate, the annual growth rate of China's overall tourism carbon emissions increased from 13.56% in 2011 to 17.95% in 2019, an increase of 4.39%. The difference of the rising range of tourism carbon emissions is relatively large. In terms of regions, the carbon emissions of tourism in the east, central, and western regions increased from 37.2162 million tons, 8.142 million tons, and 10.6621 million tons in 2010 to 118.6715 million tons, 63.2364 million tons, and 67.8244 million tons in 2019.

Note: since the tourism carbon emissions in 2010 are taken as the base period data, the annual growth rate of tourism carbon emissions in 2010 is set as 0.

Among them, the carbon emissions of tourism in the central and western regions increased fastest and the growth rate was about 5 times. This shows that although the carbon emissions in the central and western regions are lower than those in the east, the growth rate of carbon emissions caused by the rapid development of tourism industry is obviously higher than that in the east, as shown in Figure 2. However, affected by the factors of regional economic level, tourism carbon emissions in different regions are different. There are also differences in the rebound range of the two-year growth rate. In the more developed eastern region, the rebound amplitude is small and the rebound growth rate is only 6.39%. In the underdeveloped central and western regions, the rebound amplitude is relatively large, and the rebound growth rate reaches 8.24% and 10.37%, as shown in Table 2.

As shown in Table 3 and Figure 3, during the 10 years from 2010 to 2019, China's overall carbon emissions from transport, post, and telecommunications; wholesale and retail; catering and accommodation; and social services show a gradual growth trend. From 48.911 million tons, 10.662 million tons, 8.1422 million tons, and 37.216 million tons in 2010, they will increase to 198.646 million tons, 67.824 million tons, 63.236 million tons, and 118.677 million tons in 2019, with an increase of 306.13%, 536.12%, 676.64%, and 218.88%, respectively.

With 2016 as the change node, tourism carbon emissions of China's overall industries show a transformation from "low and median area" (2010–2015) to "high-value area" (2015–2019), as shown in Figure 3. In the above transformation, the increase rate of tourism carbon emissions of wholesale and retail is significantly higher than that of other industries. Tourism carbon emissions due to wholesale and retail have jumped from the fourth place in 2010 to the second in 2019, and from the "low-value area" of 8.142 million tons in 2010 to the "high-value area" (31.8091 million tons, 2019), as shown in Table 3. Although the carbon

Table 1: Stripping coefficient of tourism consumption in China and its regional industries from 2010 to 2019.

Industry	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Transportation, post, and telecommunications	0.21	0.21	0.45	0.46	0.12	0.32	0.3	0.3	0.73	0.12
Wholesale and retail	0.21	0.26	0.21	0.31	0.36	0.32	0.65	0.12	0.13	0.56
Catering and accommodation	0.35	0.36	0.46	0.44	0.46	0.2	0.12	0.3	0.44	0.62
Social services	0.16	0.05	0.22	0.21	0.05	0.37	0.32	0.58	0.33	0.32

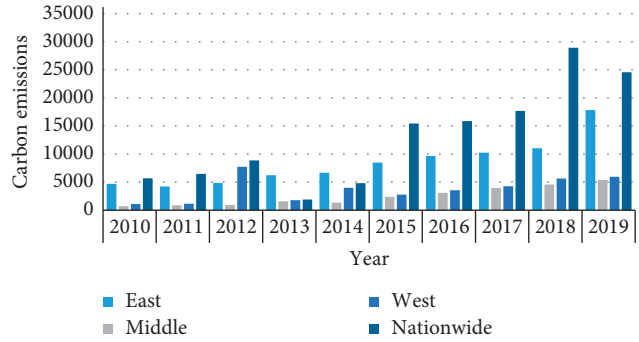

Figure 1: Tourism carbon emissions.

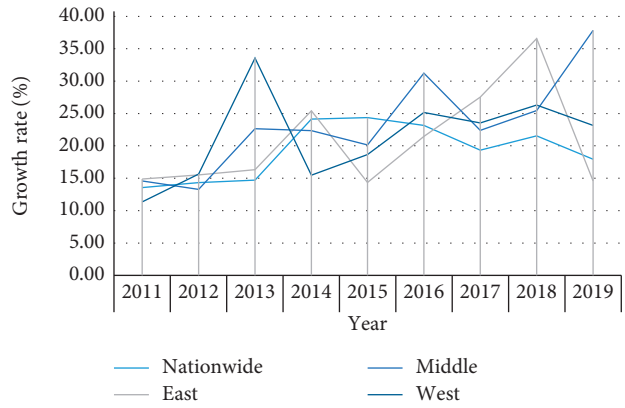

Figure 2: Annual growth rate of China's overall and regional tourism carbon emissions from 2010 to 2019.

Table 2: Annual growth rate of China's overall and regional tourism carbon emissions from 2010 to 2019.

Content	Year								
	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)	2019 (%)
Nationwide	13.56	14.33	14.69	24.16	24.37	23.17	19.32	21.54	17.95
East	14.87	15.50	16.31	25.43	14.35	21.45	27.54	36.58	14.58
Middle	14.58	13.28	22.64	22.34	20.15	31.24	22.38	25.46	37.84
West	11.35	15.64	33.56	15.48	18.65	25.16	23.54	26.31	23.15

Table 3: Carbon emissions by industry.

Content	Year									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Transport	3721.62	3978.5	4823.3	6325.3	5921.44	8288.79	9268.4	10395.6	11087.4	11867.7
Wholesale	814.22	893.16	983.85	1510.6	1765.21	2277.91	3180.9	3948.4	4909.45	6323.64
Catering	1066.21	1366.1	1407.3	1833.6	2194.43	2909.54	4018.4	4268.2	5104.86	6782.44
Social service	4891.14	6327.6	6931.1	9462.5	11342.3	13476.2	15857.	17582.2	21541.8	19864.6

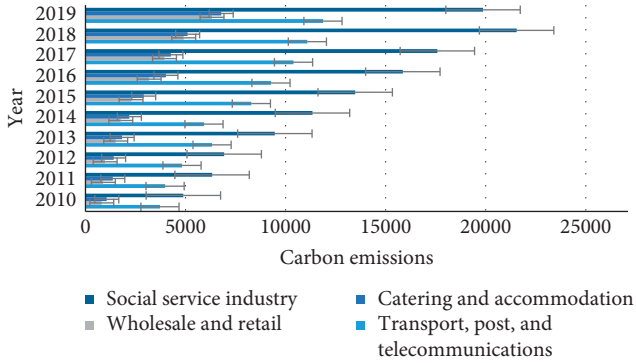

Figure 3: Analysis and comparison of carbon emission of China's overall and regional tourism growth rate from 2010 to 2019.

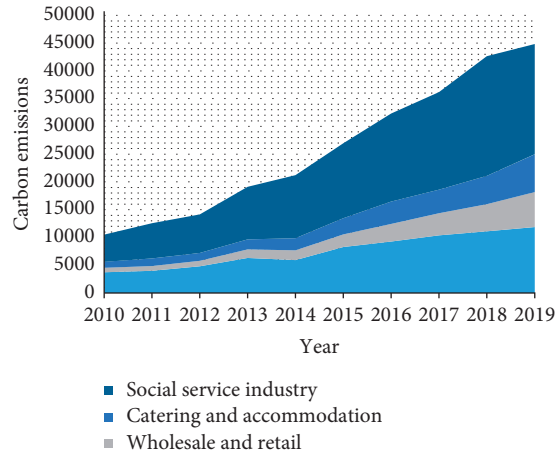

Figure 4: Carbon emissions by industry.

emission of tourism in the wholesale and retail industry is still lower than that of transport, post, and telecommunications, its rising value is obviously higher than that of transport, post, and telecommunications. This shows that when meeting the basic demand of tourism, the tourism motivation of tourists changes, which makes wholesale and retail tourism carbon emissions second only to transport. Another major source of tourism carbon emissions is post and telecommunications, catering, and accommodation, which is expected to exceed the level of tourism carbon emission caused by "food," "housing," and "transportation" in a certain period in the future.

The purpose of the research and analysis of tourism carbon emissions is to understand the current situation of tourism carbon emissions in China as a whole, regions, and industries. To analyze the intensity of tourism carbon emissions is to understand the contribution efficiency of tourism carbon emissions of provinces, cities, and industries. However, the research on the relationship between tourism economic growth and tourism carbon emissions is rare. Existing studies have pointed out that there is a correlation between energy consumption or carbon emissions and economic growth; that is, they are synchronized. This makes how to block the relationship between economic growth and resource consumption and environmental pollution become an important issue in today's academic research. Therefore, to clarify the relationship between tourism economic growth and tourism carbon emissions plays an important role in the realization of low-carbon tourism development under the premise of economic growth. In this context, this paper uses the index decomposition analysis method and cointegration relationship test method to analyze the correlation between China's overall level and its regional tourism carbon emissions.

As shown in Figure 4, combined with the data of the total amount of tourism carbon emissions and the growth rate of the eastern, central, and western industries, the three regions draw the following conclusions and suggestions: (1) the eastern region should focus on wholesale and retail businesses, with social services as the second choice; (2) make transportation, catering, and accommodation the first choice, and social service industry should be the third choice object.

The total carbon emissions (including direct and indirect) of China's tourism industry in the research years (2013, 2014, 2015, and 2016) were 140.26 million tons, 135.89 million tons, 148.93 million tons, and 16.978.47 million tons, respectively, accounting for 4.64%, 3.95%, 2.84%, and 2.71% of the total carbon emissions of all industries in China. It accounts for 4.11%, 3.50%, 2.54%, and 2.44% of China's total carbon emissions (including carbon emissions from domestic consumption). In the research year, the proportion of direct carbon emissions, indirect carbon emissions, and total carbon emissions of China's tourism industry in the total carbon emissions of all industries in China and the proportion of China's total carbon emissions (including the carbon emissions of living consumption) decreased in turn. (3) In the study years (2013, 2014, 2015, and 2016), the direct carbon emissions from tourism transportation were the largest, which were 49.9257 million tons, 42.2538 million tons, 36.8809 million tons, and 50.01427 million tons, accounting for 74%, 76%, 67%, and 68% of the total direct emissions of tourism industry. The second is commodity sales, catering, and accommodation. The proportion of tourism, entertainment, post and telecommunications, and other services is small, and the total emissions are also less. Take the tourism departments in 2007 as an example, 68% of transportation, 2% of sightseeing, 6% of accommodation, 6% of catering, 11% of commodity sales, 1% of entertainment, 1% of posts and telecommunications, and 5% of other services. In the study year, the direct carbon emissions of the tourism sector showed a trend of first rising and then decreasing, especially in the tourism transportation sector. In the research years (2013, 2014, 2015, and 2016), the indirect carbon emissions from tourism transportation were the largest, accounting for 39%, 43%, 40%, and 38% of the total indirect carbon emissions of tourism industry, which were 28.5328 million tons, 34.7507 million tons, 37.4926 million tons, and 37.04 million tons, respectively. However, compared with the percentage of direct carbon emissions from tourism transportation, these ratios are relatively small and have a large drop. The second is commodity sales, catering, accommodation, and other services, while the proportion of sightseeing, entertainment, post, and telecommunications is

small. Take the tourism departments in 2010 as an example, the traffic, sightseeing, accommodation, catering, commodity sales, entertainment, posts, telecommunications, and other services were 38%, 6%, 11%, 12%, 16%, 3%, 1%, and 13%, respectively. In the study year, the overall carbon emissions of various sectors of the tourism industry showed an upward trend, while the local changes in various sectors. The direct carbon emission of the tourism transportation sector is higher than indirect carbon emission, while the indirect carbon emission of other tourism sectors is far higher than direct carbon emission. In particular, direct carbon emissions from tourism and entertainment account for only 20% of the total carbon emissions. Besides the ministry of tourism and transportation, the indirect carbon emissions of other tourism sectors are 3 to 4 times their direct carbon emissions. Therefore, the carbon emissions generated by other tourism sectors should also be paid attention to, because it is very important for the path analysis of carbon emission reduction and the formulation of carbon emission reduction policies. Although the direct carbon emission of tourism transportation is large, its relative indirect carbon emission is not as large as that of other tourism sectors.

5. Conclusion

For the total amount of tourism carbon emissions, annual growth has become the development trend, high east and low west has become the normal development. During the 10 years from 2010 to 2019, China's overall and regional tourism carbon emissions show an upward trend year by year, and the growth rate of central and western regions is significantly higher than that of the eastern region; in this upward trend, the tourism carbon emissions and the ability of tourism development to resist the crisis cycle are significant and show a "postcrisis rebound" effect after the end of the crisis to achieve compensatory growth in carbon emissions. In terms of tourism carbon emission intensity, decreasing year by year has become the development trend, and high in the west and low in the east has become the normal development. China's tourism carbon emission intensity is decreasing year by year in time and is high in the west and low in the east in space.

Therefore, combined with the trend chart of tourism carbon emission at the overall and regional level of China, China should take "enhancing the intensity of tourism carbon emission and reducing the total amount of tourism carbon emission" as the action guideline in the process of reducing tourism carbon emission, that is, on the premise of promoting the continuous growth of tourism income at the overall level and the regional level of China. To achieve the continuous reduction of tourism carbon emissions, complete the sustainable development of tourism under the green and low-carbon economy. As for the theme of "strategic research on sustainable development of tourism industry under the background of low-carbon and green economy," due to the restriction of the author's level and practical experience, there are the following research deficiencies and areas that need to be further improved in the future.

The research on the development strategy of tourism under the green and low-carbon economy is a systematic project, which needs to be based on the theories of tourism, geography, ecology, psychology, and economics. At present, the low-carbon concepts such as the low-carbon economy and low-carbon tourism are still in the research stage, and there is no unified theoretical framework The research is less and needs to be further improved. We explained, in this paper, the concept of sustainable development and the development of low-carbon tourism research ideas, combined with the concept of low-carbon economy to supplement and improve. However, under the green and low-carbon economy, the development of tourism strategy is a comprehensive process, and the selection of the index system needs to be further supplemented and improved. With further research in the future, the development of tourism is more in line with the requirements of the low-carbon concept and sustainable development concept and more suitable for practical application.

Acknowledgments

This work was supported by Hulunbuir University Discipline Construction Project (2021XKPT011) and Hulunbuir University Outstanding Scientific Research Achievements Later Stage Funding Project (2021HQPT110).

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The Influence of Advertising Appeals on Consumers' Willingness to Participate in Sustainable Tourism Consumption

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Academic Editor: Jun Yang

Sustainable consumption has attracted much attention from the tourism industry. However, from the perspective of academic research, the psychological mechanism of collaborative consumption has not been thoroughly understood as the main form of sustainable consumption. This study explores the impact of advertising appeals on consumers' willingness to participate in collaborative consumption. Through two psychological experiments, it is believed that, relative to the rational appeal, the emotional appeal will positively affect consumers' participation willingness to collaborative consumption, and psychological ownership mediates this relationship. Furthermore, the form of information presentation moderates the influence of advertising appeals on psychological ownership.

1. Introduction

While the sharing economy craze remained unabated in 2017, collaborative consumption in the business world staged a song of ice and fire after 2019. Even though leaders in the Chinese tourism industry such as Tujia Homestay and Huazhu Hotels Group have accelerated the timeshare tourism business, the industry is still full of chaos and disputes [1]. While Mobike rapidly developed in the field of bike sharing locally and abroad, Wukong Bike and 3Vbike ceased operations one after the other [2]. There are different explanations for this complicated business situation, which generally include the choice of profit model, change in national policy, and management and control of company operation [3]. In the context of a sharing economy, consumers can directly participate in collaborative consumption. Knowing that the degree of participation mainly depends on the intention of consumers, this study examines the factors that affect consumers' willingness to participate in collaborative consumption.

This research also aims to analyze the role of psychological ownership in the process of collaborative consumption. As an important sustainable consumption model, collaborative consumption refers to consumption based on the right of use. In contrast to ownership consumption, it reduces consumer costs, especially consumption responsibilities, for products or services [4]. The form and process of collaborative consumption also determine that consumers will focus on meeting individual needs and repeatedly interact with companies, from passive consumption service to active participation and responsibility [5]. This enhances consumers' psychological ownership of products or services [6]. Furthermore, psychological ownership strengthens the participation tendency of consumers and avoids negative behaviors similar to damaging shared products [7]. From the perspective of communication between companies and consumers in a sharing economy, social media advertisements of collaborative consumption companies mostly emphasize the functional value of convenience and saving on products or services. Its prosocial emotional characteristics, such as environmental protection, sustainable

development, and building intimate relationships, are also highlighted [8].

Sharing is the most basic form of communication in human economic behavior, which can be traced back to tens of thousands of years ago [9]. However, it has not received much attention from tourism research [10]. There are two main reasons for consumer participation in collaborative consumption. One is convenience and price from the utilitarian perspective, and the other is environmental protection and sustainable development from the perspective of self-extension [11]. Compared with market practices, collaborative consumption has not been thoroughly understood, and the mechanism of consumers' participation in collaborative consumption remains unclear [12]. There are also no specific operational opinions on how to carry out collaborative consumption models [11, 13]. From the viewpoint of the rapid development of sharing economies, there are still many problems that need to be further examined in the field of collaborative consumption, including its influencing factors [14, 15] and the change of psychological ownership and marketing consequences [16, 17].

This paper aims to explore the influence of different advertising appeals and information types on consumers' collaborative consumption intentions. It also analyzes the mediating effect of psychological ownership on the above relations by combining the development status of sustainable consumption.

2. Literature Review and Hypotheses Development

2.1. Collaborative Consumption. Collaborative consumption is when consumers coordinate the acquisition and allocation of resources for consumption in exchange for some form of compensation [18]. In the context of a sharing economy, it has become the main form of sustainable consumption. Collaborative consumption usually occurs within organizations or communities, where participants allocate goods, services, travel plans, venues, and even money in the form of leasing, lending, exchanges, and transactions [13, 18, 19]. There are two factors that affect consumers' participation in collaborative consumption. The first is that they are driven by utilitarianism. Consumers who participate in collaborative consumption can obtain direct economic benefits through factors such as function and convenience. These economic benefits are the main factors driving consumers to participate in plans of car sharing, bike sharing, and call time sharing of mobile phones [20]. The lack of perception of economic interests will hinder consumers' participation in this form of consumption [21]. Collaborative consumption provides more value when consumers pay less [19, 20], making the sharing economy more attractive since its benefits are greater than the costs [22].

The second factor is the pursuit of prosocial value. Collaborative consumption can reduce the consumption of new products and raw materials, which is conducive to environmental protection [19, 23]. It enables participants to establish and maintain social contact with others by cooperating with social networks, direct peer-to-peer interaction, and personal experience sharing. Participation in collaborative consumption provides a platform for making new friends and developing valuable relationships [19]. This platform not only helps strangers meet and communicate online, but also provides opportunities for personal offline communication. For example, community building, antimaterialism, and voluntary behavior will affect the sharing behavior of consumers in toy houses and tourism events [24, 25]. Having a sense of pleasure and consumption sustainability will also have a significant effect on the behavior tendency of collaborative consumption [26].

Compared with the transaction of goods or services, the development of collaborative consumption benefits from the recent advancement of internet technology, which is an emerging market phenomenon. However, empirical studies on the influencing factors of participating in collaborative consumption are rare, and the psychological mechanism of participation has not been deeply explored [13].

2.2. Advertising Appeals. Advertising appeals refer to different types of interests or information that appear when communicating with consumers [27]. Persuasive information needs to adopt appropriate appeals and provide information related to emotion, desire, or rationality and operability in order to communicate with potential consumers [28]. Advertising appeals can be divided into emotional and rational appeals [29]. Emotional appeals strive to convey the pleasant feeling of the product, which is related to soft marketing appeal, and emphasize the emotion [12], that is, the emotion and subjective impression of the product's tangible characteristics [30]. Rational appeals show how the product works, tell consumers the actual interests, and regard the product itself as the purpose. The information it provides is more focused on the use and description of a product, which is related to hard marketing. The two kinds of appeals differ in terms of method and purpose [31]. When the advertisement focuses on the emotion or desire achieved by the product, it emphasizes the high-level goal of why it should be purchased. When it focuses on rationality or operability, it emphasizes the functions of the product.

The background of collaborative consumption and that of common consumption differ mostly in two points. The first is the emergence of prosocial value. The second is that there is no transfer of ownership. Emotional appeals are more closely related to the values emphasized by collaborative consumption for consumers, making them more likely to accept related products or services. From the market reality, when consumers choose to share products or services, the recognition of values is also the selling point of many products. When there is no transfer of ownership, consumer involvement becomes relatively weak, so they are reluctant to invest too much cognitive effort in the selection process. Emotional appeals do not need much detailed processing because they only present more general information, such as limited product features [32]. In contrast, rational appeals contain a lot of functional parameters and information on features, so more cognitive effort should be

mobilized towards understanding them [33]. Therefore, compared with theoretical appeals, emotional appeals are more consistent with collaborative consumers, which will positively affect the intention of consumers to participate:

> H1: in the context of collaborative consumption, emotional appeal advertising will positively affect consumers' willingness to participate, compared with rational appeal advertising.

2.3. Psychological Ownership. Psychological ownership refers to a state in which a person feels that he or she owns the target object or a part of it [13]. It originates from the extension of the concept of "I" in psychology. People's sense of ownership or the experience of psychological possession is not limited to actual possession [31]. There are three main motivations of psychological ownership: efficacy, self-identity, and owned space [34]. For the pursuit of efficacy, people control the environment and objectives by gaining disposal power to obtain ideal results. For the promotion of self-identity, people are mainly through the self-involvement in the process of pursuing goals and personal identification of the goal concept. For owned space, emotional connection and pride are mainly formed through familiarity with the subject matter [35].

Collaborative consumption does not advocate ownership, believing that it bears the responsibility of use, maintenance, and disposal. However, in practice, the relevant liability caused by ownership or violation loss is only reduced in the collaborative consumption scenario, but does not disappear. For example, in the process of collaborative consumption, consumers have the responsibility to use products or services reasonably to ensure that other consumers can use them smoothly. Sanitation, delivery, and other links need to be carried out according to relevant requirements. Although physical ownership has not been transferred, psychological ownership does not disappear and still exists.

The emotional appeal will emphasize the values of collaborative consumption, such as environmental protection, literature, and art, among others. It makes it easier for consumers to form self-related meanings and situations and increase their sense of identity for collaborative consumption. It is easier to enhance the consumer's involvement in identity goals and strengthen the relationship between consumers and collaborative consumption, thus strengthening psychological ownership [36]. The rational appeal lays more emphasis on the efficacy of products or services. In the context of collaborative consumers, the sense of efficacy is not well supported by entities, and the power of control or disposal is weakened. Relatively speaking, it has a small impact on psychological ownership. Emotional appeal advertising involves values and emotions, which will have a greater impact on the identity of consumers associated with it. Consumers will attach more importance and become more willing to "own" it [37]. Accordingly, the following hypothesis is proposed:

> H2: compared with rational appeal advertising, emotional appeal advertising has a positive impact on consumers' psychological ownership of collaborative consumption products or services.

It is generally believed that psychological ownership has a positive effect on consumer behavior [17]. As the promotion of psychological ownership will strengthen the idea that products or services become an extension of the self, it will be easier to resist the impact of competitive brands. Psychological ownership will enhance word of mouth and brand loyalty. In the process of collaborative consumption, it will reflect more important consumption significance without the transfer of entity ownership, which will directly affect the choice of consumers. Research in the field of organization also believes that the psychological ownership of the organization will enhance employees' citizenship behavior, strengthen their commitment to the organization, and reduce turnover rate. At the same time, due to the strengthening of psychological ownership, there will be an ownership effect, and individuals will evaluate the "owned" products or services more positively. Therefore, the following hypothesis is proposed:

> H3: consumers' psychological ownership of collaborative consumption products or services has a positive impact on consumers' willingness to participate.

Collaborative consumption products emphasize convenience and play down responsibility in the consumption process. This, coupled with the uneven quality of consumers, can damage shared products from time to time, seriously affecting the development of related industries. The key mechanism is that consumers do not have a strong sense of psychological ownership, so they do not feel that they "own" the products or services. The right to use can partly replace ownership. However, from the perspective of company operations, consumers who have no connection with companies and only pay attention to functions are more likely to transfer their affection to other products. In comparison with rational appeals, emotional appeals more easily develop consumers' resonance to product values and emotions, strengthening psychological ownership, and enhancing their willingness to participate. Therefore, the following hypothesis is proposed:

> H4: consumers' psychological ownership of collaborative consumption products or services mediates the relationship between advertising appeals and participation intention.

There are many forms of advertising appeals. Since collaborative consumer advertising takes into account more factors, such as prosocial factors and network effects of participants, this study only focuses on two commonly used forms of such advertising: consumer- and company-oriented information [38]. Consumer-oriented information places emphasis on encouraging consumers to participate in products or services and tends to stimulate self-related ideas to help solve social and economic problems [39]. It often uses the form of "Would you like to join us?" and uses the second person point of view to describe the form of shared values and narrative

appeals. The corresponding company-oriented information mainly conveys the company's practice to the target audience. It often uses the form of "What will we do?" in the first person point of view to show the value of products and services from the perspective of companies [40]. The above communication methods enable the audience to connect information with self-related experiences, which is called self-reference [41].

Self-reference can promote the in-depth processing of information and stimulate self-related memory [42]. Consumer-oriented information is more likely to arouse self-reference, which tends to use analytical thinking to process information. In contrast, the correlation between company-oriented information and the self is not high. Consumers will think in a holistic way and not pay attention to specific information [43]. The adoption of consumer-oriented information will strengthen consumers' understanding of emotional appeals, improve the relationship between products or services and the consumer, and further emphasize psychological ownership. Although it also contributes to understanding functional appeals in the context of collaborative consumption, the function of a single product or service becomes weak, and the sense of efficacy is low. Therefore, consumer-oriented information will strengthen the relationship between appeals and psychological ownership. Company-oriented information lays more emphasis on corporate behavior and has a weaker connection with consumers. This makes it difficult for consumers to develop self-identity and will not affect the impact of appeals on psychological ownership. Therefore, the following hypothesis is developed:

> H5: the means of expression of collaborative consumption advertising can adjust the relationship between advertising appeal and psychological ownership. That is to say, compared with company-oriented information, consumer-oriented information will strengthen the H2 relationship.

The topic of this research involves four variables: advertising appeal, psychological ownership, participation willingness, and means of expression. Logic is proposed according to hypotheses. The relevant conceptual framework is shown in Figure 1.

3. Data and Research Methods

3.1. Research 1

3.1.1. Research Design and Subjects. Research 1 mainly focused on the influence of advertising appeals on consumers' willingness to participate and the mediating effect of psychological ownership. The research adopted the control group experimental method, and the collaborative consumption scenario adopted tourism short rentals. The advertising materials were extracted from actual advertisements of Airbnb, Mayi, and Xiaozhu, and the kind of pictures and words commonly used by these companies was adopted. The main reasons for choosing this scenario are as follows. First, tourism short rental originated before the current boom in the sharing economy and has a more mature industrial development. Second, research 1 involves college students, who represent the key consumer groups of tourism short rentals and have a certain understanding of the short rental mode.

Through campus advertising, the researcher recruited volunteers to test the advertising design effect of the company's homepage. A total of 99 students from a university in Hubei were recruited as participants. After the test, all research participants would receive a gift worth 15 yuan. Among the subjects aged 18 to 26 years old, 37% were males and 63% were females. All subjects were randomly divided into four groups, and the experiment was conducted in different rooms within the university. In order to avoid the subjects' discovery of the true purpose of the experiment and affecting its impact, a short fictional rental company named "Woniu" was created. Actual advertising content used by Airbnb, Mayi, Xiaozhu, and Tujia were used to promote "Woniu."

The advertising content of the aforementioned companies could be divided into two categories: function and emotion, which also correspond to the focus of this research, namely, the design of emotional appeals and rational appeals. Among them, there was a lot of advertising content related to price concessions (e.g., "special offer tonight, 30% discount," "special sale on Thursday, selected beautiful houses, from 5 yuan"). The research did not pay attention to the influence of price and other factors, so content selection did not consider information on price. The content of the functional category mainly included security, credit, housing, and other services (e.g., "perfect security mechanism," "compensation in advance," and "4 million houses for you to choose"). Emotional content mainly included sharing, exploration, relationship, and other aspects of concern (e.g., "don't go here, live here," "meet with you in another place," and "all the encounters in the world are reunion after a long separation"). The experimental materials were adapted according to real advertisements. The relevant information is shown in Table 1.

To highlight the comparative effect of the experiment, the company name "Woniu" was appropriately enlarged in advertisements emphasizing company-oriented information, while "you" was appropriately enlarged in those emphasizing consumer-oriented information. In advertisements that emphasized emotional appeal, the blue sky, white clouds, green plants, and distant mountains were used as the background. In those that focused on rational appeal, actual pictures of the room were used as the background.

In the experiment, the researcher explained to the subjects that they were recruited to test the design of homepage ads. In the middle of the homepage of Woniu Company's website, one can find its company profile, which briefly introduces the company's development history, main business, scale, and service guarantee.

The related introduction enabled participants to have a basic understanding of the company and provided support for subsequent advertising content testing. Ten seconds after the homepage was opened, a window advertisement with the size of 336 $336 * 280$ px popped up in the middle of the screen. When the subjects closed the window advertisement

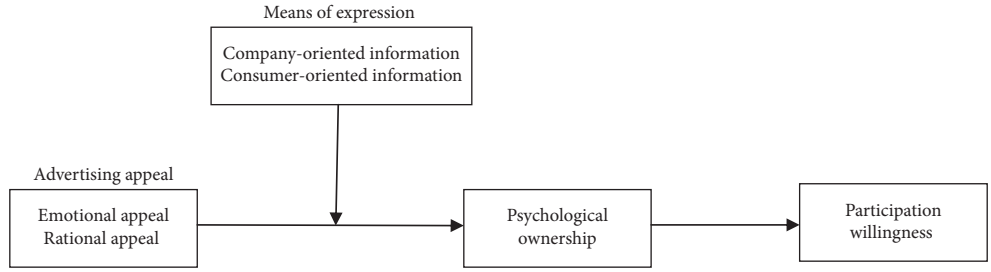

Figure 1: Research framework.

Table 1: Main text contents of experimental materials (research 1).

Type	Company-oriented information	Consumer-oriented information
Emotional appeals	Woniu provides you with the opportunity to have a good story with the world. Explore the unknown, meet and experience, and share freely.	Woniu invites you to have a wonderful story with the world. Explore the unknown, meet and experience, and share freely.
Rational appeals	Woniu has selected excellent accommodation for you. Security mechanism, credit guarantee, and real house supply.	Woniu invites you to appreciate the excellent accommodation. Security mechanism, credit guarantee, and real house supply.

for 10 seconds, the relevant questionnaire appears. In the process of collecting the experimental questionnaires, three were not completed, and a total of 96 valid questionnaires were obtained.

The content of the questionnaire mainly includes research variables, such as psychological ownership and participation willingness, customer knowledge, advertising effectiveness evaluation, and Woniu brand familiarity. These are taken as the control variables. Customer knowledge was taken as a control variable, considering that sharing economy is a new hotspot in market development, and understanding related phenomena will affect participation willingness. The evaluation of advertising effectiveness mainly involves advertising design and expression, and the differences in effectiveness will directly affect participation willingness. The Woniu brand is a virtual one, so it is necessary to avoid the influence of brand familiarity on participation willingness.

3.1.2. Control Test. All the scales used the mature items in the literature. Among them, the five-item scale ($\alpha = 0.87$) [44] was used for the two kinds of advertising appeals, the single-item mode for advertising expression [38], the seven-item scale ($\alpha = 0.83$) for psychological ownership [45], the five-item scale ($\alpha = 0.79$) for participation willingness [46], the five-item scale ($\alpha = 0.85$) for customer knowledge [47], and the five-item scale ($\alpha = 0.93$) for advertising effect evaluation [46]. The single-item mode was used for the degree of familiarity of the Woniu brand (i.e., "Do you know the Woniu brand"?).

The five-item scaling method was used for the control test. The results of emotional and rational appeals were M emotional appeal = 2.91 vs. 4.02, $F = 9.7$, $p < 0.05$; M rational appeal = 2.43 vs. 3.86, $F = 5.9$, $p < 0.05$, which all had significant differences. The results of company- and consumer-oriented information were M company = 3.12 vs. 4.33, $F = 7.3$, $p < 0.05$; M consumer = 3.40 vs. 4.56, $F = 6.5$, $p < 0.05$, which all had significant differences that prove the success of the experimental manipulation. For the emotional and rational appeal groups, the result of the customer knowledge test was $M = 3.11$ vs. 4.02, $F = 2.7$, $p = 1.08$, and the evaluation result of the advertising effect was $M = 3.51$ vs. 3.02, $F = 1.2$, $p = 4.28$. There was no significant difference between the two control variables. The awareness rate of the Woniu brand was at 3%, so the virtual brand had little influence on the result.

3.1.3. Results Analysis. An independent sample T-test was carried out on two groups of data of emotional and rational appeals. The results showed that the psychological ownership of the emotional appeal group was significantly higher than that of the rational appeal group (M emotional appeal = 3.76, M rational appeal = 2.27, $t = 6.34$, $p < 0.05$). The participation willingness of the emotional appeal group was also significantly higher than that of the rational appeal group (M emotional appeal = 3.82, M rational appeal = 3.18, $t = 3.59$, $p < 0.05$). The relevant results supported the viewpoints of H1 and H2. The psychological ownership was grouped by means (M mean = 3.04), and the data within one standard deviation were removed. A T-value comparison was made on participation willingness. The results showed that there was a significant difference between the willingness of the customers from both groups to participate in innovation, $t = 7.56$, $p < 0.05$, which supported H3. The above results also prove the interaction among advertising appeals, psychological ownership, and participation willingness.

A bootstrap program was used to test the mediating effect of insider identity perception. The sample size was 5000. At a 95% confidence interval, the mediating test results of psychological ownership did not include 0 (LLCI = 0.02, ULCI = 0.35) and was significant with an effect size of 0.39. After controlling psychological ownership, it was observed that advertising appeals still had a significant effect on

participation intention ($\beta = 0.19$, $p < 0.05$). The effect size decreased by 0.20, indicating that psychological ownership played a partial mediating role, which supported H4.

To further verify the moderating effect of expression, an ANOVA analysis was carried out on psychological ownership under different advertising appeals. The results showed that the interaction between advertising appeals and expression was significant, $F(2, 98) = 6.85$, $p < 0.05$. When the advertisement had emotional appeal, the score of the psychological ownership of the company-oriented information group was significantly lower than that of the consumer-oriented information group (M emotional appeal—company-oriented = 3.26; M rational appeal—consumer-oriented = 4.08, $F = 6.67$, $p < 0.05$). When advertising had rational appeal, the score of the psychological ownership of the company-oriented information group was significantly lower than that of the consumer-oriented information group (M rational appeal—consumer-oriented = 3.25 > M emotional appeal—company-oriented = 2.72, $F = 3.25$, $p < 0.05$). The specific data are shown in Table 2, which presented above support H5.

The five hypotheses have been verified from the experimental data. The first is that advertising appeals and expression will affect consumers' willingness to participate in collaborative consumption. Compared with the rational appeal, the emotional appeal of advertising is more consistent with the values advocated by collaborative consumption, which has a positive impact on consumer participation. When the expression is consumer-oriented information, the impact on consumers will be greater. The second is the psychological mechanism of consumer participation. Contrary to common sense, the internal mechanism of a collaborative consumption scenario which emphasizes the right to use is still the change of psychological ownership. For consumers, the sharing economy is only the change of market manifestation, which is the difference of scenario variables in the research. However, as the consumer psychological decision-making mechanism, it has not been affected. The third is the mediating role of psychological ownership. The influence of advertising appeals on consumers will be affected by many factors, and psychological ownership is only one of them. In the literature on advertising appeals, variables such as customer expectation and cognitive fluency may also play a mediating role.

The background of research 1 is the tourism service industry. Due to the intangible characteristics of the service itself, consumers pay more attention to the right to use the service than the right to use the product. Consumers also relatively accept the collaborative consumption model more easily. Therefore, research 2 used the collaborative consumption of shared products to further demonstrate the hypotheses of the paper.

3.2. Research 2

3.2.1. Research Design and Subjects. The content of research 2 is consistent with that of research 1 and still applied the control group experimental method, and the collaborative consumption scenario used the shared picture book library. The external validity of the conclusion can be effectively improved by using products for experiments. At the same time, children's picture book is a product that customers choose very carefully. The experiment scene would have a stronger supporting effect on the hypothesis. The advertising materials were taken from real advertisements of companies related to picture books sharing, and the form of pictures and words used by these companies were adopted. The main reasons for choosing this scenario are as follows. First, with the improvement of living standards, picture books are gradually recognized by many parents in family education. Second, as the picture book sharing industry rapidly develops, all kinds of picture book libraries are very common in large- and medium-sized cities in China. Third, picture books involve children's education, which is not only a hotspot in the development of the education market, but also the focus of parents' attention.

Due to the particularity of the audience of picture books, the researcher did not choose children as subjects, but parents which are consumer decision makers. Participants were recruited through three kindergartens in Wuhan City, Hubei Province. For the research, 108 parents were recruited as participants. After the test, all participants would receive a picture book worth 15 yuan. Most of the children's educational consumption choices are completed by parents, so parents are explicitly required to participate. Among the subjects aged 22 to 48, 32% were males and 68% were females. To avoid the deviation caused by different sources of students, all subjects of each kindergarten were randomly divided into four groups. The participants completed the experiment in a separate classroom before the children were picked up from school in the afternoon.

To avoid revealing the purpose of the experiment to the subjects and affecting the effect of the experiment, a virtual company named "Starlit Sky Picture Book Library" was created. Its advertising content is adapted from that of the Quxiaopiao Picture Book Sharing Platform, Liangmiao Picture Book Library, Yingtao Picture Book Library, Old John Picture Book Library, and other companies. Similar to research 1, the advertising content of the above companies was divided into emotional and rational appeals. The content related to emotion mainly included the concern of sharing, company, and relationship (e.g., "the neighbors' children are here," "the founder of the concept of picture book sharing," "changing three generations with reading," "reading together with parents, growing up with children," "looking for a dazed afternoon," "meeting picture books, achieving various possibilities," and "sowing the seeds of happiness together"). The content related to rationality mainly included convenience, credit mechanism, abundant book sources, and other services ("borrow and return," "combination of online and offline," "only select excellent picture books," "all the books you want to read are available here," and "100000 + mom's choice"). Experimental materials were adapted according to the actual advertisement. The relevant information is shown in Table 3.

The processing method of highlighting the contrast effect of the experiment was consistent with that of research 1. In advertisements emphasizing company-oriented information, the company name "Starlit Sky Picture Book" was

Table 2: Moderation of advertising information expression (research 1).

Type	Psychological ownership	
	Emotional appeals	Rational appeals
Company-oriented information	3.26 (22)	3.25 (25)
Consumer-oriented information	4.08 (24)	2.72 (25)

appropriately enlarged. In those emphasizing consumer-oriented information, the appellation of "baby" to consumers was appropriately enlarged. In advertisements that emphasized emotional appeal, photos of starry skies and seed growth were used as the background. In those which emphasized rational appeal, classical picture books and picture book library address distribution photos were used as the background.

In the experiment, the researcher told the subjects that they were recruited to do a customer survey to open a picture book library in the city. The initial content included a brief introduction of the company, including its development history, main business, scale, service guarantee, and other similar information. The relevant content was also adapted for the introduction of real companies. The company profile was followed by advertisements and then the questionnaire. To avoid revealing the real purpose of the experiment, the questionnaire was also interspersed with statements like "What brand of picture book library do you know?", "Your baby's weekly reading time," "What kind of picture books your baby is most interested in?", and other market research items. There were 11 questionnaires rejected due to incomplete or incorrect information and 97 valid questionnaires were obtained.

The main content of the questionnaire is consistent with that of research 1, including research variables of psychological ownership and participation willingness. The control variables included customer knowledge, advertising effectiveness evaluation, "Starlit Sky" brand familiarity, perceived risk, and parents' education level. Perceived risk was taken as a control variable due to the importance of children's education. Additionally, taking the difference of parents' perception of risk will directly affect consumption decision-making. Parent's educational level was taken as the control variable mainly because the acceptance of picture books is increasing in China, but it is still largely affected by parents' education level.

3.2.2. Control Test. All the scales used the mature items in the literature. Among them, the five-item scale ($\alpha = 0.87$) [44] was used for the two kinds of advertising appeals, the single-item mode for advertising expression [38], the seven-item scale ($\alpha = 0.83$) for psychological ownership [45], the five-item scale ($\alpha = 0.79$) for participation willingness [46], the five-item scale ($\alpha = 0.85$) for customer knowledge [47], the five-item scale ($\alpha = 0.93$) for advertising effect evaluation, and the five-item scale ($\alpha = 0.83$) for perceived risk. The education level was directly compared with parents' educational level. The single-item mode was used for the degree of familiarity with the Starlit Sky brand (i.e., "Do you know the Starlit Sky brand?").

The five-item scaling method was used for the control test. The results of emotional and rational appeals were M emotional appeal = 2.89 vs. 3.77, $F = 4.7$, $p < 0.05$; M rational appeal = 2.36 vs. 3.54, $F = 6.7$, $p < 0.05$, which all had significant differences. The results of company- and consumer-oriented information were M company = 2.98 vs. 4.02, $F = 4.9$, $p < 0.05$; M consumer = 3.12 vs. 4.33, $F = 8.2$, $p < 0.05$), which all had significant differences, proving that the experimental manipulation was successful. For the emotional and rational appeal groups, the results of the customer knowledge test were $M = 3.26$ vs. 3.98, $F = 3.1$, $p = 0.74$. The evaluation result of the advertising effect was $M = 2.88$ vs. 3.31, $F = 2.3$, $p = 1.33$, and the result of perceived risk was $M = 3.08$ vs. 2.68, $F = 7.2$, $p = 3.36$. There was no significant difference in the above control variables. For the parents' educational backgrounds, 14.5% were graduates or above, 68.4% were university education, 12.8% were senior high school or technical secondary school education, and 4.3% were junior high school and other education. The scores of the above levels of educational attainment were four to one, and the results showed that there was no significant difference between various groups. The awareness rate with the Starlit Sky brand was 4.7%, so the virtual brand had little influence on the result.

3.2.3. Results Analysis. The independent sample T-test was carried out on two groups of data of emotional and rational appeals. The results showed that the psychological ownership of the emotional appeal group was significantly higher than that of the rational appeal group (M emotional appeal = 3.47, M rational appeal = 2.66, $t = 4.38$, $p < 0.05$). Further, the participation willingness of the emotional appeal group was significantly higher than that of the rational appeal group (M emotional appeal = 3.73, M rational appeal=3.09, $t = 4.17$, $p < 0.05$). The relevant results supported the viewpoints of H1 and H2.

The psychological ownership was grouped by means (M mean = 3.11), and the data within one standard deviation were removed. A T-value comparison was made on the participation willingness. The results showed that there was a significant difference between the willingness of the two groups of customers to participate in innovation, $t = 6.35$, $p < 0.05$, which supported the viewpoint of H3. The above results also prove the interaction among advertising appeals, psychological ownership, and participation willingness. A bootstrap program was used to test the mediating effect of insider identity perception [48]. The sample size was 5000. At 95% confidence interval, the mediating test results of psychological ownership did not include 0 (LLCI = 0.14, ULCI = 0.46) and was significant, with the effect size being 0.32. After controlling psychological ownership, it was observed that advertising appeal still had a significant effect on participation willingness ($\beta = 0.17$, $p < 0.05$), and the effect size decreased by 0.15, indicating that psychological ownership played a partial mediating role, which supported H4.

Table 3: Main text contents of experimental materials (research 2).

Type	Company-oriented information	Consumer-oriented information
Emotional appeals	"Starlit Sky" sow the seeds of happiness for babies: sharing environmental protection, reading growth, and creating infinite possibilities.	"Starlit Sky" invites babies to sow the seeds of happiness together: sharing environmental protection, reading growth, and creating infinite possibilities.
Rational appeals	"Starlit Sky" builds a library around your babies. Provide home delivery service, select carefully, and have rich sources of books.	"Starlit Sky" invites babies to build a library around them. Provide home delivery service, select carefully, and have rich sources of books.

To further verify the moderating effect of expression, an ANOVA analysis was carried out on psychological ownership under different advertising appeals. The results showed that the interaction between advertising appeals and expression was significant, $F\ (2,\ 99) = 5.28,\ p < 0.05$. When advertising used emotional appeal, the score of psychological ownership of the company-oriented information group was significantly lower than that of the consumer-oriented information group (M emotional appeal—company-oriented = 3.21; M emotional appeal—consumer-oriented = 4.12, $F = 3.71,\ p < 0.05$). When advertising used rational appeal, the score of psychological ownership of the company-oriented information group was significantly lower than that of the consumer-oriented information group (M rational appeal—company-oriented = 3.89>M rational appeal—consumer-oriented = 2.50, $F = 4.34,\ p < 0.05$). The above data are shown in Table 4, which presented above support H5.

From the experimental data, the relevant hypotheses have also been verified in the field of shared products. From the experimental process, there are still several points worthy of attention. First, the consumption of picture books is special. Although parents as decision makers generally participate in the whole process when purchasing picture books, it is still a product that separates consumers from decision makers. In addition, children occupy a special position in Chinese families. The above characteristics may affect the judgment of the subjects, and there may be a certain gap between the participation willingness and the actual market. Second, the mediating effect of psychological ownership may be stronger. Compared with children, parents will have a more rational view of consumption, which can better separate the right to use and the right of possession. However, from the perspective of children, the connection with products will lead to stronger psychological ownership, and the mediating effect may be stronger. Third, advertising is not the best way to promote the sharing of picture books. Consumers are highly involved in the products and services related to children's education. Advertising is more about information release. From the influence of advertising design on participation willingness, there is still some distance between attitude and behavior. In comparison with advertising, the actual market effect of personal promotion and word-of-mouth communication will be more effective.

Table 4: Moderating of advertising information expression (research 2).

Type	Psychological ownership	
	Emotional appeals	Rational appeals
Company-oriented information	3.21 (24)	3.89 (25)
Consumer-oriented information	4.12 (26)	2.50 (24)

4. Discussion

In terms of theoretical contribution, there are three main points. First, the concepts related to the sharing economy are further clarified. This study discusses collaborative consumption close to the market, highlighting the essential characteristics of the impact of a sharing economy on the market. Second, it expands the research field of advertising appeal. It is of certain theoretical value to extend the research of advertising appeals to the field of collaborative consumption. Third, it reveals the psychological mechanism of consumers in sustainable consumption. The common sense of sustainable consumption, especially in a sharing economy, generally thinks that the right to use is more important than ownership, and the advantages of sustainable consumption also come from the worship of the right to use. However, as observed from the research, the right to use cannot replace ownership. The recognition and involvement of customers on collaborative consumption rely more on the promotion of psychological ownership.

From the perspective of practical value, the first is that collaborative consumption companies should pay attention to the promotion of customer psychological ownership. Companies can strengthen their connection with customers on the aspects of consumption link design and customer interaction to enhance customers' recognition of companies. The second is the choice of advertising appeals and information of collaborative consumption companies. When designing advertisements, companies should adopt more emotional appeals to realize the combination of philosophy and culture between customers and companies. Furthermore, companies should release more consumer-oriented information, enhance consumers' sense of participation, and guide more consumers to choose company products or services.

5. Conclusions

Two experiments were conducted to demonstrate the hypotheses. It is believed that in the process of collaborative consumption based on sustainable tourism consumption, advertising appeals will affect participation willingness through psychological ownership. At the same time, the expression of advertising information will moderate the relationship between advertising appeals and psychological ownership.

Although this study discusses market phenomena and theories, conducts experimental research with the background of tourism and picture books, and supports relevant hypotheses, it still has some deficiencies in the research process. The first is that the research did not take price into account. As collaborative consumption is a new market phenomenon, price is extremely important as the threshold of consumption. Moreover, price may have a cross effect with the advertising appeal, which is often referred to in the market as "pay for the feelings." The second is that the research sample is still limited. There are many industries involved in the sharing economy. This study only chooses tourism and picture books in the analyses, and the externality of the research conclusion can still be further strengthened. The third is that part of the mediating effect shows that there may be other mediating factors between advertising appeals and participation willingness, including company positioning, brand impression, and more. Future research can verify the research hypotheses with multiple industries and diverse samples and explore the psychological mechanism of consumer participation around collaborative consumption.

Acknowledgments

This research study was supported by the National Natural Science Foundation of China (Grant nos. 71672053 and 71772141), Projects of the National Social Science Foundation of China (Grant no. 20BGL091), and Philosophy and Social Science Research Key Project of Education Department of Hubei Province (Grant no. 19D091).

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Cloud Computing and Internet of Things in the Evaluation of Ecological Environment Quality in Rural Tourist Areas in Smart Cities

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Academic Editor: Sang-Bing Tsai

With the increase of tourist environment, the real-time monitoring of ecological environment has become a concern. This study mainly discusses the application of cloud computing and Internet of things in the evaluation of ecological environment quality of rural tourism areas in a smart city. In this study, the real-time monitoring of the atmosphere, water, and meteorological data is collected through the GPRS data transmission module and then sent back to the local server by the GPRS network, and the obtained non-real-time and real-time data are used to establish the ecological monitoring database, the database analysis of its information, and get real-time data, monthly data, and longer cycle data. In the cloud GIS platform, there are multiple subnodes. The split tasks can be processed by each subnode through a map, and the results after processing can be summarized through reduce, which completes the implementation process of the whole idea of map reduce. Monitoring station management is mainly to establish monitoring stations in rural tourism areas and collect first-hand environmental monitoring data by using temperature, humidity, infrared, ultrasonic, and other sensors and cameras. The monitoring objects are the air quality, water quality, meteorology, etc. of the scenic area, mainly showing the location of monitoring stations and the placement of sensors. At the same time, an LED screen is set at the monitoring station to display the air quality data of the scenic spot. The data content is introduced into the DPSIR model, combined with social and economic data; according to the ecological health grading evaluation standard, the evaluation score and health grade are obtained and the ecological health status of rural tourism area is judged and evaluated. When the amount of data is less than 500 MB, there is little difference between the storage speed of the cloud GIS platform and single machine, but with the continuous increase of the amount of data, the storage speed of the cloud GIS platform is significantly higher than that of a single machine. This study is helpful in improving the ecological environment quality of rural tourism areas.

1. Introduction

Foreign research on ecotourism and original ecotourism mainly focus on how to achieve the purpose of natural area protection in the process of ecotourism development and the role of relevant factors and stakeholders in achieving the common goal; domestic research is mainly focused on the theory of the development planning and management of the original ecotourism resources, and there are also some results about the development mode of the original ecotourism and the protection of ecological vulnerability.

The Internet of things and cloud GIS is a spatial database based on the unified geographical coordinates, which uses the geoscience model to analyze the spatial data, manage and analyze the environment, resources, and other spatial information, and provide a variety of spatial and dynamic geographic information in real time. The GIS spatial analysis system selectively collects and analyzes various kinds of information, provides tourism resources spatial association data for tourism development decision makers, and provides support for tourism management decision making. This is also one of the main purposes and tasks of establishing a spatial analysis system based on cloud GIS.

Mobile edge cloud computing is a new paradigm. Chen W believes that mobile edge cloud computing (MECC) has become an attractive solution for enhancing the computing and storage capacity of mobile devices (MDs) by leveraging the available resources at the edge of the network. He first formulated the multiuser and multitask computing offloading problem for the green MECC and then used the Lyapunov optimization method to determine the energy harvesting strategy how much energy each WD needs to collect and the task offloading schedule: a set of computing to be accepted into the mobile edge cloud unloading request, assigned to each WD group that has allowed the unloading request, and how much workload is to be processed in the assigned WD. His research put forward the concept of MD, but did not briefly describe its performance [1]. Cloud computing allows users to consume various IT resources on demand and has low management overhead. Han et al. believes that customers may face new security risks when using cloud computing platforms. He chose to solve the problem from different angles, by studying how to improve the virtual machine allocation strategy, so that it is difficult for the attacker to colocate with the target. Specifically, he defined security indicators used to assess attacks, modeled these indicators, and compared the difficulty of achieving coexistence under three common policies and designed a new strategy that not only mitigates the threat of attacks but also meets the needs of work quantity balance and low power consumption requirements. His research scheme is not novel enough [2]. Chen et al. formulated the decision-making problem of distributed computing offloading among mobile device users. He analyzed the structural nature of the game and proved that the game has limited improvements. Then, he designed a distributed computing shunt algorithm. The game theory method he adopted is unreasonable [3]. Xia et al. researched the performance improvement of the centralized cloud and integrated optical fiber wireless (FiWi) access network supporting MEC. He proposed a novel unified resource management solution that combines centralized cloud computing and MEC computing offloading activities into the basic FiWi dynamic bandwidth allocation process. By using time division multiple access, both MEC and cloud traffic are arranged outside the transmission time slot of FiWi traffic. He developed an analysis framework for the data packet delay and response time efficiency of cloud and broadband access traffic. The integrated optical fiber wireless he proposed has no specific performance test indicators and lacks logic [4].

This study mainly discusses the application of cloud computing and Internet of things in the evaluation of ecological environment quality of rural tourism areas in a smart city. In this study, the real-time monitoring of the atmosphere, water, and meteorological data is collected through the GPRS data transmission module and then sent back to the local server by the GPRS network, and the obtained non-real-time and real-time data were to establish the ecological monitoring database, the database analysis of its information, and get real-time data, monthly data, and longer cycle data. In the cloud GIS platform, there are multiple subnodes. The split tasks can be processed by each subnode through a map, and the results after processing can be summarized through reduce, which completes the implementation process of the whole idea of map reduce. Monitoring station management is mainly to establish monitoring stations in rural tourism areas and collect first-hand environmental monitoring data by using temperature, humidity, infrared, ultrasonic, and other sensors and cameras. The monitoring objects are the air quality, water quality, meteorology, etc. of the scenic area, mainly showing the location of monitoring stations and the placement of sensors.

2. Ecological Environment in Rural Tourist Areas

2.1. Rural Tourism. Rural tourism is not only an ancient way of tourism but also a trendy way of tourism for modern urbanites. Rural tourism is an inevitable product in the development of modern tourism [5, 6]. The countryside was originally a conservative and relatively backward place with conservative economic, political, and cultural traditions, but now, it has become a situation that many urbanites yearn and pursue, which undoubtedly makes people puzzled. Modern society pursues nature and returns to the original. As the most primitive, most natural, most harmonious, most peaceful, and most charming place in society, the countryside is an ideal paradise for modern cities to escape the noise, relieve work pressure, and relax themselves. Rural tourism is popular nowadays. It has become one of the hotspots studied by scholars at home and abroad. With the continuous development of rural tourism, the main population of rural tourists has changed, and the source market is constantly being refined [7].

$$\min F(x,z) = \sum_{k=1}^{m}\sum_{i=1}^{n} A_{ki}x_{ki}z_i + \sum_{i=1}^{n}\sum_{j=1}^{l} B_{ij}x_{ij}z_i + \sum_{k=1}^{m}\sum_{i=1}^{n} Z_i F. \tag{1}$$

In the equation given above, x and z are the corresponding data management services [8, 9]. The original tourism motives of rural tourists are expressed as the pursuit and enjoyment of the natural environment, return to nature, and enjoy the body and mind, and their environmental motives are the main tourism motives. However, as the development of rural tourism deepens, their tourism motives have also changed, showing diversity and uniqueness, not only pursuing the enjoyment of nature but also paying more attention to rural culture, experiential activities, and participatory activities outside the natural environment. The rural tourism market is also growing, the types of tourists are more diverse, and the needs are more diverse, which has also become an important content of practical and theoretical research [10]. For the overclocked carrier f, let the transmission phase be Φ; then,

$$\begin{aligned} G(t) &= \left[\cos\left(2\pi f_0 t + \phi_s\right) + A\right] \cdot \cos\left(2\pi f_c t + \phi_c\right), \\ R(t) &= \left[\cos\left(\pi f_0 t + \phi_r\right) + A\right] \cdot \cos\left(\pi f_c t + \phi_d\right). \end{aligned} \tag{2}$$

Here, $\phi_d = \phi_c + f_c \cdot \tau_d$ [11, 12].

2.2. Ecological Environment Quality. Ecological environmental quality evaluation not only provides a scientific quantitative basis for environmental management and decision making but also has important practical significance for regional sustainable development strategic decision making [13]. The objects of ecoenvironmental quality evaluation are mainly concentrated in countries, provinces, cities, and even specific areas. The evaluation methods used are also relatively diverse, mainly including the analytic hierarchy process, comprehensive index method, fuzzy evaluation method, principal component method, gray evaluation method, artificial neural network evaluation method, and other methods, and establish corresponding ecological environment evaluation according to the difference of evaluation objects system, such as the regional ecological environment quality evaluation system of provinces, cities, and ecologically fragile zones [14, 15].

Let $\Phi = (2\pi n f_0/f_s) + \phi_s$ have [16]

$$\begin{aligned} u &= \left[\cos\left(\frac{2\pi n f_0}{f_s} + \phi_s\right) + A\right] \cdot \cos\left(\frac{2\pi n f_c}{f_s}\right), \\ y &= \left[\cos\left(\frac{2\pi n f_0}{f_s} + \phi_r\right) + A\right] \cdot \cos\left(\frac{2\pi n f_c}{f_s} + \phi_d\right). \end{aligned} \tag{3}$$

Among them, f_s is the sampling frequency [17]. Ecological quality evaluation is to select a certain evaluation index system and quality standard within a certain space and time range and use certain methods to evaluate the pros and cons of the ecological environment quality of a certain area and the influence relationship between various factors. The rural tourist area is a specific area, which is different from a large area such as a province or a country, but as an independent subsystem, its own system is complete, and there is also a certain relationship between factors. The method and theory of ecological environment quality evaluation should also be applicable [18, 19].

The choice of ecological environment quality evaluation indicators differs greatly due to the different research angles and research purposes. From the perspective of tourists, it focuses on the evaluation of ecological environmental factors that have a greater impact on tourists' sight, hearing, touch, and other senses. The United Nations integrated the advantages of the PSR model and the DSR model and proposed the DPSIR model for comprehensive analysis and description of environmental issues and their relationship with social development. The DPSIR concept is based on the extension of the PSR model and the DSR model. Social factors such as society and population act as drivers to promote or affect the ecological environment [20]. Average relative precipitation utilization efficiency, RUE, is

$$\mathrm{RUE} = \frac{\mathrm{RUE}_1 - \mathrm{RUE}_0}{\mathrm{RUE}_0}. \tag{4}$$

Maximum relative precipitation utilization efficiency:

$$\mathrm{RUE}_{\max} = \frac{\mathrm{RUE}_{\mathrm{ex}} - \mathrm{RUE}_0}{\mathrm{RUE}_0}. \tag{5}$$

RUE_0 is the minimum value of maximum precipitation utilization efficiency [21]. Organic matter content H is an important indicator for calculating soil parameters:

$$H = \frac{2.6}{B1 + B2 + B3} - 1.6. \tag{6}$$

Here, $B1$ is the reflectivity of red light [22].

2.3. Cloud GIS. Compared with cloud computing, the key technologies of cloud GIS implementation are mainly reflected in a "spatial" feature. It needs to consider more fully the spatial problems on the basis of cloud computing implementation, such as distributed storage, access, and processing of spatial data, study how to combine this spatial feature of GIS with the coding mode of cloud computing, and realize the seamless link between the them [23]. According to the requirements of the optimal allocation of system resources, the following functions are implemented:

$$\begin{aligned} k(t) &= \sum_{i=1}^{n} p_i F_i, \\ R_i &= E^{-rt}\left[a_1 p_s + a_2 p_E + a_3 p_0\right]. \end{aligned} \tag{7}$$

Among them, p_i is the value of big data asset F [24]. Let G be the point set of the real 3D model and R be the test point set of the model obtained by the reconstruction algorithm:

$$T = \min_{g \in G} |\gamma - G|. \tag{8}$$

The precision of the reconstructed point set γ is defined as the cumulative result of all points [25].

$$P(D) = \frac{100}{|R|} \sum_{r \in R} \left[e_{r \longrightarrow G} < D\right]. \tag{9}$$

For any real three-dimensional point, $g \in G$:

$$E = \min_{r \in R} |g - r|. \tag{10}$$

The recall rate of the reconstructed model R for a given distance threshold d is defined as

$$W(d) = \frac{1}{|G|} \sum_{g \in G} X. \tag{11}$$

The construction of the cloud computing environment is the basis for the construction of the entire cloud GIS platform, including software and hardware environments such as network, storage, and virtualization. By using basic hardware facilities, virtualization software is used to build a server virtualization environment, and then, database software is deployed on virtual machines and GIS server software cluster environment [26]. The value of k after iteration is recorded as P, and the prediction function is as follows:

$$W(C, P) = \sqrt{W^2(C) + B^2(C)}. \tag{12}$$

In terms of popularization and civilianization, private cloud will provide the public with more public information

online services, such as transportation, catering, renting, and tourism. With the support of an efficient and stable architecture, cloud GIS will break the original "professional circle," bring more value-added services related to spatial information to the public, and bring users who wish to build their own GIS application platform to achieve a revolution in GIS itself. Sexual changes continue to expand the market and serve the masses [27, 28].

Arc GIS Online is an important part of the Arc GIS series products. It can be seamlessly integrated with other products in the series. Other series products can fully use various service resources in Arc GIS Online to complete their own operations. At the same time, they can use Arc GIS Online to interact with other products. The function of the product is expanded. In the cloud platform, users can not only use data but also the cloud platform provides computing power that is incomparable to ordinary stand-alone computers. Distributed computing and parallel computing are used to greatly increase the speed of data processing and accelerate the progress of scientific research.

3. Evaluation Experiment of Ecological Environment Quality in a Rural Tourism Area

3.1. Ecological Monitoring System in Rural Tourist Areas. This research collects the ecological environmental factors of rural tourist areas, including air quality, temperature, humidity, negative oxygen ion concentration, sulfur dioxide concentration in the tourist area, and weather information. We used various sensors such as temperature, humidity, infrared, ultrasound, and cameras to collect first-hand environmental monitoring data, design the ecological environment monitoring system of rural tourist areas, and transmit various indicator data back to the system for analysis and processing. Superimposed on dynamic monitoring data, each monitoring point can display the monitoring data of this place and the monitoring data of a period of time in the past, realizing all-weather, all-round 24 h real-time dynamic monitoring of multiple controlled areas. We provide visual management for relevant departments to take timely response strategies and control measures.

3.2. Overall System Design. The ecological environment monitoring system of the rural tourist area is shown in Figure 1. It obtains its own rural social and economic indicator data, as well as ecological environment (water quality, air quality, and meteorological) data, and automatically collects, processes, integrates, displays, and queries statistics; the quasi-real-time monitoring of the atmosphere, water, weather, and remote sensing images based on real-time monitoring is the original data; the real-time monitoring of the atmosphere, water, and weather data is collected through the GPRS data transmission module and then transmitted back to the local server through the GPRS network. An ecological monitoring database with real-time data is established. The database analyzes its information to obtain real-time data, monthly data, and longer-period data. According to the ecological health classification evaluation criteria, to obtain evaluation scores and health levels and judge and evaluate the ecological health status of rural tourism areas, in the cloud GIS platform, there are multiple subnodes. The split tasks can be handed over to each subnode for processing through a map, and the results after processing are aggregated through reduce, which will greatly improve efficiency. The execution process of the whole idea of map reduce is completed.

3.3. Cloud GIS Platform. Cloud computing mainly provides three service modes, namely, software and service, platform-as-a-service, and infrastructure-as-a-service. GIS is put into the cloud to build the cloud GIS platform. The original interface, module, and other aspects need to be changed in order to connect with the existing cloud computing platform. Cloud GIS can be constructed in the following four ways: geographic information content as a service, geographic information software-as-a service, geographic information platform-as-a-service, and geographic information infrastructure-as-a-service.

3.4. Database Design. The purpose of the database design is to collect and integrate the complex information of rural tourist areas, store and efficiently manage the data of ecological environment factors in rural tourist areas, and establish an ecological monitoring database. Due to the large amount of monitoring data and fast update, it requires strong data access and interaction capabilities. The daily record of real-time monitoring data needs to be extracted and processed by the GPRS data transmission equipment to be displayed in the data management and display, and the ecological environment monitoring database is used to read the data. The ecological monitoring system database is designed with a process-oriented data update function, and the platform can automatically record and release the temporal information of the data according to the data update situation. Data analysis can read database data, generate statistical reports, display chart, etc. Among them, the database structure includes two types of tables: the first type is user management tables, back-end management log tables, etc.; the second type is monitoring data tables, which are mainly basic data, collector tables and equipment tables for non-real-time and real-time data, and the control instruction list.

3.5. Functional Module Design. The main functions of the rural ecological environment monitoring system include platform management, monitoring station management, equipment management, data management, data analysis, and data expression. The functional module design is as follows.

3.5.1. Platform Management. Platform management includes user, security, and platform management. It is mainly to create users, add and delete user name information such as passwords and names, and perform security management such as user management in the background of the platform,

setting user permissions, setting administrator status, platform setting operation log records, internal and external network management, and other security management.

3.5.2. Monitoring Station Management. Monitoring station management is mainly to establish monitoring stations in rural tourist areas. The monitoring objects are the air quality, water quality, and weather of the scenic area and mainly display the location of the monitoring station and the placement of sensors. At the same time, LED screens are set up at the monitoring sites to display air quality data in the scenic area.

3.5.3. Equipment Management. Equipment management is the use of equipment management for each monitoring data. It is mainly to realize the functions of adding equipment, deleting equipment, viewing equipment configuration, uploading equipment configuration information, downloading equipment information, and modifying equipment parameters, mainly modifying equipment table, serial port channel, geographic location information, administrative district number and project, etc.

3.5.4. Data Management. The data management function is the three modules of data collection, data processing, and data backup. It uses the GPRS data transmission equipment to obtain data, performs data preprocessing, and uses software to write to the local server, establish an ecological monitoring database, and obtain real-time monitoring data from the local server. Unified and integrated management of various service data resources is used to ensure the consistency of data resources. The ecological monitoring system constructs monitoring data, attribute data, site data, and thematic data for seamless splicing and integrated management. At the same time, the data are backed up regularly. The platform can do a level-one incremental backup once a week and a full-database backup once a month.

3.5.5. Data Analysis. Data analysis includes three modules: query and retrieval, statistical analysis, and model analysis. Non-real-time socioeconomic index data, remote sensing data, and real-time monitoring data are queried and retrieved. Statistical analysis is to count monthly or longer cycle monitoring data, display in the form of charts, and use the data to predict the ecological status and pressure of rural tourism areas. Model analysis is to bring the social and economic data and annual monitoring data into the DPSIR model, calculate the evaluation results of the model, and determine the health status and health level of rural tourism areas.

3.5.6. Data Expression. Data expression includes thematic information display, comprehensive information display, and electronic map display. The data expression can satisfy all kinds of users' browsing and query of the monitoring data of rural tourist areas involving basic operating functions (roaming, zooming, ranging, etc.), statistical charts of social and economic data and real-time monitoring data in rural tourism areas, uploading and downloading remote sensing data in rural tourism areas, and monitoring the dynamic changes of the ecological environment in rural tourism areas, such as monitoring lakes' amount of water level change displayed on the air quality LED screen in rural scenic spots. The electronic map interactively displays the air quality, negative oxygen ion content, PM2.5 value, and meteorological information (including wind direction, humidity, and temperature) of each scenic spot. The air quality data are shown in Table 1.

4. Results and Discussion

According to the principle of selection of ecological environment quality evaluation indicators, the indicators are divided into three levels: target level (A), support level (B), and index level (C). Among them, the target layer (A) is the ecological environment quality (A) and the support layer (B) is divided into the natural environment ($B1$), the social environment ($B2$), and the human environment ($B3$). The ecological environmental indicators of rural tourist areas are shown in Table 2.

Understanding the characteristics of the market segmentation of rural tourism tourists is an important content of studying rural tourism ecological environment evaluation and the main basis for formulating rural tourism marketing strategies. We selected time points when the passenger flow is relatively large during the Spring Festival, Golden Week, weekends, etc. and conducted a random survey of local or out-of-town tourists visiting the scenic spot. The information of local or foreign tourists is shown in Table 3.

Regarding gender characteristics, the ratio of males to females in this survey is 1 : 1.2, with the majority of female tourists and fewer males; age characteristics: the frequency of selection for the 19–25 age group accounts for 24.4% of the sample, for the 26–40 age group, the segment is 36.3%, and for the 41–60 age group, it is 19.4%. The total selection frequency of the 19–60 age group accounts for 80.1% of the sample, indicating that the age group of tourists is mainly concentrated between 19 and 60 years of age. The specific comparison of each age group is shown in Figure 2.

The characteristics of education level: the proportion of junior high school to undergraduate level is 89.4%. Most tourists have middle-school and high-school education, and there are fewer tourists with other education levels. The comparison of the proportions of different education levels is shown in Figure 3.

Household monthly income characteristics: income segments above 2501–8001 Yuan accounted for 99.3% of the sample, of which the 4001–6500 Yuan segment reached up to 34.3%. The proportion of each household's monthly income segment is shown in Figure 4.

In the design of the questionnaire, "excellent = 5" and "extremely poor = 1" were used to evaluate the ecological environment quality. Therefore, the closer the mean is to "5," the better the quality is, and the closer the mean is to "1," the poorer the quality status is, the smaller the standard

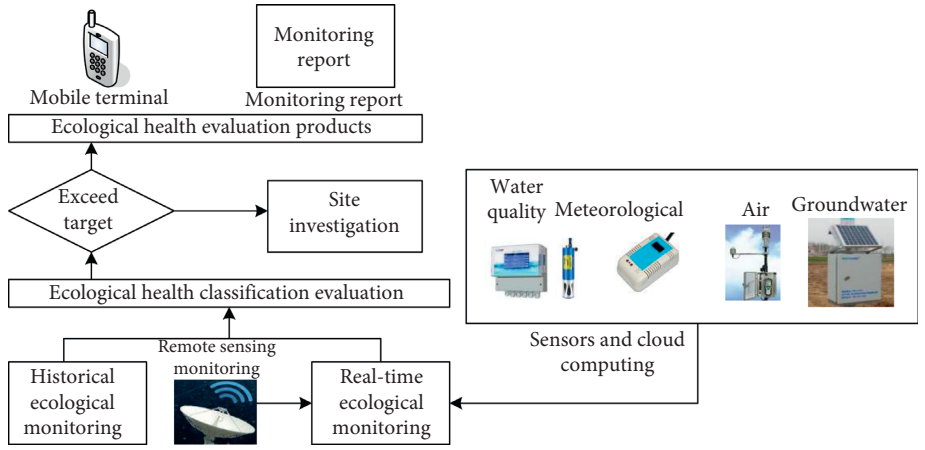

Figure 1: Ecological environment monitoring system in rural tourist areas.

Table 1: Air quality data.

Substance	Numerical value	Unit
SO_2	10	mg/m^3
NO_x	50	mg/m^3
Particulates	9	mg/m^3
Pressure	−20	Pa
O_2	15	%
Temperature	37	℃
Flow	9940	m^3/h

Table 2: Ecoenvironmental indicators of rural tourism areas.

Ecological environment quality (*A*)	Natural environment (*B*1)	Water quality (*C*1)
		Air quality (*C*2)
		Climate comfort (*C*3)
	Social environment (*B*2)	Resident warmth and friendliness (*C*6) (*C*3)
		Location and traffic conditions (*C*7) (*C*3)
		Accommodation conditions (*C*8)
	Humanistic environment (*B*3)	Local public security environment (*C*11)
		Local characteristic culture (*C*12)
		Resource cultural connotation (*C*13)

deviation is, and the more consistent the evaluation of tourists is. The specific evaluation is shown in Table 4.

It can be seen from Table 4 that tourists have the best evaluation of the quality of the natural environment (*B*1), the quality of the social environment (*B*2) is good, and the quality of the human environment (*B*3) is not good. Judging by the standard deviation, the standard deviations of the three are relatively close, indicating that tourists' evaluation of the quality of these three aspects is relatively consistent. Therefore, it is determined that, in terms of the quality of the ecological environment in rural tourism areas, the natural environment is the best, the social environment is better, and the human environment is not good. The ranking of the quality of the three is shown in Figure 5.

The descriptive statistical analysis of the quality of 9 indicators of the ecological environment is shown in Table 5.

It can be seen from Table 5 that tourists have the best quality evaluations of air quality (*C*2) and climate comfort (*C*3); environmental noise (*C*4) and green area (*C*5) are evaluated by tourists; for water quality (*C*1), tourism reception infrastructure (*C*9), and other factors, the evaluation of tourists is average, of which the water quality (*C*1) and tourism reception infrastructure (*C*9) are less satisfactory; the residents' warmth and friendliness (*C*6) is not well evaluated by tourists. The four factors, traffic conditions (*C*7) and accommodation conditions (*C*8), are the worst evaluated by tourists. Among them, the evaluation of accommodation conditions is the worst. The ranking of the average quality scores of some indicators is shown in Figure 6.

The comprehensive evaluation of the ecological environment quality of rural tourist areas involves the weight of each indicator and the actual score of the indicator. Therefore, the total score of ecological environmental quality is set as 100 points, and the theoretical score of ecological environmental quality (100) = the theoretical score of natural environment (36.5) + the theoretical score of social environment (31.7) + the theoretical score of humanistic environment (31.8), theoretical score of the

Table 3: Information for local or foreign tourists.

Influencing factors	Basic tourist information	Frequency	Proportion (%)
Gender	Male	88	55
	Female	72	45
Age	Less than or equal to 18	22	13.8
	19–25	39	24.4
	26–40	58	36.2
	41–60	31	19.4
	61 or more	10	6.2
Education level	Elementary school and below	10	6.2
	Junior high school	25	15.6

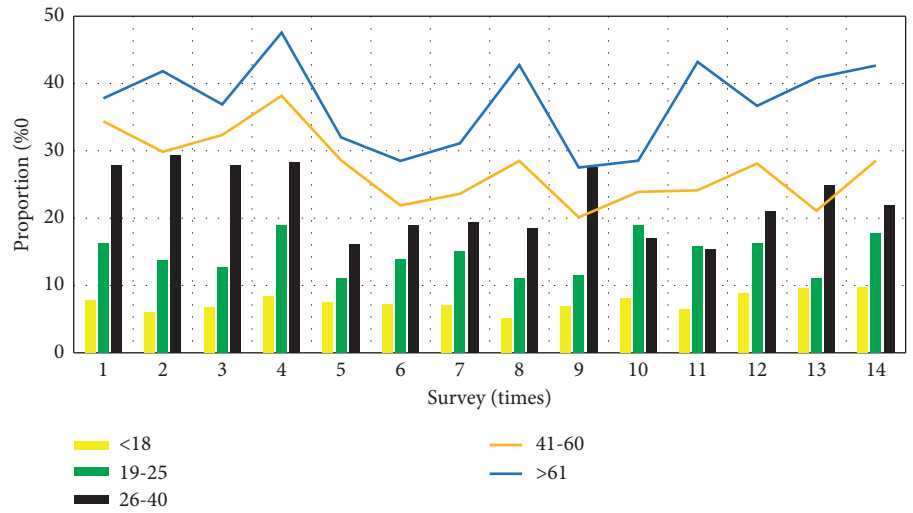

Figure 2: Comparison of the specific share of each age group.

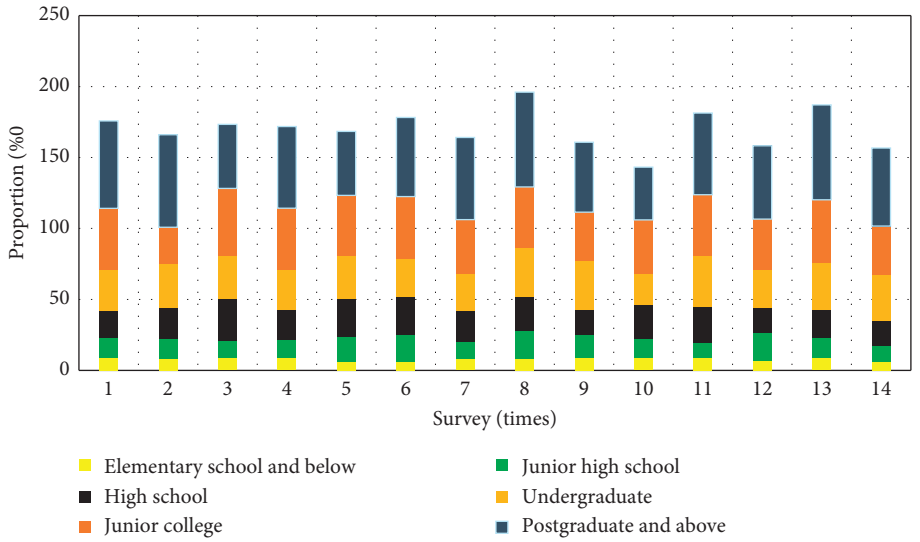

Figure 3: Comparison of the share of each degree of education.

indicator = weight ∗ total score, the weight of the indicator is determined by the important average value of each indicator, and the theoretical score and weight of each indicator can be calculated by analogy. The comprehensive evaluation of ecological environment quality is shown in Table 6.

The importance-performance score of the index-level index is shown in Table 7.

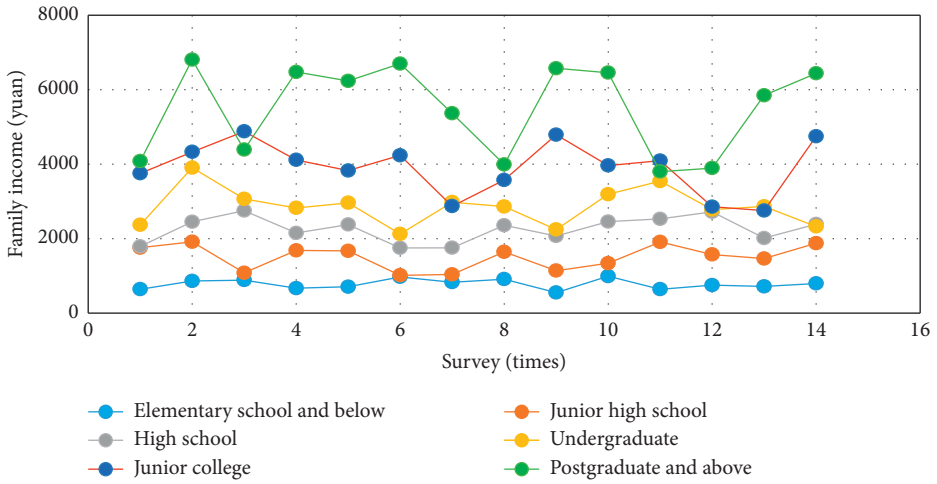

Figure 4: Proportion of each household's monthly income segment.

Table 4: Specific evaluation.

Index	Minimum	Max	Average value	Standard deviation
Natural environment (*B*1)	2	5	3.61	0.67
Social environment (*B*2)	2	5	3.44	0.63
Humanistic environment (*B*3)	1	5	3.40	0.60

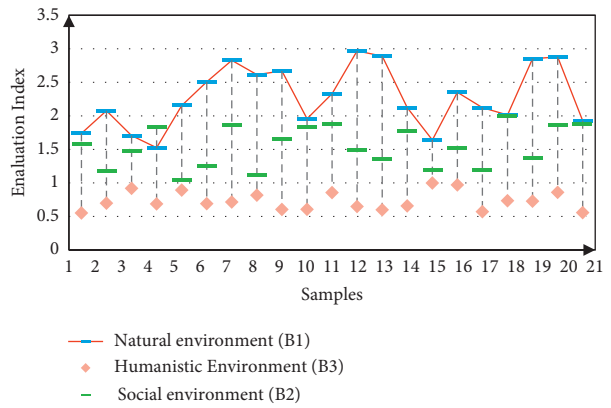

Figure 5: The ranking of the quality of the three.

Table 5: Descriptive statistics on the quality of 9 indicators of the ecological environment.

Index	Average value	Standard deviation
Water quality (*C*1)	3.47	0.64
Air quality (*C*2)	3.68	0.63
Climate comfort (*C*3)	3.81	0.60
Environmental noise (*C*4)	3.58	0.61
Green area (*C*5)	3.56	0.62
Resident warmth and friendliness (*C*6)	3.33	0.62
Location and traffic conditions (*C*7)	3.28	0.64
Accommodation conditions (*C*8)	3.23	0.62
Tourist reception infrastructure (*C*9)	3.42	0.69

The performance of the cloud GIS platform is shown in Figure 7. Regardless of whether it is based on a stand-alone or cloud GIS platform, the amount of data stored in the database is always linearly correlated with the storage time; that is, with the increase or decrease of the amount of stored data, the storage time will increase or decrease accordingly:

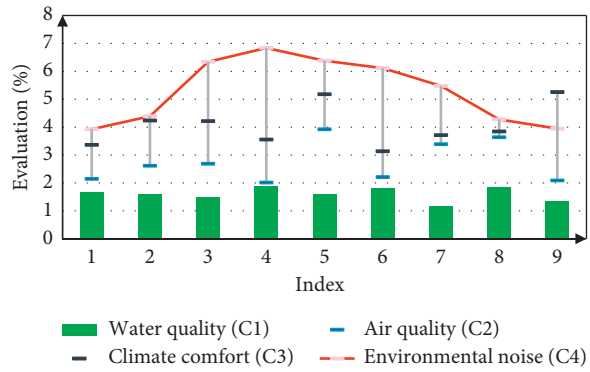

Figure 6: The ranking of the average size of the quality scores of some indicators.

Table 6: Comprehensive evaluation of ecological environment quality.

Index	Mean importance	Weights	Index
Natural environment (*B*1) 36.5	4.7	0.365	Water quality (*C*1) Air quality (*C*2) Climate comfort (*C*3)
Social environment (*B*2) 31.7	4.1	0.317	Resident warmth and friendliness (*C*6) Location and traffic conditions (*C*7) Accommodation conditions (*C*8)
Humanistic environment (*B*3) 31.8	4.2	0.318	Local public security environment (*C*11) Resource cultural connotation (*C*12)

Table 7: Importance of indicators at the index-level performance score.

Factor	Importance average	Performance average
Water quality (*C*1)	4.68	3.47
Air quality (*C*2)	4.71	3.68
Climate comfort (*C*3)	4.25	3.81
Environmental noise (*C*4)	4.16	3.58
Green area (*C*5)	4.34	3.56
Resident warmth and friendliness (*C*6)	3.99	3.33

when the amount of data is small (100 MB Below), the storage time of the cloud GIS platform and the stand-alone machine is not much different, and the storage time of the stand-alone machine is even shorter. However, as the amount of data increases, the time spent on a single machine is significantly longer than that of the cloud GIS platform, and this advantage of the cloud GIS platform continues to deepen. By analyzing the comparison chart of image storage speed (MB/S) based on a single machine and the cloud GIS platform, it can be found that there is a linear positive correlation between the storage data volume and storage speed based on cloud GIS platform; that is, as the amount of data increases, storage speed is also increasing. On the other hand, there is a positive correlation and then a negative correlation between the data volume and the speed of the storage based on a single machine. The inflection point occurs when the data volume is 300 MB; when the data volume is less than 500 MB, the cloud GIS platform and the storage speed of a single machine are not much different, and even the storage speed of a single machine was higher than that of the cloud GIS platform. However, as the amount of data continues to increase, the storage speed of the cloud GIS platform is significantly higher than the speed of a single machine, and this advantage continues to expand.

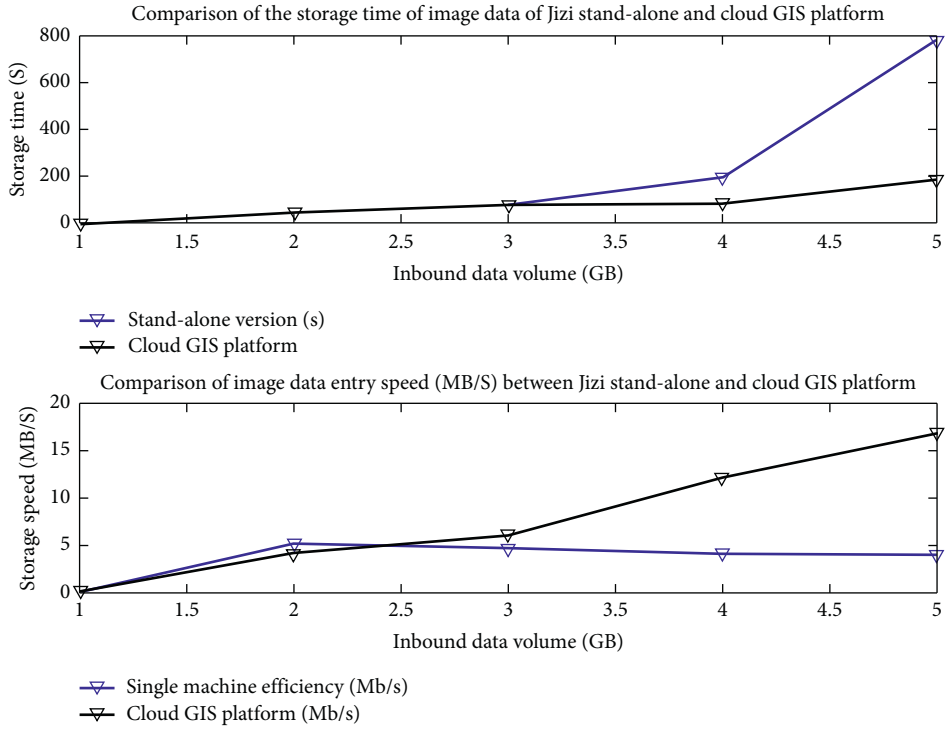

Figure 7: Cloud GIS platform performance.

5. Conclusions

The development of tourism is inseparable from the environment, so we must pay attention to the quality of tourism environment closely related to tourism. Only by establishing a good relationship with the tourism environment can the tourism industry walk out of a harmonious and low energy consumption development mode. This study mainly discusses the application of cloud computing and Internet of things technology in the evaluation of ecological environment quality of rural tourism areas in a smart city. In this study, the real-time monitoring of the atmosphere, water, and meteorological data is collected through the GPRS data transmission module and then sent back to the local server by the GPRS network; the obtained non-real-time and real-time data are used to establish the ecological monitoring database, the database analysis of its information, and get real-time data, monthly data, and longer cycle data. In the cloud GIS platform, there are multiple subnodes. The split tasks can be processed by each subnode through a map, and the results after processing can be summarized through reduce, which completes the implementation process of the whole idea of map reduce. In the future work, we should include the working environment into the environmental assessment standards, apply 3S technology to the environmental monitoring of scenic spots, reasonably plan the ecotourism, and ensure the protection of the tourism environment.

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Analysis on the Countermeasures of Optimizing Urban Tourism Public Service System under the Background of Smart City

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Academic Editor: Wei Wang

At present, there are problems in the construction of the tourism public service system such as poor coordination and coordination among various departments, lack of resource integration mechanism, and low level of information of tourism public services. Therefore, by analysing the problems existing in the tourism public service system in the context of smart cities, this paper puts forward strategies to optimize the tourism public service system. First, we build a smart tourism public service system platform for overall development and optimize the tourism public service platform. Secondly, by focusing on the behaviour of tourists, we construct a big data analysis and management system for the behaviour of smart tourism tourists. Finally, for the traffic situation in the process of tourism, a smart traffic line network based on pheromone ant colony is constructed. The results of the questionnaire survey on tourists show that the optimized public service system platform has achieved great satisfaction.

1. Introduction

China's tourism industry is undergoing a rapid transition from the period of mass travel to individual travellers. With the in-depth development of the tourism industry, individual tourists will gradually become the main body of the tourism consumer market [1, 2]. The rise of the individual consumer market has changed the relationship between traditional tourism demand and supply. Tourists' demand for tourism information is increasing, especially the demand for tourism public service systems. The development of information technology, the integration of information technology, and tourism, especially the construction of smart city system, provides a more systematic, more convenient, intelligent, and humanization of ideas and means to solve the visitors access and application of public service. It has laid a solid foundation for the basis of tourism public service system construction under the background of intelligent city. In addition, it further promotes the construction of urban tourism public service system [3, 4].

Smart tourism is to use the Internet to allow tourists to interact with the scenic area in real time, making the information of the scenic area more transparent and the travel schedule more personalized [5, 6]. Tourist attractions integrate tourism resources and tailor tourism products for tourists. With the help of terminal Internet access devices, tourists can arrange and adjust travel plans at any time, to achieve intelligent perception and convenient use of various types of travel information. There are relatively many foreign studies on the behaviour of tourists using public tourism services, including the search behaviour of tourists "information, tourists" demand preference, and satisfaction with services. Their research results are mainly concentrated on the process of obtaining and using tourist information research. San et al. [7] distinguished domestic and foreign tourists and studied the importance and cultural differences of services of tourist destination information. Ahmadimanesh et al. [8] emphasized the public information supply in the tourism management of government marketing decision support system. Li et al. [9] expounded the construction of the service system of destination tourism information from

the perspectives of organizational structure and economic structure, information and data sources, quality control, and technology application. Wu et al. [10] introduced the tourism information service system, including transportation, climate, and other information services. Zhang et al. [11] introduced in detail the types, contents, and functions of free information provided by the US tourist information centre. They believed that the free travel information in the United States is rich in content, focusing on information updates, emphasizing the timeliness of information, the accuracy of maps, and copyright attributes. Zhu et al. [12] understood the concept of public tourism information service as a general term for tourism information services, such as information consultation and tourism information distribution, provided by government departments, public institutions, social organizations, and other organizations to tourists and the public at the destination. In order to meet the needs of tourists for tourism basic information, tourism product promotion information, tourism safety information, public environment, and other related information services, Li et al. [13] developed and processed information products and delivered them to tourists in a convenient way. Tan et al. [14] proposed the construction of a modern tourism information consulting service system with urban tourism information consulting service centre as the core, with various functions such as tourism orientation, consulting services, publicity and promotion, market research, image communication, and tourism shopping. Zhou et al. [15] proposed a public service system of tourism information from the four systems of tourism public information platform system, display system of tourism information, service system of tourism transportation, and consultation system of tourism information from the perspective of smart tourism.

Various aspects, such as the development level and technical level, restrict the public tourism service and application environment of the tourism industry, and the construction is relatively low. Therefore, its research will usually be based on the status quo and deficiencies and have some general recommendations. Ruan et al. [16] pointed out the problems existing in the tourism-consulting service centre through field visits and put forward corresponding constructive opinions from the aspects of institution construction, operation mode, service content, and development trend. Shen et al. [17] emphasized that tourism public information is the basis of tourism public services and believed that the government and enterprises should speed up the construction of the tourism public information service system, improve the online service system based on the tourism information website, and base on the tourism-consulting centre. The service window and audio service system cantered on the tourism service hotline make it a perfect public service system of tourism information covering different people and fields. Alfred et al. [18] developed a kind of information service function traditionally provided by tour operators and tour guides through research. Shigematsu et al. [19] discussed the construction and application of intelligent transportation systems from the perspective of improving the traffic flow at tourist destinations. Based on the value of global positioning services and web-driven technological innovation, Montealegre et al. [20] have studied the forms that influence the creation, exchange, and evaluation of tourism information, which will promote the formation of more convenient tourism models. Mehraliyev et al. [21] proposed a framework model of smart tourism that guides visitors to a convenient experience.

By analysing the problems in the tourism public service system under the background of smart city, this paper puts forward the countermeasures to optimize the tourism public service system. Specifically, it includes the construction of a smart public tourism service system for overall development, a big data analysis and management system for smart tourist visitor behaviour, and a public transportation service system for smart transportation. Finally, through a questionnaire survey of tourists, it is concluded that tourists have a higher evaluation of the optimized public service system than unoptimized.

The rest of this paper is organized as follows: Section 2 analyses related concepts and technologies of smart cities and smart tourism. Section 3 proposes strategies for optimizing the tourism public service system in the context of smart cities. Section 4 verifies this article through a questionnaire survey the effectiveness of the optimization strategy. Section 5 summarizes the full text and points out future research direction.

2. Smart City and Smart Tourism

2.1. Smart City. A smart city uses a new generation of information technology to manage the operation of the city in an integrated and systematic manner, allowing the various functions of the city to operate in harmony with each other, providing high-quality development space for enterprises in the city, and providing citizens with a higher quality of life. The city has become an all-round development city suitable for people. Smart cities need smarter city planning and management, more reasonable and adequate resource allocation, and urban environmental protection in place, can provide more job opportunities, have emergency response capabilities for emergencies, and have sustainable development capabilities. Smart city is not only a brand-new urban development concept, but also a new way of development, operation, and management. It uses cloud computing, mobile Internet, Internet of Things, artificial intelligence technology, data mining technology, and information processing technology as basic platforms. With the help of smart phones, smart computers, and other terminal facilities to collect and mine information, analyse, and organize real-time transmission. As shown in Figure 1, it is a smart city application. After real-time application to enhance the autonomy, intelligence, and interactivity of information collection, consumption decision, product purchase, arrival in the city, and all tangible or intangible processes arrive in the city, the ultimate goal of the smart city is to meet differentiation service makes it enjoy an impressive experience [22].

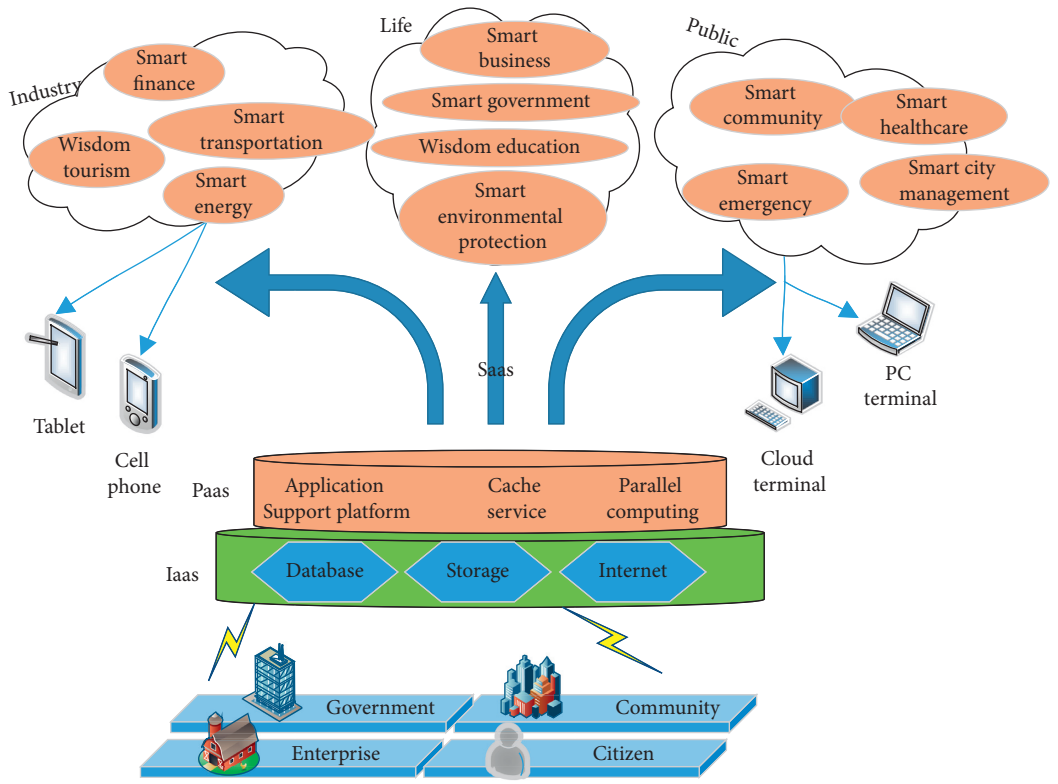

Figure 1: Smart city applications.

According to the summary of the development of smart cities at home and abroad, smart cities can be roughly divided into five types [23]:

(1) Industry-driven: it refers to an urban development path that takes high-tech information technology industry as the guidance and forms an intelligent industrial chain or industrial cluster as the core driving force.

(2) Innovation-driven: the innovation-driven path refers to the application of emerging information and network technologies, and the innovation system as the core, including smart city innovation subjects, innovation infrastructure construction, innovation talent system, and innovation resource environment.

(3) Sustainable development: the sustainable development path refers to the starting point of environmental protection and sustainable development of resources, to form intelligent management of environmental resources and to be rational, efficient, and reusable, and to create a sustainable development of environmental resource system and urban development path.

(4) Management service-driven: the management service-driven path refers to the use of technological means to upgrade, optimize, etc., to enhance public management service capabilities, making the city's public management functions more efficient, intelligent, precise, and convenient.

(5) Multiobjective development: the multiobjective development path refers to a development path formed by comprehensively considering factors such as the intelligent upgrading of industries, the improvement of public management services, the improvement of residents' lives, and the sustainable use of resources and environment during the construction of a smart city.

In addition, smart cities have the following characteristics [24]. First, the support of smart cities is the Internet, Internet of Things, mobile Internet, smart terminals, and other high technologies. Second, the basic purpose of smart cities is to provide information services to governments, city management departments, and city operators. Finally, the fundamental purpose of a smart city is to meet people's basic needs.

2.2. Tourism Public Service System. Tourism public service refers to the timely delivery of processed and developed information products to relevant tourists in a convenient way to meet the needs of tourists for basic information, product information, safety information, public

environment, and other related information services of tourist destinations [25, 26].

Tourism public information service is the core part of the construction of the tourism public service system, which realizes the connection between tourism suppliers and tourism demanders, prompts potential tourists into real consumers, and can effectively enhance the tourist experience of tourists and improve tourist satisfaction, and improving services at tourist destinations are conducive to the development of the tourism industry.

Tourism public service quality is whether the public information services such as tourism products, information consultation, tourism orientation, product ordering, promotion, complaint and rescue, and security transportation are provided by the destination tourism-related institutions and enterprises through the tourism public information service platform or other facilities [3].

The essence of smart tourism refers to the application of smart technologies, including communication technology, in the tourism industry, with the goal of enhancing tourism services, improving tourism experience, innovating tourism management, optimizing the use of tourism resources, enhancing the competitiveness of tourism enterprises, and improving tourism modernization project of industry management level and expansion of industry scale.

It can be seen from this that the development of smart tourism will inevitably place higher demands on the construction of tourism public information services. Tourism public information service is the foundation of the development of smart tourism, the booster for the upgrading and transformation of the tourism industry, the support for the improvement of the level of tourism services, and the reliable guarantee for the harmonious development of regional tourism. The overall framework of the public service system for smart tourism is as shown in Figure 2.

2.3. Problems in Tourism Public Service System in the Context of Smart City. As the tourist spots scattered in the city are far apart, the service facilities that should be provided are not complete. For example, in the guidance system of tourist traffic, there are a small number of tourist attractions signs, guide maps of tourist traffic, traffic guidance signs, etc., and the standards are not uniform. Poor play, poor food, and poor accommodation have led to tourists visiting mostly for one-day or half-day trips. The bottom line is that under the current management system, various government departments cannot form synergy and lack unified planning and coordination, cannot effectively integrate tourism elements, have difficulty coordinating large industries, and cannot coordinate overall advancement of the tourism industry.

According to the survey, the online information service level of the tourism public information service platform is very low, the information update speed is slow, and the content coverage is insufficient. The lack of an electronic tour guide system has affected the access of tourists to information on attractions, tourist routes, and public facilities. The distribution of tourism-consulting service points is unreasonable and limited in number. The lack of popularization of tourist call centres has led to unblocked channels for tourists to defend their rights. Although it has a dedicated tourism, official websites work with many travel e-commerce companies (OTA). However, the official tourism website mainly focuses on the maintenance of tourism government information, and the actual travel information available to tourists is very small. In addition, there is a single type of cooperative OTA product. Moreover, mainly based on the sale of scenic spot tickets, leading to the diversified immediate needs of tourists is difficult to meet. This situation shows that the intelligence of travel consulting services needs to be improved.

At present, although tourism information centres have been set up in railway stations and most scenic spots, few tourists come to consult and the overall function is not perfect. Although the scenic area has a rest area in the visitor centre, it provides convenient tools such as baby carriages, wheelchairs, umbrellas, etc. and is specially equipped with barrier-free facilities and passages. However, there are many thresholds and steps in various scenic spots, the existing barrier-free passages are not smooth, and it is not convenient for special people to travel. There are too few rest facilities on the key roads in the scenic area. There is a lack of financial service facilities such as ATMs at the tourist hub. These circumstances illustrate the asymmetric supply of tourist public services and tourist demand. The reason for the problem is that the main supply department does not understand the real needs of tourists and lacks effective public participation channels. As a result, some tourism public service facilities are idle or in short supply, and it is difficult to achieve optimal disposal of resources.

3. The Optimization Strategy of Tourism Public Service System under the Background of Smart City

3.1. Building a Smart Tourism Public Service System for Overall Development. At present, the development of most tourism public services is not integrated with the construction of public services in the entire city. Therefore, taking the smart city construction as an opportunity, in the process of smart city construction, we will strengthen the special planning research in a targeted manner and incorporate the construction of the tourism public service system into the future economic and social development work planning and deployment. It is necessary to create a unified mechanism and open platform for the unified organization and coordination of various tourism-related departments in order to sort out and build a smart tourism public service system that can be developed as a whole. In this paper, the content of the tourism public service system is improved from the aspect of tourism transportation services. The specific design is shown in Figure 3.

As shown in Figure 3, according to the status and objectives of the construction of a public tourism service system, a unified tourism public service system platform is built using smart city construction as a carrier to form a unified service interface, authority management, user

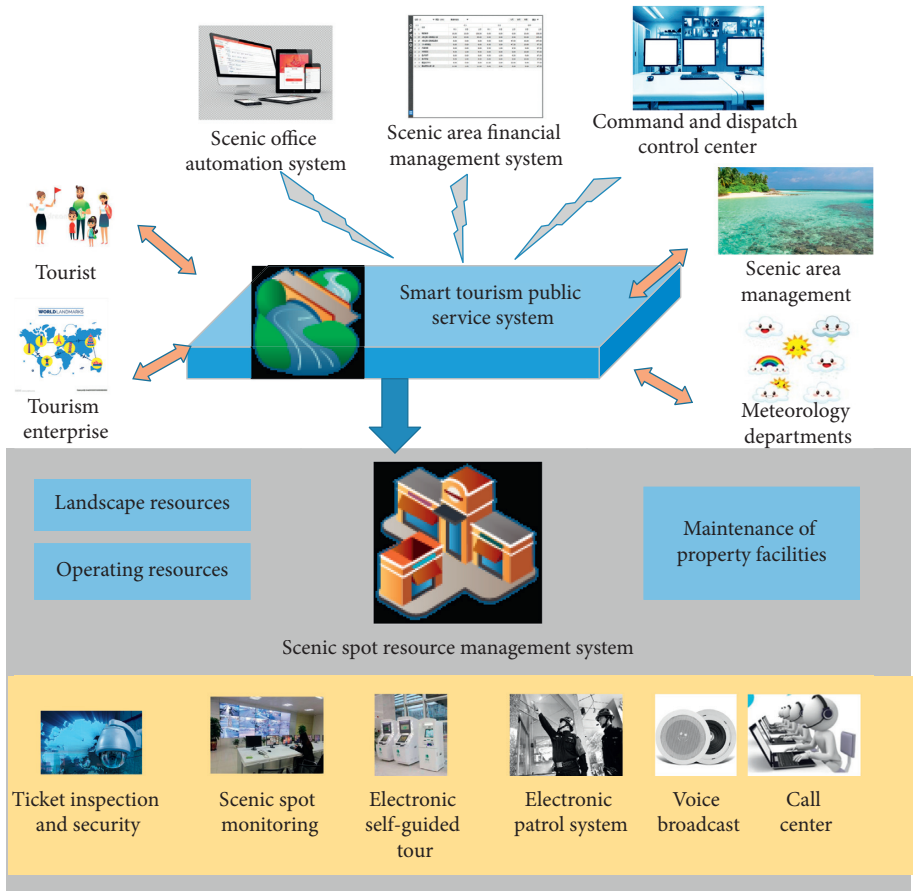

Figure 2: Overall framework of the public service system for smart tourism.

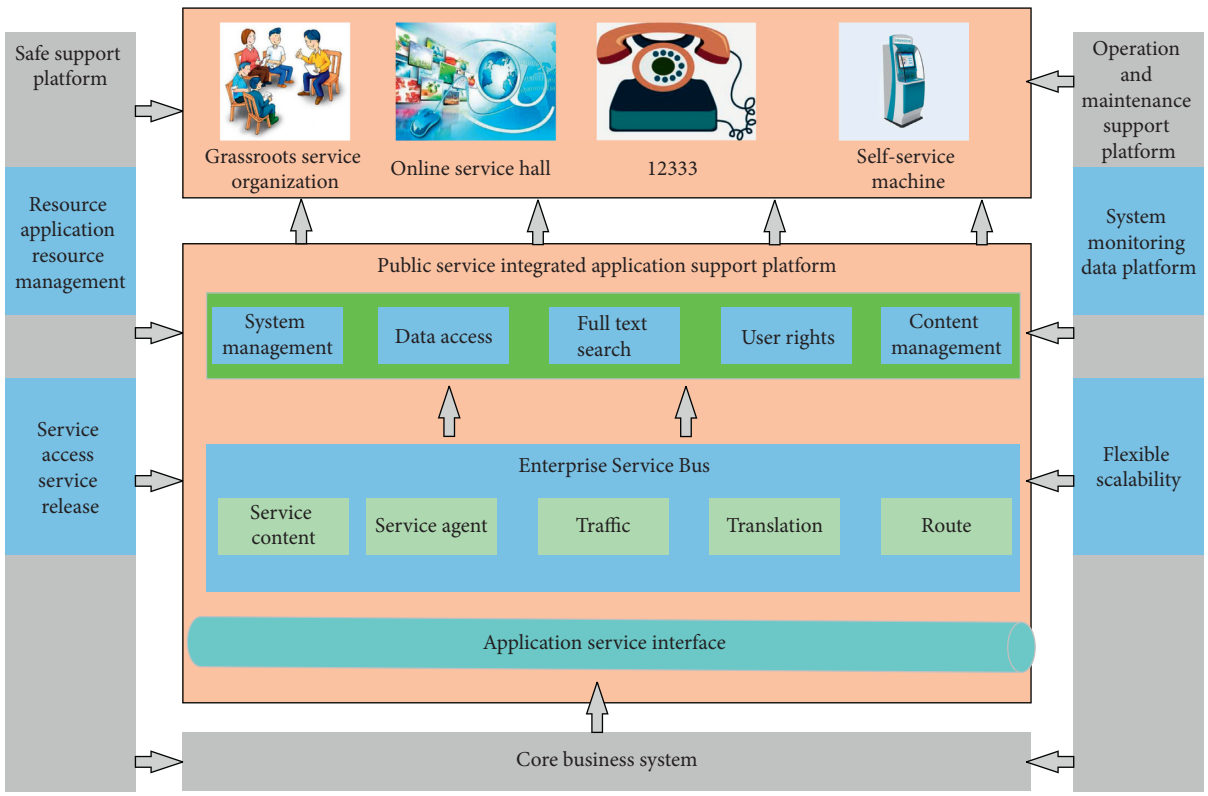

Figure 3: Design of a smart tourism public service system platform.

management, and data management. Taking basic data of the tourism information system as resources, it integrates online service hall, self-service system, telephone consultation system, and grassroots management information system to build a multiform, multichannel, multilevel, and comprehensive public service platform. The platform calls the data resources through the service bus and finally realizes the service call, and it realizes data synchronization and business collaboration.

3.2. Construction of Big Data Analysis and Management System for Tourist Behaviour. Modern information technology is developing rapidly, and the Internet era has arrived. It has brought new challenges to all occupations and has spawned new formats. The tourism industry will also accelerate the integration and development of information technology and accelerate the transformation from traditional service industry to modern service industry.

In the Internet age, tourists' travel behaviour and ways of obtaining information are changing. Only after studying the needs of tourists, they can know what the government is going to do and what the enterprises are going to do. According to the statistical survey on the development of the Internet in China, as of June 2013, mobile phone netizens accounted for 78.5% of the total netizens. Relevant data reports show that 89% of Chinese tourists will obtain information through online media in the next year. This shows that the Internet has become the main channel for tourists to obtain information. In response to the problems of asymmetric public service supply and demand and low resource utilization, in the process of smart city construction, special seminars and public opinion surveys were conducted to timely grasp and understand the demand for local public residents and foreign tourists for tourism public services and establish participation mechanism. Information feedback is used as a reference basis for construction to achieve a balance between the supply and demand of tourism public services, thereby creating a system of benefiting the people and sharing convenience between hosts and guests.

As shown in Figure 4, the analysis of tourists' behaviour patterns can be divided into three stages, namely, before, during, and after the trip. The predeparture stage is a stage where tourists make consultations and make choices. This stage is mainly marketing for government enterprises, and smart tourism marketing is here. In the past, tourists' food, accommodation, travel, shopping, and entertainment were all done through travel agencies. Now, with the prevalence of Internet and free travel, many of them are realized through the Internet and mobile clients. This stage is the most important stage of smart tourism, that is, smart service. In the "post-travel" stage, tourists' sharing of travel experiences and complaints and so on must be realized through the Internet, and smart tourism must play a certain role.

3.3. Constructing a Smart Public Transportation Public Service System. The bus to the scenic spot in the city has low accessibility, lack of public bicycle rental points, few car rental companies, and no consideration of the needs of tourists. The location and distribution of parking lots in transportation infrastructure is unreasonable, and road conditions are congested. Traveling by tourists requires more time and energy, which is not conducive to improving the overall quality of life. The construction of intelligent transportation refers to the introduction of information technology into the traffic construction process, thereby reducing the phenomenon of vehicle congestion and saving the cost of travel time for tourists. Throughout the evolution of domestic and foreign urban transportation, the increase in private cars is the main reason for the traffic problem. By building transportation facilities with stronger bearing capacity and larger capacity, the urban transportation mode is gradually changed to meet public travel needs. The results of the survey are shown in Table 1. The percentage of tourists choosing public transportation is 0.282, the percentage of tourists choosing electric vehicles is 0.093, the selection of private vehicles is 0.215, the selection of taxis is 0.311, and the selection of bicycles is 0.064. The choice for hiking is 0.035.

Road traffic routes have relatively long waiting times for passengers due to peak commuting times. Various mobile terminal public transportation inquiry systems have been opened. However, due to the lack of an intuitive image, the average number of people currently using the query system is only more than 30,000 people per day. Obviously, the usage rate is still low. Although the city has many main roads, the lack of expressways and branch roads is the main reason for frequent traffic jams and traffic safety accidents on the city's main roads. The significance of constructing intelligent transportation facilities is to help tourists understand the traffic situation in advance and adjust the travel routes in time, which can effectively reduce the time cost of travel for tourists.

The optimization problem of the urban transportation network is a classic optimization problem.

Let variable m be the number of ant colonies, and $\tau_{ij}(t)$ represents the amount of information remaining on the i to j line at time t. At the initial moment, the amount of information on each path is equal. During the movement of ant k according to the amount of information on each path, we determine the city to be transferred next. Variable $p_{ij}^{k}(t)$ means that ant k is transferred from position i to probability of j:

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{\left[\tau_{ij}(t)\right]^{\alpha}\left[\eta_{ij}(t)\right]^{\beta}}{\sum\left[\tau_{is}(t)\right]^{\alpha}\left[\eta_{is}(t)\right]^{\beta}}, & j \in \text{allowek}_k, s \in \text{allowek}_k, \\ 0, & \text{otherwise.} \end{cases} \tag{1}$$

As time goes by, the pheromone left on the path will gradually disappear. The parameter ρ is used to indicate the degree of pheromone disappearance. After time n, the ant completes a cycle, and the pheromone on each path should be adjusted according to the following formula:

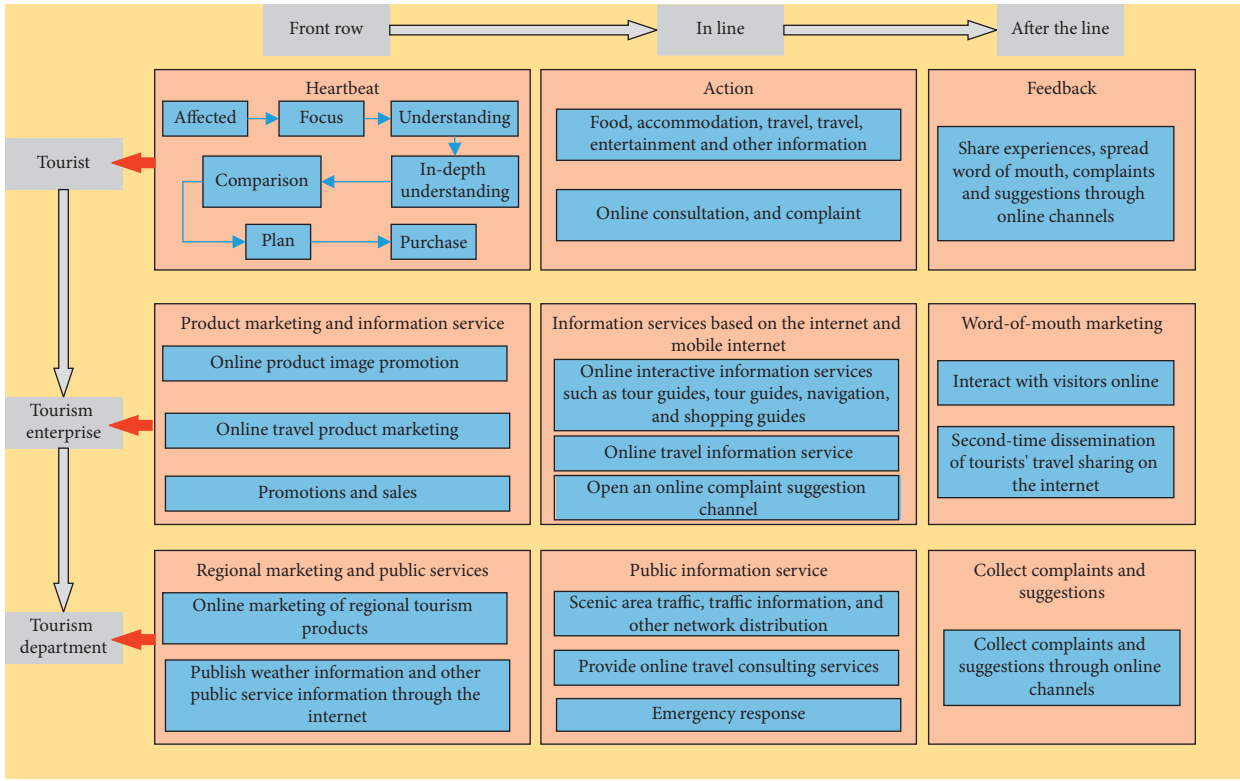

Figure 4: Supply-demand relationship diagram based on tourist travel behaviour.

Table 1: Travel methods for tourists.

Travel mode	Number	Proportion
Bus	141	0.282
Taxi	156	0.311
Private car	124	0.215
Electric car	35	0.093
Bicycle	26	0.064
Walk	14	0.035

$$\tau_{ij}(t+n) = \rho\tau_{ij}(t) + \Delta\tau_{ij},$$
$$\Delta\tau_{ij} = \sum_{i=1}^{m} \tau_{ij}^{k}. \tag{2}$$

The variable $\Delta\tau$ represents the pheromone increment left on the path by all the ants that have gone through the path i to j in this cycle:

$$\Delta\tau_{ij} \begin{cases} \frac{Q}{L_k}, & \text{The } k-\text{th ant goes through path } I_j \text{ in this cycle,} \\ 0, & \text{otherwise.} \end{cases} \tag{3}$$

Among them, the variable Q is a constant. The variable L_k represents the length of the path taken by the k-th ant in this cycle.

Due to the noncontinuous nature of the design of the transportation network, it is difficult to obtain an accurate solution to this type of combinatorial optimization problem. In this paper, the ant colony algorithm with decreasing pheromone is used to optimize the bus network problem. Now, suppose that there are 6 road points A1, A2, A3, A4, A5, and A6, and the connectivity of each road point is shown in Figure 5. Among them, the distance between A6 and A3 is two, the distance between A6 and A4 is two, the distance between A5 and A3 is one, and the distance between A5 and A4 is one. Obviously, the distance from the road point A3 through the road point A5 to the road point A4 is smaller than the distance from the road point A6 to the road point A4. For an ant colony system with equal time intervals, it is assumed that 60 ants are placed in the ant colony system. Each ant has the same walking speed. At the same time, the concentration of pheromone released per unit time is one. For the 30 ants placed at road point A3 and road point A4, let them start at the same time and each ant chooses the walking path randomly. Suppose that 15 ants chose the A6 route to reach A4, and 15 ants chose the A5 route to reach A4. Since the distance of the A3-A5-A4 route is smaller than that of the A3-A6-A4, the ants who choose the A3-A5-A4 route in the same time interval arrive earlier and the pheromone concentration of the route is greater. In the case of a given waypoint, ants in the ant colony system prefer to keep the path with thicker pheromone when choosing the forward route, and the path with more pheromone means shorter "distance."

Based on the above principle, the ant colony system can find the shortest path in the road network through random

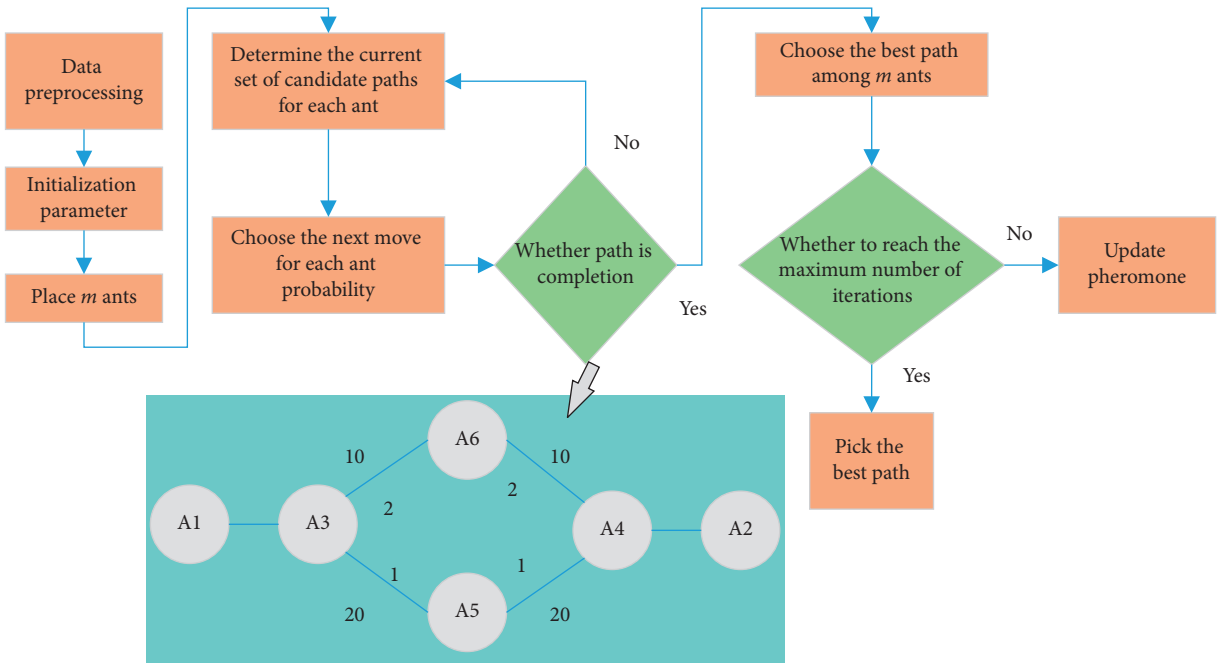

Figure 5: Schematic diagram of path selection.

search. The main point of the new pheromone update method is to strengthen the first half of the pheromone update range and reduce the second half of the pheromone update range during a cruise. In addition, the influence of a certain proportion of paths on the successor ants can reduce the nonoptimal search results of the predecessor ants and achieve the purpose of improving the quality of the offspring ants.

4. Test Experiments

4.1. Questionnaire Survey and Evaluation Criteria Design. Experts and scholars at home and abroad have conducted research on the related content and system construction of tourism public information service research. On the basis of comprehensive consideration of the principles of science, applicability, and operability, we have constructed 4 standard layers, namely, tourism network information services, tourism information consulting services, tourism logo translation services, and tourism information publicity services. They can be divided into 10 factors and 22 evaluation indicators, as shown in Table 2.

Using Likert's five-point scale method, tourists are given satisfaction based on a total of 5 points. The higher the score is, the higher the satisfaction is. The 22 questionnaires in the evaluation system are used as the object of tourist satisfaction evaluation to design questionnaires. Questionnaires were randomly distributed, 400 were returned, and 336 valid questionnaires and the questionnaire validity rate were 84%. The age groups of tourists interviewed are mainly young, middle-aged, and urban residents. The education level is mainly university. The types of occupations are mainly students, enterprise management personnel and professional/cultural, educational, and scientific personnel. The age level, education level, living environment, and occupation type of the interviewees determine their certain contact and understanding of tourism activities and information technology, which is beneficial to the objectivity and reliability of the data collected in this survey. The types of tourist sources are diverse, and the gender ratio is balanced, which is conducive to the authenticity of the survey data.

It can be seen from Figure 6(a) that the travel methods of the interviewed tourists are mainly self-service and only 2.44% of the ways to participate in tour groups. It can be seen that the "free travel" travel mode has become the main travel method for domestic tourists. The construction of tourism information plays an extremely important role in "free travel" travel activities. The real-time acquisition and update of tourist information brings convenience to "free travel" tourists. On the other hand, the satisfaction evaluation of "free travel" tourists can also most directly reflect the construction and operation level of a city tourism public information service system. In the "understanding channels" option in Figure 6(b), local tourists mainly learn about the city's tourism information through other channels, online media, introductions by relatives and friends, and TV advertisements. Foreign tourists mainly obtain city information through the introduction of relatives and friends, other online media, and other channels. The above data show that with the advent of the information age, the promotion of

Table 2: Evaluation model of the urban tourism public service system.

City tourism public information service system		
Criterion		Factor layer
Tourism network information service	Travel information (C1)	Website information of tourism administration website
	Tourism e-commerce (C2)	Tourism enterprise portal public welfare information
	Travel mobile information (C3)	Mobile phone and tablet network information push
Tourism information consulting service	Tourist information facility (C4)	Tourist information service centre (C41), tourist information kiosk (C42), tourist information touch inquiry machine (C43), and tourist map guide information service (C44)
	Tourism information platform (C5)	Tourism service telephone (C51), telephone inquiries (C52), mobile message prompt and information (C53), and other auxiliary hotlines (C54)
Interpretation of tourist signs	City tourism logo interpretation service (C6)	Traffic guidance sign (C61), tourist reception facility sign (C62), urban environment information (C63), and public facility symbol system (C64)
	Tourist attraction logo interpretation service (C7)	Scenic traffic guidance sign (C71), scenic reception facility sign (C72), scenic electronic display screen (C73), and self-guided tour service (C74)
Tourism information promotion service	Promote product (C8)	Paper brochure and map
	Propaganda media (C9)	Radio, television, newspaper, and magazine media
	Tourism public information service (C10)	Traffic conditions, weather information, parking information, and medical information

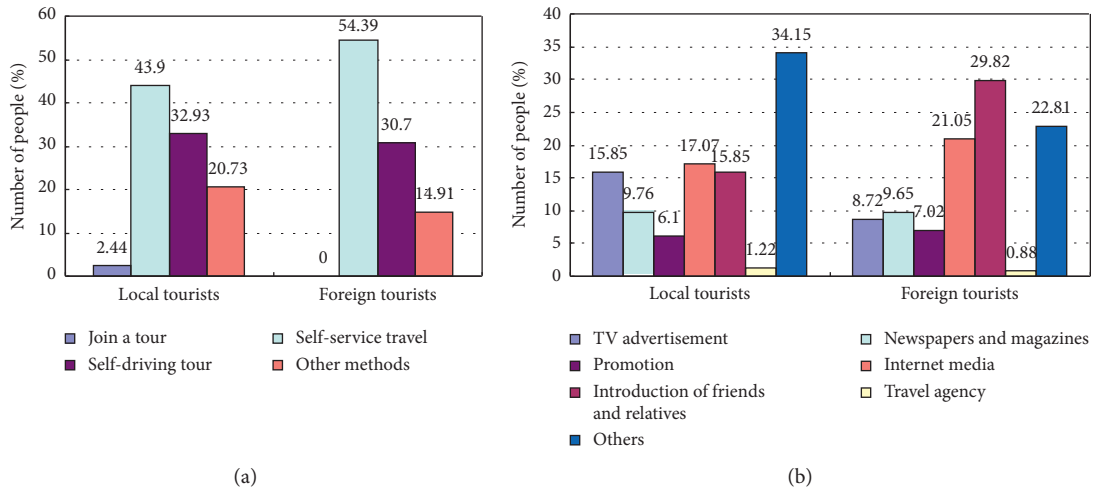

Figure 6: Characteristic analysis of tourist travel behaviour: (a) way of travel; (b) understanding channels.

cities through online media has become the main channel, but the high proportion of introductions by relatives and friends reflects to a certain extent the gap between the charm of the city itself and its promotional efforts. The means of information, its strength, and the degree of expansion still need to be strengthened.

4.2. Tourists' Evaluation of the Optimized Public Service Platform. Compare the scores of local tourists and foreign tourists horizontally, as shown in Figure 7. The scores of 22 indicators of local tourists are higher than that of foreign tourists, excluding subjective factors. The main reason is that local tourists live in the area for a long time, and they are familiar with the city's tourism information model and carrier. The time and space of exposure to tourism information services and carriers are limited, so the perception and evaluation value are relatively low. This also shows to a certain extent that the construction of Ningbo's tourism public information service system is mainly based on a static model. The dynamic and active tourism information push and service model still need to be strengthened. At present, it does not effectively serve the free travel information collection of foreign tourists. Among the evaluation values of foreign tourists, the five items with the lowest scores are tourist information kiosks, mobile text message prompts and information, mobile network information push, and tourism-consulting service centre. This also demonstrates the existence of the above problems to a certain extent.

Among the 22 indicators, the top five items with the highest evaluation values are traffic guidance signs (C61), scenic traffic guidance signs (C71), scenic reception facilities signs (C72), public facility symbol system (C64), and tourist reception facilities signs (C62). The top five

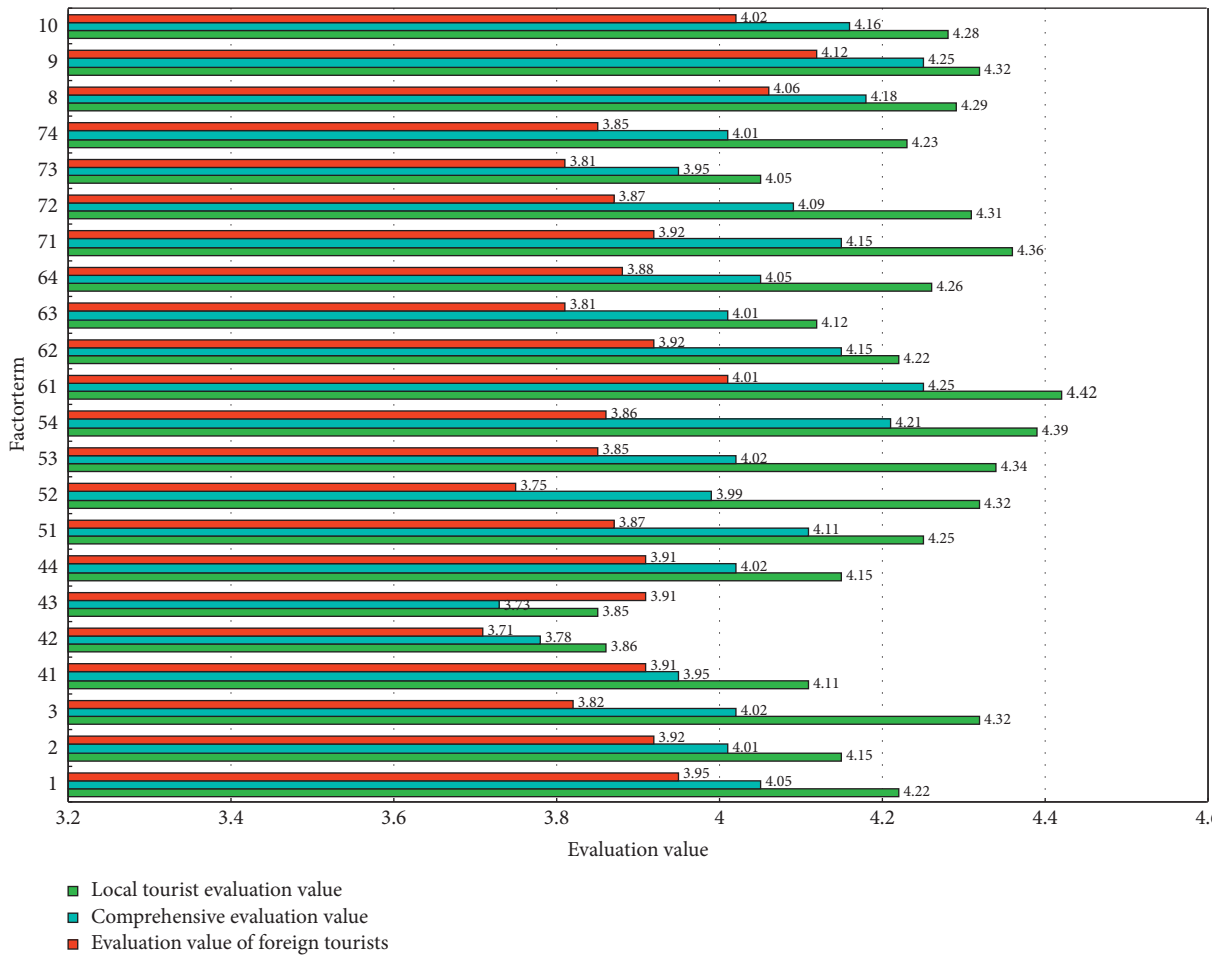

Figure 7: Comparison of evaluation values of different customers.

items with the lowest ratings are tourist information kiosk (C42), tourist information touch (C43), query all-in-one machine and tourist consultation service centre (C41), self-guided tour service (C74), and mobile SMS prompt and information consultation (C53). It can be seen that the relative score of tourism identification services is relatively high. Both urban public tourism service identification and scenic tourism identification construction are relatively mature, allowing tourists to obtain information in a timely manner. Information service of tourism identification is the most basic part of the tourism public information service system. However, the scores on the construction of tourism-consulting services and consulting platforms, the interpretation of tourist attractions, and the push of tourist information are relatively low, indicating that the most core and most informative features in the public tourism information service system reflect the intelligence of information technology. The tourism-consulting service still needs to be improved.

4.3. Performance Test of Tourism Public Service Platform. In this paper, we use pressure tools to simulate real-world concurrent requests from the client to the application server and compare the performance of the application server before and after optimization. The main indicators for evaluating server performance are the 10 s click rate and the corresponding response times.

It can be seen from Figure 8 that in the first 10 s, since the number of clicks is not very large, there is not much difference before and after optimization. After 20 s, as the number of clicks increases and the number of concurrent increases, the server before optimization is gradually unable to process requests quickly. Although the number of responses increases, the growth trend is not as fast as that of the optimized server.

It can be seen from the analysis in Figure 8 that when the server load is small, the performance of the server is not significantly improved before and after optimization. Moreover, when there are many clicks, the performance of the server will be improved by about 20%.

4.4. Analysis of the Optimization Performance of Urban Transportation Network. In the optimization algorithm proposed in this paper, ants randomly select cities before each departure. This paper compares the ant colony algorithm with the algorithm proposed in this paper. Each algorithm is run 50 times, each run is iterated 1000 times, and

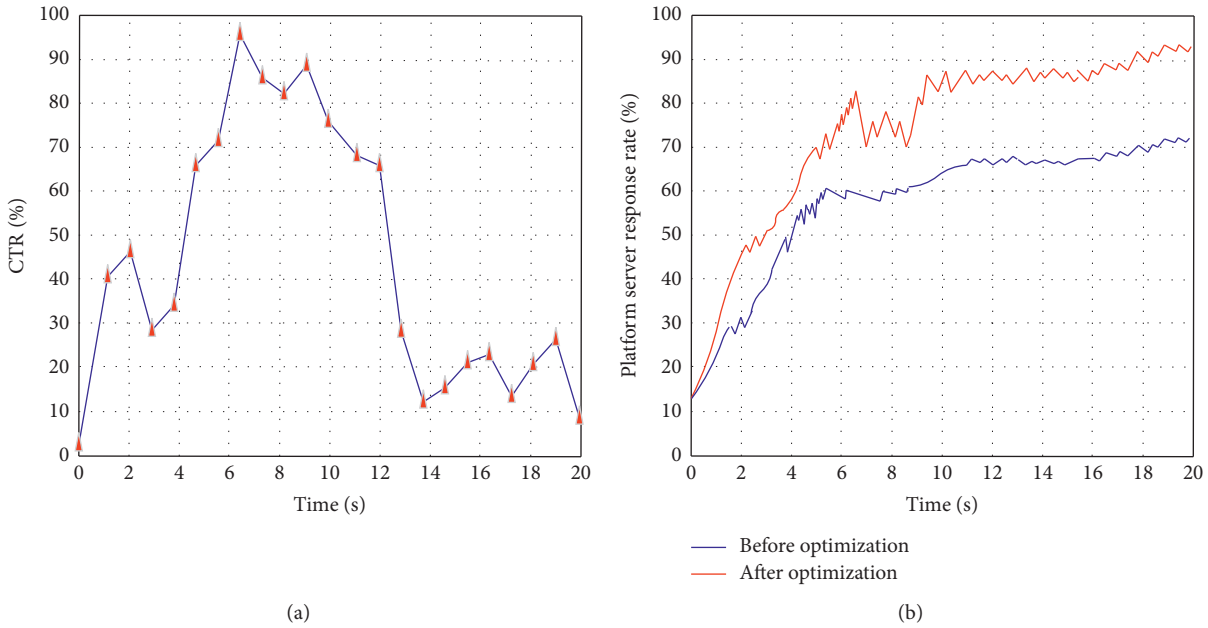

FIGURE 8: Server performance analysis of the public service platform: (a) the user clicks on the graph in each time period; (b) response graph of platform server before and after optimization.

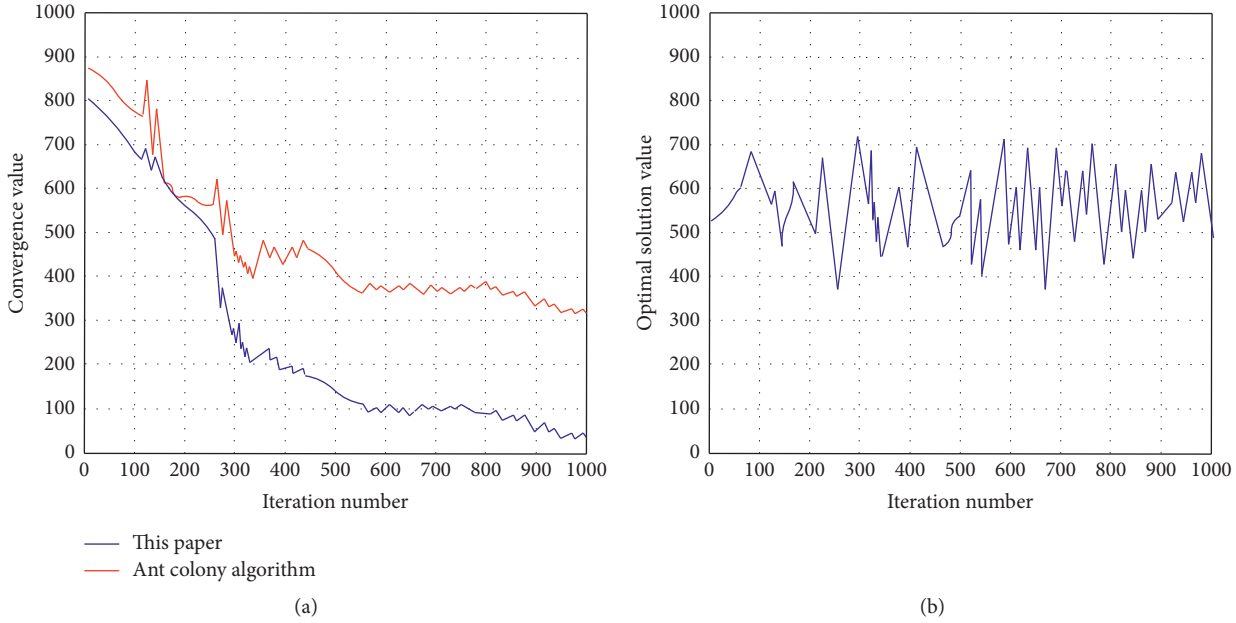

FIGURE 9: Convergence characteristics of the algorithm and diversity of solutions: (a) convergence performance of different algorithms; (b) diversity graph of the solution of this algorithm.

the best 20 sets of solutions are taken as samples. Among them, the average time is the average value of the average time to find the best solution in each run. Figure 9(a) shows a comparison result of the convergence characteristics of different algorithms. It can be seen that compared with the ant colony algorithm, the convergence of the algorithm in this paper is faster. From the experimental results of several sets of data given, the solution of the algorithm in this paper is better than that of the ant colony algorithm. In addition, from the perspective of computing time, the computing time of the algorithm in this paper is significantly shortened. Figure 9(b) gives the solution diversity diagram, which shows that the solution diversity has been very good, has a strong search ability, can obtain the global optimal solution,

is not easy to fall into the local optimal, and has good stability.

5. Conclusion

At present, there are problems in the construction of tourism public service system under the background of smart city, such as poor coordination among various departments, lack of resource integration mechanism, and low level of information of tourism public services. Using new technologies such as cloud computing and the Internet of Things, with the help of portable terminal Internet access devices, people can understand the information in time, arrange and adjust work and travel plans in time, and optimize the current public service system. Therefore, in this paper, first, we build a smart development public tourism service platform and optimize the tourism public service platform. Secondly, by focusing on the behaviour of tourists, construct a big data analysis and management system for the behaviour of smart tourism tourists. Finally, for the traffic situation in the process of tourism, a smart traffic line network based on the algorithm of pheromone ant colony is constructed. The results of the questionnaire survey on tourists show that the optimized public service system platform has achieved great satisfaction.

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Value Preferences and Intergenerational Differences of Tourists to Traditional Chinese Villages

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Academic Editor: Guangdong Wu

Tourist values determine the behavior of tourists. To pinpoint the behaviors and preferences of tourists, it is necessary to explore their value orientation and intergenerational differences. The exploration is of great significance to the activation of tourism in traditional villages. After analyzing the value of tourists to two traditional villages (Hongcun and Xidi), this paper investigated the value preferences and intergenerational differences of tourists of four generations to traditional villages, using means-end chain (MEC) theory and hard laddering. Through a questionnaire survey on tourists born in the 1960s, 1970s, 1980s, and 1990s, the authors established 36 MEC value chains of 18 classes. The results show that the post-60s traditional village tourists are a generation of wisdom-loving learners, who prefer the values of wisdom and self-improvement; the post-70s and 80s tourists are a generation of beauty lovers with a strong sense of belonging, who prefer the values of beautiful world, inner harmony, and sense of belonging; the post-90s tourists are a generation of inclusive advocators of diversity, with no special value preference. These results provide theoretical support and practical enlightenment for the market segmentation of traditional village tourism and the protection and activation of traditional villages.

1. Introduction

Traditional villages are the basic units of rural China and the living fossils of traditional culture [1]. In June 2019, the Chinese Ministry of Housing and Urban-Rural Development, in association with other departments, released the fifth batch of Chinese traditional villages. In total, 6,819 traditional villages are being protected in China. The main protective method is to activate tourism to these villages [2]. The ancient village tourism and rural tourism are an important means to activate and protect traditional villages [3]. Driven by the boom of domestic tourism, the purpose of traditional village tourism has shifted from sightseeing to both sightseeing and vacation. Thanks to unique regional cultures, improving infrastructure, better public services, and new business products, traditional villages are attracting more and more tourists of different generations.

At present, fruitful results have been achieved on the description of the behavior features of tourists to traditional villages. However, there is a lack of in-depth research on the intergenerational differences of tourists. The Travel Industry Association of America (TIA) considered intergenerational analysis as the most common and effective approach for dividing the population and segmenting the market. Tourists of different generations vary significantly in behavior features and preferences [4]. A good understanding of the intergenerational differences in tourist behaviors helps to mine the deep-seated inducers of their tourism behaviors and preferences [5]. On this basis, it is possible to accurately predict the value preferences of tourists of different generations [6] and segment the market to provide products and services tailored to their needs, thereby promoting the sustainable development of traditional village tourism. The tourists' pursuit of value is the fundamental determinant of their travel behaviors [7]. Therefore, this paper analyzes the values of tourists of

different generations to traditional villages through hard laddering, a technique of means-end chain (MEC), and tries to disclose the value preferences and intergenerational differences between traditional village tourists.

2. Literature Review

2.1. Traditional Village Tourism. The development of traditional villages as travel destinations is always accompanied by the game between core stakeholders, dormant stakeholders, and marginal stakeholders. There are differences and interconnections between these stakeholders [8]. Culture and environment are their common focuses [9]. The government plays a decisive role in the development of traditional village tourism [10], which suffers the greatest impact from community and residents [11]. Being the owners of traditional villages, the residents determine how well the tourism of these villages develops with their satisfaction, support, and active participation [12–17]. Therefore, the active involvement of the community can promote the sustainable development of tourism in traditional villages [18, 19], enhance community capacity [20], spur community development [21, 22], and underpin the good interaction between community and tourism. Hence, the development of traditional village tourism is not only a game, but also the symbiosis of multiple stakeholders.

Symmetrical reciprocity and integrated symbiosis are the optimization objectives of the symbiosis systems for traditional villages [23, 24], such as the "community participation + enterprise operation" model of stakeholders [25], the typical model of valley economy in mountainous regions [26], the diversified mixed effect model of market game [27], and the synchronized/asynchronized "urbanization + community participation + protection zone" model [28].

During the game and symbiosis of stakeholders in the development of traditional village tourism, the space of traditional villages is evolving into two social spaces, namely, tourist area and resident area, with the continued growth of tourist immigrants and tourists. Some traditional villages have developed into small towns [10], creating new ethnic cultures [29]. In this process, the spatial social order has also been reorganized: the niche space of community populations is replaced by tourist populations, which occupy the core area of traditional villages [30]. Driven by tourism interests, the tertiary industry-centered land urbanization has taken place around some traditional villages. The population is dominated by residents and tourism practitioners. Under the influence of outside cultures, the original residents of traditional villages are increasingly urbanized and modernized [31], and the rural culture is shifting from traditional farming culture to modern culture [32].

In the development of traditional village tourism, culture is the soul and resources are the body [33]. The tourism resources of traditional villages include the local environment, village shape, human landscape, and local culture [34–37], which embody the history, culture, and artistic value of traditional villages [38]. This precious heritage wins the favor of tourists. With the emerging demand from niche markets of tourism, new businesses spring up in the tourism industry. For example, the sketching tourism, research tourism, sports tourism, and gourmet tourism in traditional villages are very popular among tourists [39, 40]. Being the subjects of traditional village tourism, tourists attach the greatest importance to the authenticity of architecture and cultural relics [41, 42], and their primary travel motives are experiencing traditional culture, sightseeing, and family trips [43–46]. The existing studies on the niche markets of tourism in traditional villages mostly discuss the consumption behaviors of overseas tourists, female tourists, and sketching tourists [47–49], as well as the trend and seasonal variation of tourism demand [50]. However, there is not yet any discovery about the niche markets, value preferences, or intergenerational differences of traditional village tourists of different generations.

2.2. Theory of Generations. Based on anthropology, Manheim [51] proposed the theory of generations, which holds that people born in the same period have the same position in the historical process of social development and form common values, thinking patterns, and behavioral features, as they experience the same major external events. The theory of generations is composed of three progressive concepts: the site of generation, the realistic sense of generation, and the intrageneration division. This theory has been further verified, extended, and improved by many scholars [52–54], who found that different generations differ markedly; the intrageneration values are relatively stable and directly affect future behaviors and attitudes [55]; intragenerational personalities and features are predictable [6].

Foreign researchers have relied on the theory of generations for empirical analysis of tourist preferences for consumption behaviors and intergenerational differences. Most of them tackled the behaviors and preferences of tourists in two or three generations [6, 56–63]. In recent years, researchers from countries and regions like South Korea, the United States, and Taiwan have explored the intergenerational differences in the travel behaviors of strait tourists from Chinese mainland [4]. Nevertheless, the research results are not necessarily valid, because the researchers adopted the division rules for foreign generations and did not know much about the situation in Chinese mainland. In China, the studies on the generational behaviors of domestic tourism consumers mainly deal with the behavior differences between tourists born in the 1980s and 1990s [64, 65]; the differences in the impression of destinations between the tourism consumers born in the 1950s, 1960s, and 1970s [66]; and the description of the behavior differences between tourism consumers across generations [5, 67], female tourism consumers [68], domestic tourism consumers in scenic spots [69], and tourists searching for tourism information [70]. However, the sample sizes are relatively small, without many samples on the national scale.

3. Research Design

This paper designs a questionnaire survey based on hard laddering. All the questions were extracted from the literature and in-depth interviews (Table 1). In 2019, the authors

Table 1: The As, Cs, and Vs of traditional village tourists born in the 1960s, 1970s, 1980s, and 1990s.

Attributes (As)	Consequences (Cs)	Values (Vs)
A1, ancient architecture	C1, culinary experience	V1, inner harmony
A2, water system of traditional village	C2, harmony between man and nature	V2, satisfaction
A3, local delicacies	C3, gaining experience	V3, self-improvement
A4, environment of traditional village	C4, ecological protection	V4, sense of belonging
A5, local traditional culture	C5, spirit of workmanship	V5, wisdom
A6, engravings/couplets	C6, wisdom of the ancients	V6, sense of security
A7, lifestyle of residents	C7, cultural experience and inheritance	V7, beautiful world
A8, family tours	C8, picturesque landscape	V8, long-lasting life
A9, native products	C9, escaping from reality	V9, cleanness
A10, layout of traditional village	C10, idyllic life	V10, joy
A11, natural landscape around traditional village	C11, neatness	—
—	C12, beauty	—
—	C13, shopping experience	—
—	C14, novel experience	—
—	C15, lodging experience	—
—	C16, photo taking and sharing	—

The categories of "attribute, consequence, and value" are determined based on the first-hand data obtained from the soft-step progressive interview.

conducted a stratified sampling [71] on weijuan.com. Taking generation, gender, and residence as control variables, the questionnaire survey targets 60s, 70s, 80s, and 90s tourists who had traveled to traditional villages in the previous 12 months. The occupation and education of the respondents were also taken into account. A total of 642 questionnaires were recovered, including 600 valid ones (Table 2).

The data analysis was carried out in four steps, as suggested by Reynolds and Olson [72], Gong [73], Kim et al. [74], and Richter and Bokelmann [75] for hard laddering. The correlation between attribute (A) and consequence (C) was obtained through questionnaire survey. The questionnaire is divided into three layers to design questions. First, visitors are asked to choose the attribute motivation of rural tourism, then to choose the possible results caused by the attribute motivation, and finally to choose the value motivation caused by the results. In the questionnaire, there is a blank item after each C_i item, and the respondents are asked to fill in the result caused by A_i (multiple choices can be made), so as to establish a connection. Firstly, the frequency of each attribute (A) motive, consequence (C) motive, and value (V) motive was counted, so it was with the number of consequence-value connections. Secondly, the As, Cs, and Vs were tabulated, and the frequency of A-C and C-V connections was quantified. We counted the occurrence times of A_i, C_i, and V_i in the questionnaire, respectively, to calculate the frequency. According to the results of the questionnaire, the frequency of the occurrence of A_i was marked as N_{Ai}, and then the number of the results C_j brought by A_i (the data obtained from the questionnaire) was counted and marked as n_{Cj}, so the quantitative relationship between A_i and C_j could be expressed as n_{cj}/N_{Ai}. The quantitative relationship between C and V was similar to this. Thirdly, the cut-off point for analysis was determined based on the quantified data of A-C and C-V connections. Finally, the data above the cut-off point was plotted into a hierarchical value map (HVM) of MEC value chains. Each row of the HVM was analyzed, revealing the value preferences and intergenerational differences of traditional village tourists.

4. Results

According to the survey data, two interconnected matrices were set up for the A-C connections (Table 3) and C-V connections (Table 4) selected by these respondents, and the cut-off point of the analysis was set to 50% (any data greater than or equal to 49.5% were treated as equal to 50%). The data above the cut-off point of 50% were selected to build the HVM, forming MEC value chains (A-C-V). In the HVM, the connections between A, C, and V are shown in percentages, reflecting the proportion of tourists to each connection [75]. The percentages help to determine the important Cs and Vs [76]. According to the criteria of the 50% cutoff point, 75 or more of the 150 questionnaires selected attribute motivation to be marked, respectively, as follows: A4, traditional village environment atmosphere ($n = 101/67.3\%$); A5, local traditional culture ($n = 96/64.0\%$, 64.0%); A3, local characteristic food ($n = 95/63.3\%$, 63.3%) motivation; A1, attribute motivation of ancient building and B&B ($n = 88/58.7\%$, 58.7%); A10, pattern of traditional villages ($n = 76/50.7\%$, 50.7%).

4.1. MEC Value Chains of the Post-60s Traditional Village Tourists. A total of 150 post-60s tourists were surveyed. According to the survey data, two interconnected matrices were set up for the A-C connections (Table 3) and C-V connections (Table 4) selected by these respondents. The number of A-C connections (Table 5) and C-V connections (Table 6) being selected by the respondents was counted and used to prepare the HVM for the MEC value chains (A-C-V) of the post-60s tourists (Figure 1).

Based on 50% of the cut-off point to build hierarchical value map (HVM), six MEC value chains have been formed, including three attributes such as ancient building, local traditional culture, and local characteristics food; four consequences such as the wisdom of the ancients, spirit, culture and heritage, and dining experience; and four values such as wisdom, self-improvement, satisfaction, and happiness.

Table 2: Demographic statistics of respondents in traditional villages ($n = 600$).

Population information		Percentage
Gender	Male	52.0
	Female	48.0
Generation	Post-60s	25.0
	Post-70s	25.0
	Post-80s	25.0
	Post-90s	25.0
Education	Junior high school	2.0
	Senior high school or secondary technical/vocational school	19.0
	Undergraduate college/junior college	75.0
	Graduate school and above	4.0
Occupation	Civil servant	5.8
	Manager of enterprise/public institution	27.0
	Staff member/worker	40.2
	Self-employed	11.2
	Education/research/cultural practitioner	9.3
	Freelancer	4.0
	Student	1.5
	Others	1.0

Table 3: C motives of the post-60s traditional village tourists.

A-C	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	n
C1	—	—	65	—	—	—	—	2	18	—	—	85
C2	19	15	—	15	16	3	—	3	—	24	23	118
C3	34	25	37	23	39	23	17	10	9	24	10	251
C4	15	31	10	40	19	11	15	3	7	26	28	205
C5	54	18	—	21	18	25	9	3	2	17	6	173
C6	55	22	15	24	35	18	12	2	1	21	7	212
C7	30	17	28	34	48	19	31	5	8	31	12	263
C8	22	32	—	36	20	—	—	5	—	18	33	166
C9	11	11	—	—	17	13	11	3	—	—	7	73
C10	18	19	31	41	25	13	36	3	6	25	25	242
C11	16	13	23	30	17	13	18	3	5	9	13	160
C12	8	17	11	19	10	7	9	2	3	9	22	117
C13	—	—	12	12	—	—	8	3	22	—	—	114
C14	14	10	17	19	24	8	17	2	12	17	13	153
C15	8	5	—	10	10	3	16	1	3	13	—	138
C16	9	4	17	14	10	4	6	1	8	9	18	100

n is the number of connections. C_{ij} is the amount of C_j caused by A_i.

Table 4: V motives of the post-60s traditional village tourists.

C-V	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
C1	25	60	—	—	9	10	—	—	—	41
C2	36	33	21	33	16	23	—	34	—	17
C3	22	52	58	30	46	27	42	24	—	23
C4	—	—	—	30	32	39	76	53	55	25
C5	21	39	53	24	57	—	39	27	—	10
C6	—	37	—	35	82	—	—	—	—	30
C7	—	—	75	57	62	33	—	—	—	41
C8	29	48	22	22	30	19	63	35	—	17
C9	26	26	—	28	—	29	—	—	—	17
C10	56	48	—	44	20	—	73	56	40	29
C11	—	42	—	—	—	33	—	—	70	—
C12	28	28	—	—	—	—	52	29	31	21
C13	11	32	—	19	—	—	—	—	12	23
C14	20	47	—	15	28	23	27	16	—	25
C15	14	27	—	16	—	32	—	—	18	11
C16	11	32	—	—	—	—	—	—	—	34
n	299	551	229	353	382	268	372	274	226	364

n shows the number of occurrences of C_i to V_j.

Table 5: A-C connections of the post-60s traditional village tourists (cutoff point = 50%).

A-C	A1	A3	A5
C1	—	65/95 (68.4%)	—
C5	54/88 (61.4%)	—	—
C6	55/88 (62.5%)	—	—
C7	—	—	48/96 (50.6%)

Percentage = n/N, where N is the total number of respondents recognizing an A (A_i) and n is the number of respondents agreeing that A (A_i) can produce a C (C_i).

Table 6: C-V connections of the post-60s traditional village tourists (cutoff point = 50%).

C-V	V2	V3	V5	V10
C1	60/75 (80.0%)	—	—	41/75 (54.7%)
C5	—	53/104 (51.0%)	57/104 (54.8%)	—
C6	—	—	82/103 (79.6%)	—
C7	—	75/122 (61.5%)	62/12 (50.8%)	—

Percentage = n/N, where N is the total number of respondents recognizing a C (C_i) and n is the number of respondents agreeing that C (C_i) can reflect a V (V_i).

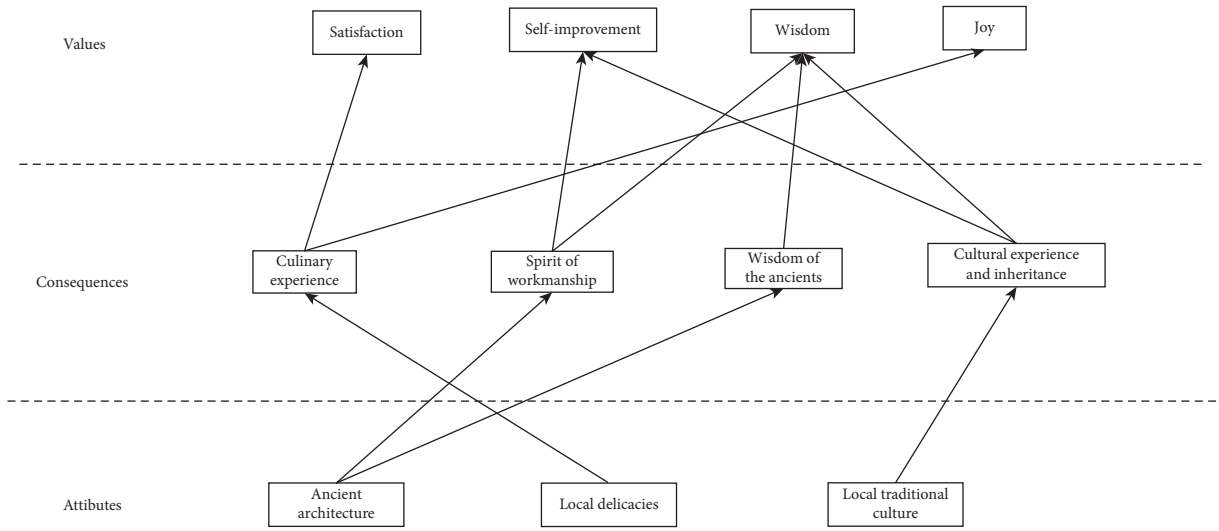

Figure 1: The HVM of the post-60s tourists to traditional villages (including correlated factors only) (cutoff point = 50%).

According to relevant literature, 50% cut-off point is used to construct HVM diagram, including two aspects: 1. If the total number of respondents choosing A, C, or V is less than 50% (i.e., 75 respondents), 50% is lower than the cut-off point. 2. The proportion of association relationship in A-C matrix, N_{Cj}/N_{Ai}, is lower than 50%, and it is also lower than 50% of the cut-off point. The above two cases are not identified in the HVM diagram, and only the association relationship above 50% is listed in the HVM diagram to improve the typicality of MEC chain. For example, only A1, A3, A4, and A5 have more than 75 respondents selected for attribute A, so other attributes are not marked in the HVM diagram. The value of N_{Cj}/N_{Ai} greater than 50% is C1 (A3-C1), C5 (A1-C5), C6 (A1-C6), C7 (A5-C7). Other paths are not marked.

The V of job comes from the pursuit of the post-60s tourists for the A of local delicacies and the C of culinary experience. In traditional Chinese culture, food is the paramount necessity of the people. Since the beginning of the 21st century, gourmet tourism has become the main travel motive for tourists [77, 78]. Tourists perceive the culture of destinations by experiencing food, which affects the travel experience [79]. Through the culinary experience of enjoying local delicacies, the post-60s tourists gain physical and psychological Vs like joy and satisfaction (local delicacies—culinary experience—satisfaction).

HVM results show that the V of wisdom stems from the pursuit of the post-60s tourists for spirit of workmanship, wisdom of the ancients, and cultural experience and inheritance. For those born in the 1960s, the traditional culture of rural tourism destinations can bring them cultural experience, and the ancient buildings can help them appreciate the craftsman spirit and the wisdom of the ancients, which are conducive to enhancing their cultural identity and acquiring more knowledge. The post-60s tourists are nurtured by traditional Chinese culture. Patriotism and heroism are their typical values [80]. Our findings are consistent with the literature. The nostalgic feelings encourage them to travel to traditional villages. Traveling through the ancient architecture, the tourists perceive the wisdom of the ancients in

planning and design and the spirit of workmanship exemplified by the builders. Such an experience satisfies their pursuit of the V of wisdom.

In addition, the post-80s tourists, like those born in the 1970s, realize the V of sense of belonging through the pursuit of the A of local traditional culture and the C of cultural experience, and inheritance exploration and learning are important motives for tourists [81]. Apart from the spirit of workmanship, the post-60s tourists learn the knowledge about traditional culture and ancient architecture and broaden their horizons [82–84]. In this way, they realize the V of self-improvement.

4.2. MEC Value Chains of the Post-70s Traditional Village Tourists. A total of 150 post-70s tourists were surveyed. According to the survey data, two interconnected matrices were set up for the A-C connections (Table 7) and C-V connections (Table 8) selected by these respondents. The number of A-C connections (Table 9) and C-V connections (Table 10) being selected by the respondents was counted and used to prepare the HVM for the MEC value chains (A-C-V) of the post-70s tourists (Figure 2).

It can be observed that the post-70s tourists pursue five As (ancient architecture, environment of traditional village, natural landscape around traditional village, local traditional culture, and local delicacies), six Cs (wisdom of the ancients, ecological protection, idyllic life, picturesque landscape, cultural experience and inheritance, and culinary experience), and seven Vs (wisdom, beautiful world, inner harmony, self-improvement, satisfaction, joy, and sense of belonging), which constitute eleven MEC value chains.

Like the post-60s tourists, the post-70s tourists realize the Vs of satisfaction and joy through the pursuit of the A of local delicacies and the C of culinary experience.

The V of wisdom stems from the pursuit of the post-70s tourists for the A of ancient architecture and the C of wisdom of the ancients. Going through the reform and opening-up, the post-70s tourists experienced the enrollment expansion of colleges and employment. Through diligent learning and hard work, these tourists achieved their goals of work, income, and life [85]. As a result, they generally believe in "knowledge can change your fate." Meanwhile, the post-70s tourists are deeply influenced by traditional culture in society and family. Therefore, they pay more attention to the V of wisdom embodied in ancient architecture, during travel to traditional villages.

The V of self-improvement originates from the pursuit of the post-70s tourists for the A of local traditional culture and the C of cultural experience and inheritance. The Chinese education advocates "reading ten thousand books and traveling ten thousand miles." Both reading and traveling are important for human development. Traveling can improve the capacity of the tourists [86] and sublimate the inner motives to higher needs, thereby promoting personal development [87]. The post-70s tourists believe that, through traditional village tourism, they can fully and deeply understand and recognize local traditional culture and customs, acquire new knowledge, broaden their horizons, and gain experience. In other words, travel to traditional villages both enriches their lives and increases their knowledge [82–84], thus helping them realize the V of self-improvement. At the same time, the post-70s tourists have a higher spiritual demand for traditional culture [88]. They personally feel the importance of inheriting local traditional culture to the development of the Chinese culture. This feeling results in the confidence in their culture, and a strong sense of belonging (local traditional culture—cultural experience and inheritance—sense of belonging).

The V of beautiful world derives from the post-70s tourists' pursuit of the As of environment of traditional village and natural landscape around traditional village and the Cs of ecological protection, idyllic life, and picturesque landscape. In traditional Chinese culture, nature is the source of human life, and tourism bridges human and nature [89]. Besides, traditional Chinese philosophy emphasizes

Table 7: C motives of the post-70s traditional village tourists.

A-C	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	*n*
C1	—	—	89	—	—	—	—	6	25	—	—	120
C2	24	27	—	26	19	9	—	2	—	27	34	168
C3	31	17	34	19	48	9	22	4	13	17	14	228
C4	22	29	18	54	24	6	13	3	5	20	39	233
C5	38	15	—	14	20	21	7	2	6	29	6	158
C6	50	23	16	22	35	23	19	3	8	31	11	241
C7	23	16	18	30	63	11	27	4	8	24	17	241
C8	15	23	—	40	18	—	—	2	—	12	58	168
C9	7	10	—	—	13	5	5	1	—	—	10	51
C10	19	30	34	50	28	3	34	4	14	22	44	282
C11	11	15	11	25	6	4	8	3	1	12	17	113
C12	8	17	9	19	10	9	6	1	5	10	26	120
C13	—	—	13	6	—	—	1	1	28	—	—	49
C14	15	13	29	12	29	4	26	5	12	16	8	169
C15	8	6	—	13	9	—	29	—	6	8	—	79
C16	10	11	23	15	15	2	7	1	14	13	21	132

n is the number of connections.

Table 8: V motives of the post-70s traditional village tourists.

C-V	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
C1	34	78	—	—	17	16	—	—	—	56
C2	65	35	33	35	28	25	—	35	—	26
C3	33	49	69	29	37	17	37	20	—	26
C4	—	—	—	33	33	40	86	46	56	32
C5	23	27	48	23	58	—	31	30	—	16
C6	—	41	—	36	86	—	—	—	—	32
C7	—	—	74	61	57	28	—	—	—	42
C8	46	29	22	26	11	16	87	41	—	33
C9	21	11	—	16	—	13	—	—	—	13
C10	61	37	—	45	21	—	67	45	33	41
C11	—	34	—	—	—	27	—	—	50	—
C12	31	23	—	—	—	—	51	27	27	28
C13	17	25	—	10	—	—	—	—	8	24
C14	36	53	—	32	23	23	24	20	—	40
C15	21	28	—	24	—	22	—	—	27	18
C16	15	49	—	—	—	—	—	—	—	46
n	403	519	246	370	371	227	383	264	201	473

n is the number of connections.

Table 9: A-C connections of the post-70s traditional village tourists (cutoff point = 50%).

A-C	A1	A3	A4	A5	A9	A11
C1	—	89/104 (85.6%)	—	—	—	—
C4	—	—	54/94 (57.4%)	—	—	—
C6	50/78 (64.1%)	—	—	—	—	—
C7	—	—	—	63/107 (58.9%)	—	—
C8	—	—	—	—	—	58/87 (66.7%)
C10	—	—	50/94 (53.2%)	—	—	44/87 (50.6%)

Percentage = n/N, where N is the total number of respondents recognizing an A (A_i) and n is the number of respondents agreeing that A (A_i) can produce a C (C_i).

Table 10: C-V connections of the post-70s traditional village tourists (cutoff point = 50%).

C-V	V1	V2	V3	V4	V5	V7	V10
C1	—	78/99 (78.8%)	—	—	—	—	56/99 (56.6%)
C4	—	—	—	—	—	86/116 (74.1%)	—
C5	—	—	—	—	58/101 (57.4%)	—	—
C6	—	—	—	—	86/109 (78.9%)	—	—
C7	—	—	74/118 (62.7%)	61/118 (51.7%)	—	—	—
C8	—	—	—	—	—	87/103 (84.5%)	—
C10	61/117 (52.1%)	—	—	—	—	67/117 (57.3%)	—

Percentage = n/N, where N is the total number of respondents recognizing a C (C_i) and n is the number of respondents agreeing that C (C_i) can reflect a V (V_i).

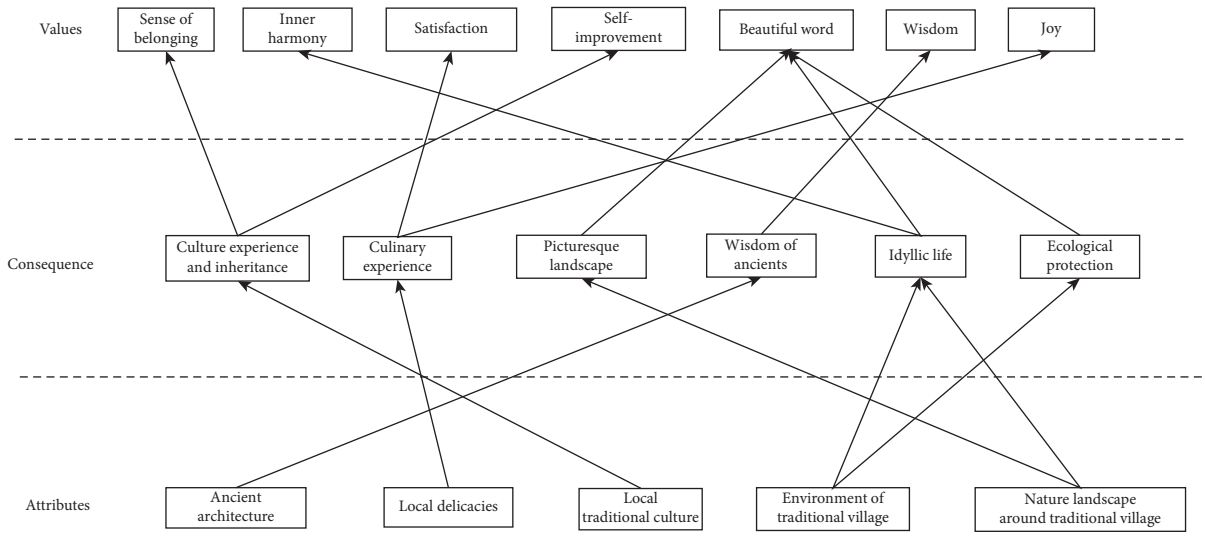

Figure 2: The HVM of the post-70s tourists to traditional villages (including correlated factors only) (cutoff point = 50%).

that the harmony between human and nature, human and society, and body and soul can promote spiritual cultivation [90]. The environment, surrounding natural landscape, and idyllic life of traditional villages reflect the philosophy of ecological protection and produce a beautiful environment with a picturesque landscape, which satisfies the appreciation and love of the post-70s tourists for human-nature harmony and beautiful sceneries, as well as their pursuit of a beautiful world [82, 83, 91, 92]. Traveling in such a picturesque landscape helps to cultivate their spirits.

Most post-70s tourists live in cities. They long to temporarily escape from the environment of daily life and work [93]. The tranquil environment (environment of traditional village—idyllic life—inner harmony) and natural landscape (natural landscape around traditional village—idyllic life—inner harmony) of traditional villages can relieve the pressure of work and life [94] and ensure the harmony between human and nature [95], realizing the V of inner harmony.

4.3. MEC Value Chains of the Post-80s Traditional Village Tourists. A total of 150 post-80s tourists were surveyed. According to the survey data, two interconnected matrices were set up for the A-C connections (Table 11) and C-V connections (Table 12) selected by these respondents. The number of A-C connections (Table 13) and C-V connections (Table 14) being selected by the respondents was counted and used to prepare the HVM for the MEC value chains (A-C-V) of post-60s tourists (Figure 3).

Table 11: C motives of post-80s traditional village tourists.

A-C	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	n
C1	—	—	93	—	—	—	—	4	46	—	—	143
C2	37	23	—	29	17	10	—	3	—	18	32	169
C3	31	21	29	25	47	14	16	5	13	25	23	249
C4	30	38	15	54	21	2	23	5	9	17	47	261
C5	51	14	—	15	14	11	8	2	10	23	7	155
C6	40	25	16	21	41	15	16	3	8	23	13	221
C7	38	26	25	29	75	19	23	9	21	22	16	303
C8	18	28	—	42	17	—	—	5	—	14	49	173
C9	5	11	—	—	11	—	6	3	—	—	10	46
C10	21	27	31	57	24	4	42	6	16	18	40	286
C11	9	18	22	23	9	1	13	2	6	12	26	141
C12	15	20	16	27	11	2	10	4	5	8	36	154
C13	—	—	23	4	—	—	6	2	36	—	—	71
C14	23	13	28	11	20	2	16	10	16	9	11	159
C15	21	10	—	24	20	3	26	3	7	15	—	129
C16	23	12	44	24	11	7	9	5	16	15	29	195

n is the number of connections.

Table 12: V motives of post-80s traditional village tourists.

C-V	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
C1	31	90	—	—	10	17	—	—	—	73
C2	60	25	29	41	19	20	—	31	—	36
C3	32	42	78	21	51	19	37	19	—	25
C4	—	—	—	34	22	37	85	53	53	30
C5	28	32	49	21	69	—	35	19	—	19
C6	—	30	—	50	96	—	—	—	—	30
C7	—	—	83	66	69	40	—	—	—	38
C8	61	37	22	22	14	26	88	37	—	48
C9	14	17	—	16	—	19	—	—	—	15
C10	54	62	—	55	15	—	84	51	26	50
C11	—	33	—	—	—	37	—	—	66	—
C12	38	27	—	—	—	—	69	30	35	35
C13	8	43	—	9	—	—	—	—	12	37
C14	21	51	—	20	27	23	35	21	—	43
C15	27	37	—	37	—	50	—	—	31	32
C16	25	66	—	—	—	—	—	—	—	70
n	399	592	261	392	392	288	433	261	223	581

n is the number of connections.

Table 13: A-C connections of post-80s traditional village tourists (cutoff point = 50%).

A-C	A1	A2	A3	A4	A5	A11
C1	—	—	93/112 (83.0%)	—	—	—
C4	—	38/76 (50.0%)	—	54/102 (52.9%)	—	—
C5	51/93 (54.8%)	—	—	—	—	—
C7	—	—	—	—	75/113 (66.4%)	—
C8	—	—	—	—	—	49/84 (58.3%)
C10	—	—	—	57/102 (55.9%)	—	—

Percentage = n/N, where N is the total number of respondents recognizing an A (A_i) and n is the number of respondents agreeing that A (A_i) can produce a C (C_i).

It can be observed that the post-80s tourists pursue six As (ancient architecture, local traditional culture, environment of traditional village, natural landscape around traditional village, water system of traditional village, and local delicacies), six Cs (spirit of workmanship, cultural experience and inheritance, ecological protection, idyllic life, picturesque landscape, and culinary experience), and seven Vs (wisdom, beautiful world, inner harmony, self-improvement, satisfaction, joy, and sense of belonging), which constitute seven MEC value chains.

Like the post-60s and post-70s tourists, the post-80s tourists realize the Vs of satisfaction and joy through the pursuit of the A of local delicacies and the C of culinary experience.

Table 14: C-V connections of post-80s traditional village tourists (cutoff point = 50%).

C-V	V1	V2	V3	V4	V5	V7	V10
C1	—	90/103 (87.4%)	—	—	—	—	73/103 (70.9%)
C4	—	—	—	—	—	85/121 (70.2%)	—
C5	—	—	—	—	69/107 (64.5%)	—	—
C7	—	—	83/130 (63.8%)	66/130 (50.8%)	69/130 (53.1%)	—	—
C8	61/111 (55.0%)	—	—	—	—	88/111 (79.3%)	—
C10	—	62/123 (50.4%)	—	—	—	84/123 (68.3%)	—

Percentage = n/N, where N is the total number of respondents recognizing a C (C_i) and n is the number of respondents agreeing that C (C_i) can reflect a V (V_i).

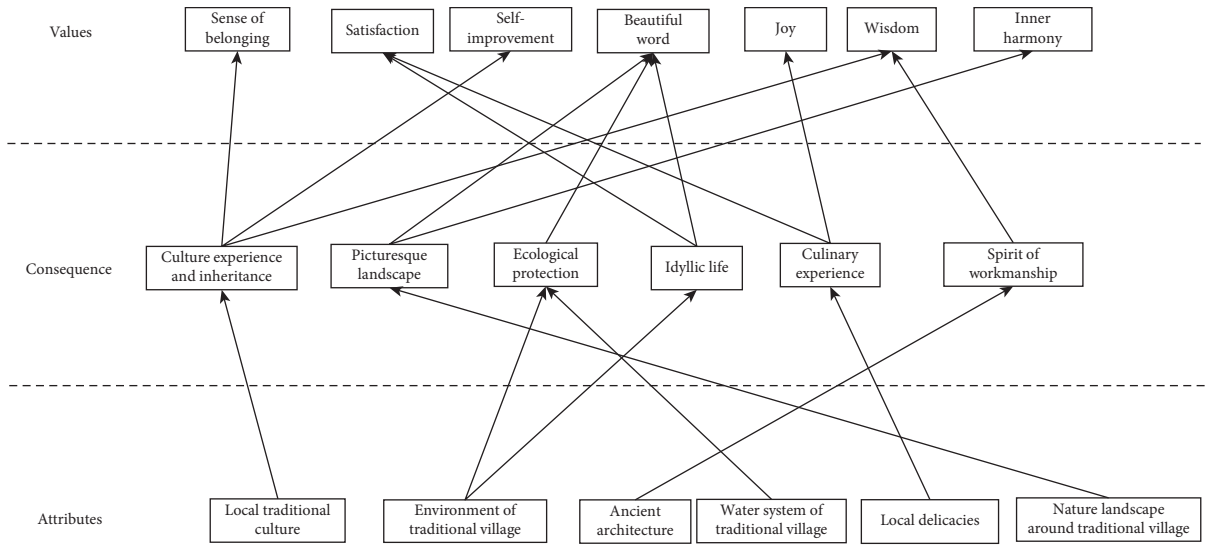

Figure 3: The HVM of post-80s tourists to traditional villages (including correlated factors only) (cutoff point = 50%).

The V of wisdom comes from the pursuit of the post-80s tourists for the As of ancient architecture and local traditional culture and the Cs of spirit of workmanship and cultural experience and inheritance. The post-80s tourists have the same Vs as the post-60s and post-70s tourists but differ from the latter in As and Cs.

The post-80s tourists achieved personal success through hard work and diligent learning [96]. Like the post-70s tourists, they believe that knowledge has the power to change one's fate and are deeply influenced by traditional culture. During travel through traditional villages, the post-80s tourists highlight the V of wisdom reflected by the spirit of workmanship among the builders of ancient architecture and perceive the V of wisdom of the ancestors of the Chinese nation in the creation and inheritance of the traditional culture.

In addition, the post-80s and post-70s tourists both realize the value of "belonging" (V4) by pursuing the attribute of "local traditional culture" (A5) and the result of "cultural experience and inheritance" (C7). In other words, the post-80s and post-70s tourists share the same MEC value chain (A5⟶C7⟶V4). Similarly, tourists born in the 60s and 70s have realized the value of "self-improvement" (V3) by pursuing the attribute of "local traditional culture" (A5) and the result of "cultural experience and inheritance" (C7). The post-60s and post-70s share the same MEC value chain (A5⟶C7⟶V3).

The V of beautiful world stems from the post-80s tourists' pursuit of the As of environment of traditional village, natural landscape around traditional village, and water system of traditional village, as well as the Cs of ecological protection, idyllic life, and picturesque landscape. In their views, the water system, environment, and surrounding natural landscape of traditional villages, plus the idyllic life of residents, protect the eco-environment and nurture a beautiful environment with picturesque landscape, providing them with the chance to realize the V of beautiful world [82, 83, 91, 92]. Hence, the post-80s tourists can cultivate their spirit by traveling to traditional villages.

The post-80s tourists share the same motive of escaping from daily routines as the post-70s tourists [93]. The environment of traditional village and natural landscape around traditional village (environment of traditional village—idyllic life—inner harmony; natural landscape around traditional village—picturesque landscape—inner harmony) set the stage for an idyllic life in the picturesque landscape, which relieves pressure [94] and realizes the V of inner harmony.

4.4. MEC Value Chains of the Post-90s Traditional Village Tourists. A total of 150 post-90s tourists were surveyed. According to the survey data, two interconnected matrices were set up for the A-C connections (Table 15) and C-V connections (Table 16) selected by these respondents. The

Table 15: C motives of post-90s traditional village tourists.

A-C	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	n
C1	—	—	96	—	—	—	—	1	40	—	—	137
C2	31	20	—	33	15	2	—	6	—	19	37	163
C3	37	20	31	31	47	9	30	5	12	23	16	261
C4	26	30	11	60	25	4	22	7	7	23	39	254
C5	48	12	—	22	24	7	12	4	7	32	8	176
C6	37	15	18	33	40	14	26	3	8	35	18	247
C7	37	31	23	35	65	8	31	11	12	26	19	298
C8	11	27	—	37	15	—	—	8	—	18	61	177
C9	6	7	—	—	15	1	10	6	—	—	9	54
C10	27	31	35	49	19	4	46	7	18	25	54	315
C11	15	15	24	33	14	3	21	4	11	14	18	172
C12	16	20	18	38	14	3	22	1	8	16	32	188
C13	—	—	18	13	—	—	8	6	32	—	—	77
C14	18	14	27	16	35	4	16	6	17	13	14	180
C15	22	11	—	20	12	2	24	3	5	10	—	109
C16	20	18	43	23	23	5	20	8	14	21	36	231

n is the number of connections.

Table 16: V motives of post-90s traditional village tourists.

C-V	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
C1	31	88	—	—	18	15	—	—	—	69
C2	51	41	37	29	27	26	—	33	—	32
C3	39	62	81	27	52	34	34	17	—	33
C4	—	—	—	33	37	41	79	55	54	39
C5	31	34	53	28	75	—	28	20	—	20
C6	—	51	—	47	95	—	—	—	—	32
C7	—	—	95	61	73	42	—	—	—	51
C8	45	35	30	23	27	25	85	48	—	40
C9	23	16	—	21	—	22	—	—	—	16
C10	66	46	—	52	25	—	82	58	36	50
C11	—	50	—	—	—	47	—	—	62	—
C12	30	41	—	—	—	—	70	43	33	49
C13	19	38	—	16	—	—	—	—	14	35
C14	26	51	—	26	30	19	36	23	—	44
C15	25	33	—	31	—	33	—	—	32	35
C16	28	68	—	—	—	—	—	—	—	65
n	414	654	296	394	459	304	414	297	231	610

n is the number of connections.

number of A-C connections (Table 17) and C-V connections (Table 18) being selected by the respondents was counted and used to prepare the HVM for the MEC value chains (A-C-V) of post-90s tourists (Figure 4).

It can be observed that the post-90s tourists pursue six As (ancient architecture, local traditional culture, environment of traditional village, natural landscape around traditional village, lifestyle of residents, and local delicacies), six Cs (spirit of workmanship, cultural experience and inheritance, ecological protection, picturesque landscape, idyllic life, and culinary experience), and six Vs (wisdom, beautiful world, inner harmony, self-improvement, satisfaction, and joy), which constitute twelve MEC value chains.

Like the previous three generations, the post-90s tourists realize the Vs of satisfaction and joy through the pursuit of the A of local delicacies and the C of culinary experience.

Similar to the post-60s and post-80s tourists, the post-90s tourists achieve the V of wisdom through the search for the As of ancient architecture and local traditional culture, as well as the Cs of spirit of workmanship and cultural experience and inheritance. These tourists are pragmatic, innovative, and aggressive [97, 98]. They are curious about the unknown and good at learning [99]. The ancient architecture embodies exquisite craftsmanship, superb technology, and wisdom of the ancestors of the Chinese nation in the creative culture. All these factors inspire the post-90s tourists to have a deeper understanding of the wisdom in the spirit of workmanship among ancient architecture builders and the wisdom of the ancestors. Moreover, the post-90s tourists can acquire knowledge through travel and realize the V of self-improvement (ancient architecture—spirit of workmanship—self-improvement; local traditional culture—cultural experience and inheritance—self-improvement).

For the post-90s tourists, the V of beautiful world originates from the As of environment of traditional village and natural landscape around traditional village and from

Table 17: A-C connections of post-90s traditional village tourists (cutoff point = 50%).

A-C	A1	A3	A4	A5	A7	A11
C1	—	96/121 (85.7%)	—	—	—	—
C4	—	—	60/100 (60.0%)	—	—	—
C5	48/82 (58.5%)	—	—	—	—	—
C7	—	—	—	65/101 (64.4%)	—	—
C8	—	—	—	—	—	61/90 (61.8%)
C10	—	—	—	—	46/79 (58.2%)	54/90 (60.0%)

Percentage = n/N, where N is the total number of respondents recognizing an A (A_i) and n is the number of respondents agreeing that A (A_i) can produce a C (C_i).

Table 18: C-V connections of post-90s traditional village tourists (cutoff point = 50%).

C-V	V1	V2	V3	V5	V7	V10
C1	—	88/101 (87.1%)	—	—	—	69/101 (68.3%)
C4	—	—	—	—	79/116 (68.1%)	39
C5	—	—	53/104 (51.0%)	75/90 (72.1%)	—	—
C7	—	—	95/132 (72.0%)	73/132 (55.3%)	—	—
C8	—	—	—	—	85/106 (80.2%)	—
C10	66/126 (52.4%)	—	—	—	82/126 (65.1%)	—

Percentage = n/N, where N is the total number of respondents recognizing a C (C_i) and n is the number of respondents agreeing that C (C_i) can reflect a V (V_i).

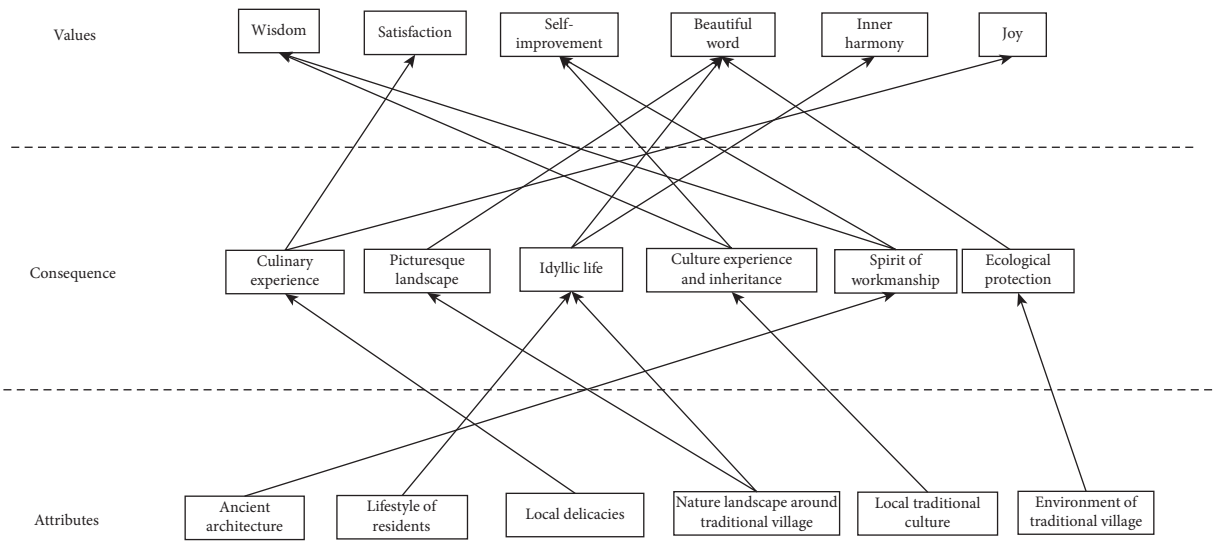

Figure 4: The HVM of post-90s tourists to traditional villages (including correlated factors only) (cutoff point = 50%).

Table 19: The MEC value chains of traditional village tourists.

	Attributes	Consequences	Values	60s	70s	80s	90s
MEC1	Ancient architecture	Wisdom of the ancients	Wisdom	✓	✓	—	—
MEC2	Ancient architecture	Spirit of workmanship	Wisdom	✓	—	✓	✓
MEC3	Local traditional culture	Cultural experience and inheritance	Wisdom	✓	—	✓	✓
MEC4	Environment of traditional village	Ecological protection	Beautiful world	—	✓	✓	✓
MEC5	Environment of traditional village	Idyllic life	Beautiful world	—	✓	✓	—
MEC6	Natural landscape around traditional village	Picturesque landscape	Beautiful world	—	✓	✓	✓
MEC7	Natural landscape around traditional village	Idyllic life	Beautiful world	—	✓	—	✓
MEC8	Water system of traditional village	Ecological protection	Beautiful world	—	—	✓	—
MEC9	Lifestyle of residents	Idyllic life	Beautiful world	—	—	—	✓
MEC10	Environment of traditional village	Idyllic life	Inner harmony	—	✓	✓	—
MEC11	Natural landscape around traditional village	Idyllic life	Inner harmony	—	✓	—	✓

Table 19: Continued.

	Attributes	Consequences	Values	60s	70s	80s	90s
MEC12	Natural landscape around traditional village	Picturesque landscape	Inner harmony	—	—	✓	—
MEC13	Lifestyle of residents	Idyllic life	Inner harmony	—	—	—	✓
MEC14	Ancient architecture	Spirit of workmanship	Self-improvement	✓	—	—	✓
MEC15	Local traditional culture	Cultural experience and inheritance	Self-improvement	✓	✓	✓	✓
MEC16	Local delicacies	Culinary experience	Satisfaction	✓	✓	✓	✓
MEC17	Local delicacies	Culinary experience	Joy	✓	✓	✓	✓
MEC18	Local traditional culture	Cultural experience and inheritance	Sense of belonging	—	✓	✓	—

the Cs of ecological protection and picturesque landscape. These As and Cs are commonly pursued by the previous three generations. Besides, this V also stems from the A of idyllic life yearned by the post-70s tourists. Out of curiosity, the post-90s tourists choose to experience the lifestyle of residents in traditional villages and find that the idyllic lifestyle of "getting up at sunrise and going to bed at sunset" is exactly what they have imagined about a beautiful world (lifestyle of residents—idyllic life—beautiful world).

In the meantime, as the previous two generations, the post-90s tourists are eager to temporarily escape the environment of daily life and work [99] and have a taste for the rural lifestyle [100]. The surrounding natural environment of traditional villages and the lifestyle of residents jointly create a slow and idyllic life, which eases the tourists' stress [94] and offers the V of inner harmony (lifestyle of residents—idyllic life—inner harmony; natural landscape around traditional village—idyllic life—inner harmony).

5. Conclusions and Discussion

5.1. Conclusions. According to the HVMs of traditional village tourists born in the 1960s, 1970s, 1980s, and 1990s, there are 36 MEC value chains of 18 classes for traditional village tourists (Table 19).

5.1.1. Intergenerational Preferences and Differences of Vs. The post-60s, post-70s, post-80s, and post-90s tourists pursue seven Vs, i.e., beautiful world, inner harmony, wisdom, self-improvement, satisfaction, joy, and sense of belonging. The four generations of tourists share the following MEC value chains: local delicacies—culinary experience—satisfaction (MEC16); local delicacies—culinary experience—joy (MEC17); local traditional culture—cultural experience and inheritance—self-improvement (MEC15). Therefore, satisfaction, self-improvement, and joy are the Vs commonly pursued by the four generations. Furthermore, the self-improvement realized through local traditional culture is a pursuit of culture, while the satisfaction and joy brought by local delicacies are Vs on spiritual level. The research results show that tourism can bring happiness, satisfaction, and self-improvement to tourists. This conclusion is applicable to the four generations from the post-60s to the post-90s, and there will be no difference in the values pursued by rural tourism due to generational differences.

The MEC value chains show that the post-60s tourists to traditional villages prefer the two Vs of wisdom and self-improvement; the post-70s and post-80s prefer the three Vs of beautiful world, inner harmony, and sense of belonging. The post-90s tourists like all the Vs favored by the traditional village tourists of the previous three generations, a sign of the diversity and inclusiveness of the post-90s tourists [101].

5.1.2. Intergenerational Preferences and Differences of As. The post-60s, post-70s, post-80s, and post-90s tourists pursue seven As, i.e., ancient architecture, local delicacies, local traditional culture, environment of traditional village, natural landscape around traditional village, water system of traditional village, and lifestyle of residents. Specifically, ancient architecture refers to the ancient buildings and the homestays with local cultural features transformed from ancient architecture within the traditional villages; environment of traditional village refers to the atmosphere of human-nature harmony in traditional villages; natural landscape around traditional village refers to the natural landscape involving artificial or natural plants in the surroundings of traditional villages; lifestyle of residents refers to the slow and idyllic lifestyle of "getting up at sunrise and going to bed at sunset."

Ancient architecture, local delicacies, and local traditional culture are the common As of the four generations of tourists. The post-80s tourists prefer the A of water system of traditional village; the post-90s tourists prefer the A of lifestyle of residents, reflecting their curiosity; the post-70s, post-80s, and post-90s tourists prefer the As of environment of traditional village and natural landscape around traditional village.

5.1.3. Intergenerational Preferences and Differences of Cs. The post-60s, post-70s, post-80s, and post-90s tourists to traditional villages have seven Cs: idyllic life, cultural experience and inheritance, culinary experience, picturesque landscape, ecological protection, spirit of workmanship, and wisdom of the ancients.

Among the seven Cs, culinary experience, and cultural experience and inheritance are shared by all four generations. The post-70s, post-80s, and post-90s tourists prefer three Cs, namely, ecological protection, picturesque landscape, and idyllic life. This is because they wish to temporarily leave the stressful environment of daily life and work [99] and take a rest in the slow and idyllic life with superior ecological conditions. The post-60s and post-70s tourists prefer the C of wisdom of the ancients. Deeply affected by traditional Chinese culture, these two generations are attracted by the wisdom of our ancestors crystallized in the

buildings, environment, and layout of traditional villages. The post-60s, post-80s, and post-90s prefer the spirit of workmanship among the builders of ancient architecture. Many ancient buildings in traditional villages are works of art, reflecting the Chinese culture and the craftsmanship of excellence. The research results show that tourists in these three ages will be motivated to explore the spirit of craftsmanship because of the ancient buildings in traditional villages.

According to the hierarchical value map (HVM) of tourists in traditional villages and the results of MEC chain research, we believe that the attributes of traditional villages produce the tourism consequence of traditional villages, and the tourism value of traditional villages is realized through the experience of the tourism consequence of villages. Meanwhile, the ultimate tourism value reflects the spiritual needs of tourists. It also affects the protection of traditional village attributes and their reuse in sustainable tourism development, so that attributes⟶consequence⟶value⟶attributes form a cycle of mutual influence and interaction of the transmission of village protection and activation model. In this process, the attribute of traditional villages is the basis of tourism activation, and the tourism consequence of traditional villages is the guidance of tourism activation. The tourism value of traditional villages, which reflects tourists' tourism values and value pursuit, is the core of tourism activation. It is also an important factor affecting the sustainable development of traditional village tourism.

5.2. Discussion. This paper collects 600 samples of traditional village tourists across China and explores the tourism values behind the tourist behaviors through hard laddering. The main findings are as follows:

(1) From value preferences, it can be learned that the post-60s traditional village tourists are a generation of wisdom-loving learners, the post-70s and 80s tourists are a generation of beauty lovers with a strong sense of belonging, and the post-90s tourists are a generation of inclusive advocators of diversity.

(2) From the root and source, this paper summarizes the essence of the sustainable development of traditional villages: realizing the ultimate values of tourists, such as joy, wisdom, satisfaction, sense of belonging, self-improvement, inner harmony, and beautiful world, through careful protection of the following attributes of traditional villages: local delicacies, local traditional culture, ancient architecture, lifestyle of residents, environment of traditional village, and natural landscape around traditional village.

(3) The MEC theory proved to be effective for the study of different types of tourists to traditional villages, the discovery of the value preferences and intergenerational differences of such tourists, and the accurate prediction of their intergenerational preferences, providing theoretical support and practical enlightenment to the product development and marketing of the niche markets of traditional village tourism.

(4) The research results help to activate the traditional village tourism, adapt to the latest changes in the tourism market, and inherit and innovate the traditional culture of traditional villages. After experiencing the traditional culture, the tourists are very likely to spread the culture voluntarily. Besides, the tourists can affect the culture of traditional villages during travel. Through these pathways, it is possible to inherit and renovate the traditional culture in traditional villages, enhance the confidence in traditional culture, and promote rural revitalization.

The contribution of this research lies in the in-depth study of the value preferences and intergenerational differences of traditional village tourists born in the 1960s, 1970s, 1980s, and 1990s and the subdivision of traditional village tourism market into different generations, providing theoretical support to and bridge the research gap of the product development for the niche markets of traditional village tourism.

Due to space limitations, this paper only analyzes the MEC value chains above the cut-off point (50%). The MEC value chains below that point were not considered. Besides, the authors did not deeply explore the relationship between the tourist values and the protection and activation of traditional villages. Adding the intergenerational values of traditional village tourists, the future work will try to establish a model for the protection and activation of traditional villages and to safeguard the key attributes or activities of traditional villages.

Finally, several suggestions were presented for the activation of traditional village tourism:

(1) To revive the attributes and values of traditional villages, it is necessary to marketize the tourist values of traditional villages like satisfaction, self-improvement, wisdom, and joy, which are the results of ancient architecture, local delicacies, environment of traditional village, and local traditional culture.

(2) The following attributes of traditional villages should be protected with special care: local delicacies, local traditional culture, ancient architecture, lifestyle of residents, environment of traditional village, and natural landscape around traditional village.

(3) Considering the MEC value chains of post-60s, post-70s, post-80s, and post-90s tourists, it is important to design tourism products meeting the market needs of different generations, making the tourism products of traditional villages livelier.

(4) It is necessary to establish a government-led, villager-dominated, and market-driven mechanism to activate the traditional villages. Under the mechanism, it would be possible to develop new tourism businesses and products for traditional villages, carry out marketization targeted at specific groups of tourists, and improve the service level, laying the basis for rural revitalization and sustainable development of traditional villages.

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Statistical Research on the Development of Rural Tourism Economy Industry under the Background of Big Data

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Academic Editor: Sang-Bing Tsai

China is rich in rural tourism resources. In recent years, rural tourism has been the focus of tourism development in various regions, which has greatly promoted the development of rural economy. But at the same time, low efficiency, unreasonable development, and homogeneous tourism environment have affected rural tourism and reduced the competitiveness of rural tourism. In order to explore innovative ideas and countermeasures for the development of "big data + rural tourism," improve the development of rural tourism economy and industry, and improve the competitiveness of rural tourism, based on related researches on rural tourism, tourism competitiveness, coordination, etc., starting from the particularity of the rural tourism system, this paper proposes the use of coordination and coupling theory to analyze the status quo of rural tourism economic industry in a certain place in Jiangxi. The interaction of efficiency and competitiveness of rural tourism, such as infrastructure, has been studied in depth. The study found that, in rural tourism, efficiency and competitiveness are positively related. The higher the environmental index, the stronger the competitiveness. When the environment and competitiveness are coordinated, the economic benefits that can be created are about 30% higher than normal. This shows that, for rural tourism to develop better, it is an indispensable condition for the coordination of competitiveness and the environment.

1. Introduction

In recent years, my country's economic development has reached a new height. The improvement of people's income and life and rich material life have strengthened people's yearning for tourism. However, as a new tourism method, rural tourism can achieve the goal of urbanization and rural construction; tourism can drive the economic development of local rural areas. The income brought by tourism to local rural areas can improve their urbanization level [1]. Many rural areas in my country are rich in tourism resources and have a good foundation for tourism development. "Rural revitalization" is a common trend in such villages. Tourism resources with local characteristics have become the focus of the development and construction of rural tourism. In the tourism construction, they are gradually protected, explored, and developed to form tourist villages with their own characteristics. Therefore, we should guide the selection and integration of tourism resources according to the situation, reasonably protect and shape tourism characteristics, and improve the local regionalization level [2].

For rural tourism, the development of rural tourism economy is the ultimate goal of the rise and development of the rural tourism industry, but in the long run, in order to enable the long-term development of the rural tourism industry, the healthy maintenance and growth of environmental capacity is very important. Therefore, how to control the change of environmental capacity is the key concern of the balanced development of tourism economy [3, 4].

For rural tourism, domestic and foreign experts have also conducted a lot of research. Foreign countries have done more research on rural tourism due to the early start of Internet big data and transportation development. Choi analyzes tourists from the perspective of the entire tour. The information they search is changed anytime and anywhere. First, search for information such as the location of tourist

attractions, hotel reservations, and route planning and then implement information tracking based on the dynamics of the scenic spot, such as some special scenic spots, performances, precautions, etc., and, finally, some experience sharing according to his own wishes, and based on these findings, he designs tourism products and services [5]. Xiang and Pan discovered through data mining on Internet users' browsing of tourist city information with search engine tools that hotel information ranks first in search volume, followed by driving guides and scenic spot overviews, while business districts are the part that tourists pay the least attention to. This discovery is used to design tourism products and services [6]. Buhalis pointed out that tourists will widely use a variety of online information sources when arranging their journeys, mainly including intermediary service providers, official websites, travel apps, WeChat official accounts, and various travel websites. On the Internet, consumers can communicate with suppliers and destinations, with dynamic communication and personalized customization of tourism products and services. Relatively speaking, domestic research started late, but it has also made great progress [7]. By tracing the process of sharing travel experiences, Li Ping noticed the important role that mobile phones play in the sharing process. Tourists are not restricted by time and space, thus attracting more attention. At the same time, sharing this way through mobile phones is very convenient [8]. Shan Na believed that rural eco-tourism products can be divided into experience-based, artistic, educational, self-guided tours, and farm stays and summarized the following product development directions: story explanation, product innovation, characteristic architecture to create artistic conception, and teaching mode [9]. Peng Xia mentioned that the main purpose of the integration of the Internet and the tourism industry is to improve the quality of tourism products and facilitate the travel itinerary, which is manifested in the booking of tickets, hotel accommodation, and other aspects. Therefore, the focus of the cooperation between the two is to build an Internet marketing and publicity platform. The tourism products and services are put on the Internet platform [10, 11]. In this survey, we will first sort out related concepts such as big data and agritourism and then summarize domestic and international surveys on the basic theory of agritourism, research methods, and influential factors. Then, on the basis of investigating the status quo of tourism development in Anyi County, it analyzes the six aspects of the development of rural tourism economic industry in the context of its big data, including the number of managers, capital investment, types of products and services, network marketing and promotion, information construction, and infrastructure, and establishes system boundaries. Secondly, it establishes a basic tree-in-tree model for the number of managers and service personnel, the total amount of capital investment, the number of types of products and services, the number of clicks on online marketing, the amount of capital invested in information construction, and the flow rate of infrastructure construction investment, to reasonably confirm the relevant flow rate. Flow position system generates typical meaning archetypes, conducts feedback analysis on archetypes, and proposes corresponding management countermeasures. Then, using the branch vector determinant calculation method to analyze all the feedback loops of the rural tourism economic system development under the background of big data, it finds out the key elements restricting the development of the system, gives the overall system feedback, and proposes corresponding management countermeasures. Finally, the management countermeasures are simulated and analyzed through the system software.

2. Rural Tourism Economic Industry Development Methods

2.1. Concept of Rural Tourism Economy Industry. Rural tourism is a new type of industry that combines agriculture and tourism. It provides tourism, leisure, entertainment, fitness, shopping, etc. for different tourists with the help of rural unique natural scenery, human folklore, ancient architectural style and cultural characteristics, and other tourism resources, a new type of tourism model with diversified and different tourism products, thereby improving the tourism network environment and increasing the income of the people [12].

The living standards of Chinese residents have generally improved. At the same time, tourism has become more and more normalized. Tourism is not only an entertainment activity, but also a change of daily habits. In the past few years, China's tourism market has achieved sustained, healthy, and rapid development. While the tourism market has expanded, people's travel habits have also quietly changed. In the past, people may choose to travel more through travel agencies, but as tourists mature, more distinctive travel modes are accepted by people, and everyone is no longer satisfied with traditional travel routes, products, habits, etc., but are expected to be able to plan a unique travel route and own unique travel products [13]. On the other hand, with the acceleration of the pace of life, people's travels are more temporary and random, and people choose to travel as soon as they say they want. After arriving at the destination, according to the actual situation, they know and book the travel situation of the destination at any time [14]. Generally speaking, people who choose to travel will choose tourist destinations purposefully, as shown in Figure 1.

With the rapid development of social economy and technology, a new rural tourism industry has also been continuously developed. Tourists are increasingly rich in tourism psychology, and the tourism experience continues to mature. Tourists are also paying more and more attention to enjoying the experience of combining spirit and material in tourism [15]. The diversification of tourist needs and the increasingly obvious trend of individualization require more in-depth development of tourism resources, so that the needs of tourists can be met, and the sustainable development of the tourism industry can be promoted. Tourism resources are the foundation of tourism development, as well as a prerequisite for tourism planning and tourism resource development [16]. Because the development status of tourism resources is not optimistic, tourism resources rely on the continuous development of tourism to survive and

Figure 1: Traveling to choose high-frequency purposes. (a) Featured tour, (b) resort, (c) farmhouse, (d) national characteristics, (e) quality resources, and (f) red base.

develop. Only through resource development can it become a tourism product and bring its economic, cultural, and social benefits into play. Generally speaking, rural tourism mainly has the following characteristics:

(1) Tourism in rural areas: The countryside has a unique geographical location. The surroundings are either scenic spots or unique advantages of ancient buildings. The strong folk customs and urban attractions form a strong contrast. Many urban residents have become accustomed to the urban scenery. Naturally, they are different. The field scenery, humanistic feelings, and folk customs of the countryside in China have become attractive points for urban residents [17]. All activities of rural tourism are in the countryside and surrounding market towns. Rural residents make effective use of rural space, plan rural tourist attractions, and innovate tourism products, so that tourists can appreciate the unique material and intangible culture of the countryside and experience rural life.

(2) Diversified forms of activities [18]: In addition to farmers, the main suppliers of rural activities include enterprises that attract investment. Therefore, the tourism products and activities provided by rural tourism are naturally rich and colorful, covering all kinds of tangible flower viewing, water entertainment, farmhouse entertainment, etc. Activities also include abstract content such as folk customs, traditional culture, and scene simulation. Urban residents choose rural tourism mainly to experience a different life mode, which is bound to inspire local farmers and enterprises to various innovate forms of activities and create "Internet + rural tourism" new model.

(3) Revitalize the local economy [19]: Rural areas have always been the key target of national support. Rural development has always relied on agriculture or animal husbandry. The vigorous development of rural tourism has brought a new direction for the development of rural economy. Especially in this Internet age, construction informatization, intelligence, convenience, and other new types of rural areas improve the infrastructure of rural tourist attractions, attract more tourists, and gradually change the way of relying on agriculture for livelihoods, revitalize the local economy, and improve the quality of life of local residents.

2.2. Coordinated Development. The industrial characteristics under the background of rural tourism planning are different from traditional industries. Plans facing different disciplines, different industries, different structures, and industries involving different levels provide multiangle and interdisciplinary knowledge to allow rural tourism to enter into collaborative development, with need to be integrated. Coordination refers to the healthy development of two or more systems or system elements. They are coordinated and unified with each other, from low-level to high-level, from simple to complex, and from disorder to order and evolve to achieve goals, the overall evolution of goals [20]. "Coordinated development" is the intersection of "coordination" and "development," emphasizing integrity, comprehensiveness, and internal cohesion. Therefore, the definition of coordinated development is as follows: on the basis of following the objective laws, through the coordination between each subsystem and the entire system, subsystems and internal components, in order to achieve the overall goal of

the overall development of the system, the relationship between the system's internal components is constantly evolving toward an ideal state. In today's society, sustainable development and scientific development concept are the highest ideas of contemporary coordinated development theory [21]. People-oriented idea not only respects objective laws, but also emphasizes the overall coordination of the complex system of population, society, economy, technology, resources, and environment. To better strengthen the coordinated development within and between systems, the following characteristics should be grasped:

(1) The principle of subjectivity: When choosing an indicator system, you should choose those indicators that best reflect objective facts, not all indicators.

(2) The principle of flexibility: Different problems have different characteristics, and the choice of index system should be adjusted according to the specific characteristics of specific problems.

(3) The principle of operability: When choosing an indicator system, you should choose indicators that can be collected and easily measured. Some indicators are important but difficult to collect or difficult to measure. Such indicators are not suitable for an indicator system.

(4) Principles of accuracy and comparability: The selected index system should be numerically accurate, such as the unity of measurement caliber, the economic aggregate calculated using constant values, and the degree of conformity with the actual situation.

Generally speaking, coordinated development between regions is the state and process of interdependence, mutual adaptation, mutual promotion, and common development formed between regions under the conditions that each region is open to the outside world [22]. Expressed in systematic language is that each region takes other regions as its own constraints, chooses its own elements, adjusts its own structure, and changes its own functions to adapt to and promote the development of other regions, so that the elements of each region are constantly updated. The continuous optimization of the structure and the continuous mutual accommodation, connection, and promotion between regions have formed a spiral upward trend in the dynamic feedback process of each region in the country. A high degree of coordination coefficient indicates that the region is in a balanced development, and the degree of coordination is small, indicating that the region is in a state of uncoordinated development and needs to be adjusted in time.

2.3. Competitiveness. The basic feature of the market economy is free competition, which is a product of the commodity economy. The emergence of competition is based on the common needs of the subjects who participate first and then cause mutual struggle. At the same time, it will inevitably include competition for scarce resources. The concept of "competitiveness" originated from people's understanding of ability. When participants compete with other participants for their own interests, the comprehensive ability reflected by it is competitiveness [23].

Competitiveness is a relative concept, which can only be manifested through comparison and competition with other participants. The understanding of "competitiveness" encompasses multiple angles and levels. It is a comprehensive and complex concept with rich connotations. According to the different types of participants, competitiveness can be divided into national competitiveness, industrial competitiveness, enterprise competitiveness, etc. According to different competition backgrounds, it can be divided into regional competitiveness, international competitiveness, etc. [24]. At the same time, "competitiveness" is a dynamic concept that includes the performance of the main body in the current competition and the capabilities that may be demonstrated in the future competition. Therefore, in order to conduct competitiveness evaluation, it is necessary to determine the target time period and define the subject type and background of competitiveness analysis.

Whether the tourism industry can be called an industry has been controversial. If the industry is interpreted as a collection of companies operating the same main industry, then the term tourism industry does not seem to be rigorous enough. However, if the composition of the industry is understood on the basis of consumers' purchasing purposes, then there is nothing wrong with the tourism industry. From this perspective, a collection of companies that provide tourists with "food, accommodation, transportation, travel, entertainment, and shopping" constitutes the category of the tourism industry. The tourism industry involves people's basic life content and has a wide range of extensions. According to different service objects, it can be divided into basic industry sectors and specialized industry sectors. The basic sectors mainly provide services for local residents, while the specialized ones are aimed at tourists (demand developed). The research done in this article will only focus on specialized industries, while basic industries such as urban transportation, postal services, taxis, general entertainment venues, and other basic industries that serve local residents will be less involved. Existing research can be divided into two levels according to the scope of the region involved. The first is overall competitiveness. The main body involved is the country. The research content mainly focuses on the ability level of a specific country in the international market competition. The second is the limitation. The tourism competitiveness of a geographical area includes a certain designated area, province, city, scenic spot, etc. [25]. The tourism competitiveness of a scenic spot mainly refers to the comprehensive performance of a certain scenic spot's market share, profitability, and development potential. Its competitiveness level is mainly evaluated from the level of economic benefits. The competitiveness of urban tourism refers to the attractiveness to tourists and the ability of sustainable development embodied under the comprehensive effect of tourism enterprises, related enterprises, and urban infrastructure within a certain city. Regional tourism competitiveness reflects the ability of a given area to maintain a sustained competitive advantage in market competition.

Tourism competition can generally be divided into three types of direct competition. Direct competition refers to the provision of similar services and products by multiple tourism companies. For example, there is direct competition between energy and water suppliers. Competition for substitutes appears among tourism companies that provide mutually replaceable services and products [26]. For example, there is competition for substitutes between airlines and car rental companies. Sometimes the main functions of services provided by multiple tourism companies are similar. For example, two hotels in the same area provide accommodation services, but because they have their own characteristics and can bring different experiences to customers, the competition between them is also summarized as competition for substitutes. The third type of competition is budget competition. Every customer has a limited travel budget. If he spends more on a certain travel service or product, he can only spend less on other services and products.

2.4. Coupling Theory. The main theoretical basis used in this study is coupling theory. The theory of the mode of coupling refers to a theory that studies the general laws of coupling between two or more modes of electromagnetic waves. The connection may occur between different modes of electromagnetic waves in the same conductor (cavity) or between modes of electromagnetic waves in different conductors. The theory studies the general law of interconnection between two or more modes of electromagnetic waves, also known as coupled wave theory. In general, it is a general theory that studies the connection between two or more waves. The connection may occur between different modes of electromagnetic waves in the same conductor (or cavity) or between modes of electromagnetic waves in different conductors (or cavity). Usually, the connection happens between the same type of waves, but it can also happen between different types of waves, such as the connection between two modes of electromagnetic waves and two modes of space charge in a rolling wave.

Let the variable $(a = 1, 2, \ldots, n)$ be the ordinal parameter of the rural development compound system and m_{ab} be the b-th index of the a-th ordinal parameter. The influence of rural development and the influence of tourism development are completely different, but they are two subsystems that influence each other. The contribution of order parameters in the subsystem to the order degree of the system is shown in the following formula:

$$m_a = \sum_{b=1}^{n} \lambda_{ab} \vartheta_{ab}. \tag{1}$$

m_{ab} is related to the overall rural development system and λ_{ab} is the weight of each order parameter. Therefore,

$$y(kT + t_i) = \frac{1}{\alpha(z)} \sum_{j=1}^{r} \beta_{bn}(z) \partial(kM + t) + v(kM + t_i). \tag{2}$$

And it can be transformed into

$$\begin{aligned} \alpha(z) &= 1 + \alpha_1 z^{-1} + \alpha_2 z^{-2} + \cdots + \alpha_n z^{-n}, \\ \beta_{ij}(z) &= \beta_{ij}^0 + \beta_{ij}^1 z^{-1} + \beta_{ij}^2 z^{-2} + \cdots + \beta_{ij}^n z^{-n}. \end{aligned} \tag{3}$$

Its function is to move the $s(kT + t_{i-1})i = 1, 2, \ldots, r-1$ sampling signal in time backward $s(kT + t_{i-1})$ by 1 nonuniform sampling interval, and a new transfer function model is proposed:

$$\begin{aligned} y(kT + t_t) &= \frac{B_i(\delta)}{A_i(\delta)} \overline{u}(kT + t_i) + v(kT + t_i), \\ Q &= 2\left(1 - \frac{m_1 m_2}{[(m_1 + m_2)/4]}\right)^{1/4}. \end{aligned} \tag{4}$$

When $Q = 0$, the deviation of the two systems is the smallest, and the coordination degree between m_1 and m_2 is the highest. Therefore, Q can be used as a measurement index of the coupling degree between m_1 and m_2.

$$R_t = \left\{ \frac{(n_1 * n_2 \ldots n_n)}{\left[\theta\left(n_j + n_l\right)\right]} \right\}^2. \tag{5}$$

The coupling function Q can be expressed by the following formula:

$$\begin{aligned} Q &= 2\frac{(m_1 * m_2)^{1/2}}{(m_1 + m_2)}, \\ d(v) &= \mathrm{rty}\left(-\int_1^s \kappa(b) v k\right). \end{aligned} \tag{6}$$

Therefore, we can get

$$\partial = 1 - t(s) = 1 - \exp\left(-\int_0^s \kappa(t)\, \mathrm{d}t\right). \tag{7}$$

When Δs approaches zero, use the following differential equation to illustrate the change:

$$\begin{aligned} \frac{dI}{ds} &= T(s) * \rho(s) * A = T(s) * \kappa(s), \\ I(s) &= I_0 + \int_0^s g(t)\, \mathrm{d}t. \end{aligned} \tag{8}$$

As shown in the following function:

$$b(c - 2) = vn(c) + Q(n). \tag{9}$$

The expression of secondary performance index is as follows:

$$M = \sum_{m=1}^{\infty} \left[x^i(n) Q c(m) + k^l(m) b A\right]. \tag{10}$$

The expression of weight matrix is as follows:

$$M = \frac{1}{2a^2 r^{-2}} \left(\frac{2b^2}{a^2 r^{-1}} N - H\right)^{-2} \left[a^2 r^{-1} t^2 + 3\left(1 - b^2\right) t\right]. \tag{11}$$

Emerging tourism industry models continue to emerge and develop under the guidance of the general trend of modern tourism, which greatly strengthens the vitality of the tourism industry and makes rural tourism occupy a place in the modern tourism industry.

3. Rural Tourism Experiment

3.1. Subjects. Taking a certain place in Jiangxi as an example, based on the analysis of the shortcomings and problems in the development of rural tourism in a certain place, this paper constructs a large data + rural tourism development problem model for a certain place and conducts an overall feedback analysis of a certain place big data + rural tourism system. It identifies the key factors restricting the development of the system and puts forward the management countermeasures to promote the development of rural tourism in a certain county under the background of "Internet +". There are 3 towns and 13 townships in a certain place, as shown in Figure 2.

3.2. Construction of Rural Environmental Index System. By consulting and summarizing relevant documents, the establishment of the indicator system should be combined with the actual situation. Based on the operability of data collection, we referred to related research results, referenced statistical data such as preliminary environmental status reports for specific counties, and divided and layered the environmental system. The tourism environment should be a complex system including economic, social, and natural environment and other elements. According to the characteristics of the development of the rural tourism industry, it is more practical to discuss the research capacity from the following four aspects, as shown in Table 1.

3.3. Construction of Tourism Economic Index System. When you build an evaluation index of economic development subsystem, based on the research literature of the current domestic and foreign experts, in combination with the current state of development of rural tourism economy, to analyze the index system of tourism economy subsystem, it is divided. According to many studies, when most scholars conduct economic analysis, tourism income and number of tourists are important factors for investigating economic development. Inbound tourism is also an important consideration when analyzing the tourism economy. It needs to be included in the tourism economic indicator system. Per capita expenditure is also an important indicator to measure the economic development of a city. It represents an important source of income for a city's tourism economy. It needs to be taken into account in economic development. The tourism economic index system is shown in Table 2:

3.4. Data Processing. When our test data are consistent with the normal distribution, as an intragroup comparison, we can use the double t-test and the independent sample P test. However, if the regular distribution of data is insufficient, two independent samples and two related samples should be used for testing.

4. Analysis of Rural Tourism Development

4.1. Situation in a Certain Place in Recent Years. We have made statistics on the GDP of a certain place in recent years and then determined the proportion of rural tourism economy in it. The GDP of a certain county in recent years is shown in Table 3:

From the table, we can see that, with the development in recent years, the industrial structure of a certain county has been continuously adjusted, from the original secondary industry as the main industry to the tertiary industry, and the tourism industry is a component of the tertiary industry. Part of the development has also been achieved. The tourism investment of a certain county is shown in Figure 3.

It can be seen from Figure 3 that, in recent years, the government's investment in tourism has gradually increased, and the main investment is concentrated in transportation and infrastructure projects to create a convenient environment for tourists. In this regard, we investigated the environment and related capacity of a certain place, as shown in Figure 4.

From the figure, we can see that both the overall benefit index of the tourism environmental capacity and the overall benefit index of the tourism economy show a gradual upward trend and the growth trends of the two are approximately the same. This also requires us to follow the thematic positioning when constructing rural tourism in a certain place, to sort out the context and grounds, and on the basis of analyzing the characteristics of tourism resources and digging out local culture, we should plan and construct suitable one for the actual situation of a certain place and the surrounding tourism market based on local conditions (travel items).

4.2. Changes and Development of Rural Tourism. There are many factors affecting the development of rural tourism industry. We classify the different effects and simulate their impact on the rural tourism industry, as shown in Figure 5:

As shown in the figure, after the improvement of talent welfare and treatment, the number of management personnel and service personnel, the total capital investment, the types of products and services, the frequency of online marketing and promotion, and the amount of investment in information construction have all increased. This is because retention of talent is largely dependent on it. It is the treatment of talented welfare. As the treatment of human resources welfare improves, it will attract more and more local tourism management and service personnel. Once the number of management and service personnel increases, it will stimulate product development creativity and marketing promotion creativity and increase the number of types of products and services and the number of clicks on online marketing and promotion, thereby increasing the income of local tourism, allowing tourists to experience information-

Figure 2: Topographic map of Yihuang County.

Table 1: Tourism capacity and index system.

First-level index	Secondary indicators	Three-level indicators
Tourism environmental capacity	Tourism resources space bearing capacity	Line environment capacity (X1)
		Scenic environment capacity (X2)
	Tourism ecological environment bearing capacity	Water environmental capacity (X3)
		Solid waste environmental capacity (X4)
		Atmospheric environmental capacity (X5)
	Tourism facilities bearing capacity	Accommodation facility capacity (X6)
		Catering facilities capacity (X7)
		Road traffic facility capacity (X8)
		Capacity of leisure and entertainment facilities (X9)
	Tourism psychological bearing capacity	Tourist mental capacity (X10)
		Psychological capacity of residents in tourist areas (X11)

Table 2: Diagram of tourism economic system.

System	Evaluation index
Tourism economic system	Total rural tourist visits/ten thousand visits (Y1)
	Rural tourism income/100 million yuan (Y2)
	Domestic tourism/10,000 person-times (Y3)
	Income from domestic tourists/100 million yuan (Y4)
	Domestic travel per capita expenditure/yuan (Y5)
	Inbound tourists/10,000 person-times (Y6)
	External consolidated income/100 million US dollars (Y7)
	Per capita cost of inbound tourism/USD (Y8)
	The ratio of total rural tourism revenue to GDP (Y9)
	Hangzhou GDP (Y10)
	Number of star-rated hotels/*a* (Y11)
	Number of travel agencies/one (Y12)

Table 3: Yihuang County's GDP in recent years.

Output value (100 million yuan)	2016	2017	2018	2019	2020
GDP	61.74	66.68	72.68	82.13	85.91
Primary industry	7.82	8.25	8.79	9.35	10.23
Secondary industry	29.17	31.37	32.16	34.17	34.93
Tertiary industry	24.75	27.06	31.73	38.61	40.75

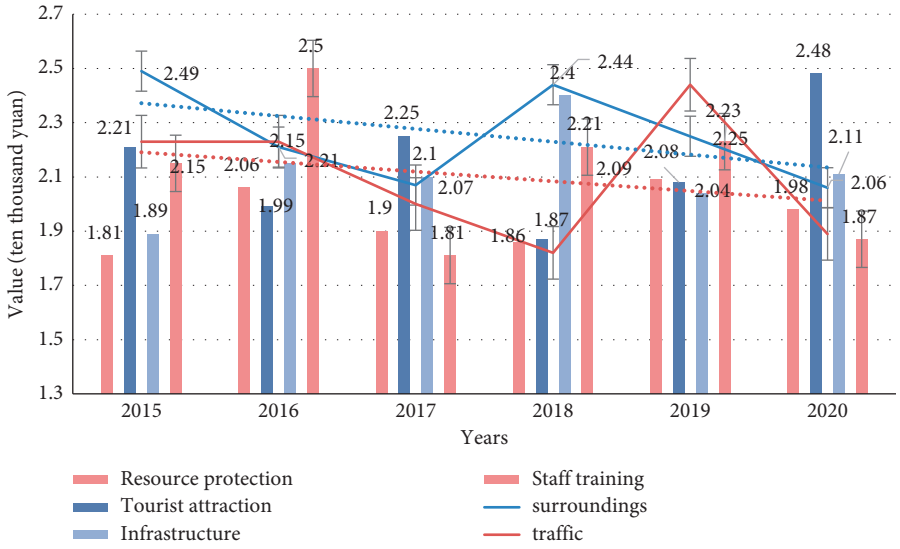

Figure 3: Tourism investment in Yihuang County.

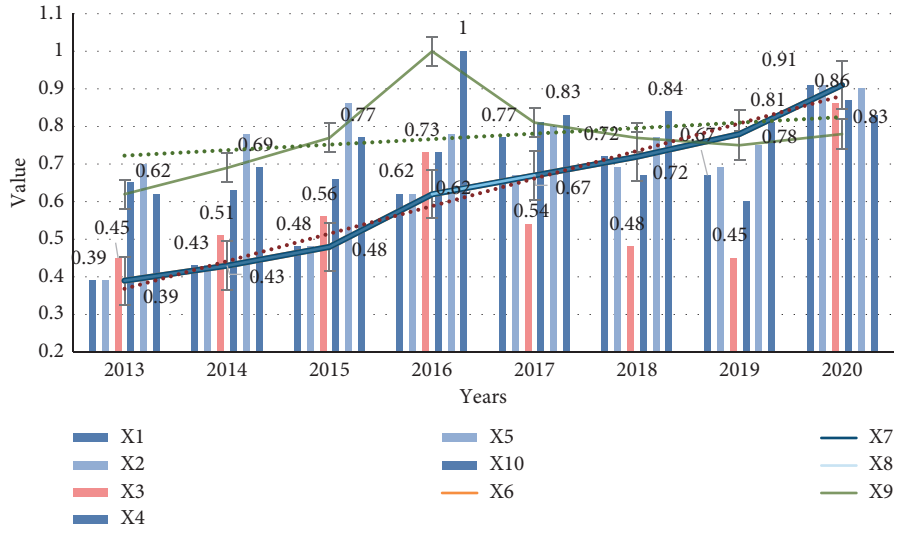

Figure 4: Environment and tourism development.

based, multistyle rural tourism. In order to understand the degree of satisfaction of tourists when traveling in a certain county, we conducted a related questionnaire survey on tourists. The results of the survey are shown in Figure 6:

From Figure 6 it can be seen that the local characteristics are rich in red pores and agricultural resources. Tourists have the highest satisfaction with these two tourist projects. Therefore, in future planning, these two resources should be

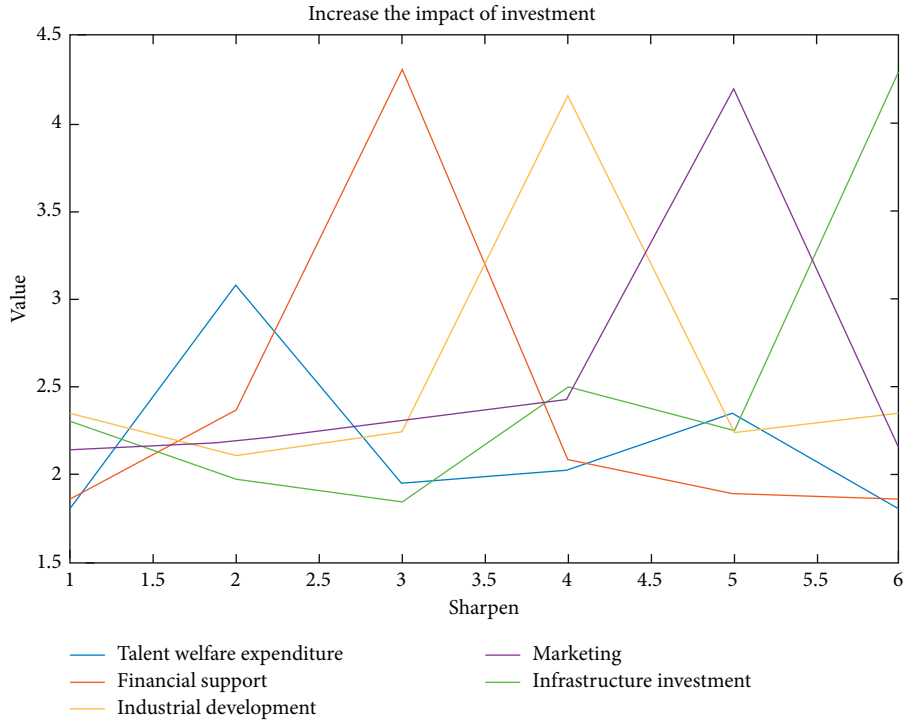

Figure 5: Factors influencing the development of rural tourism industry.

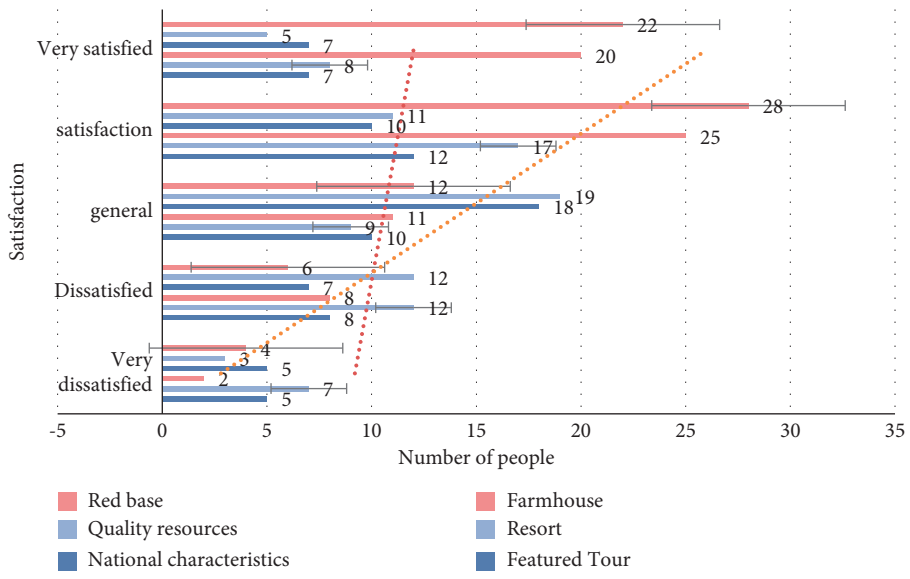

Figure 6: Passenger satisfaction survey.

rationally planned and integrated, making it bigger and stronger to promote the development of other tourism resources.

5. Conclusion

This paper studies the definition of rural tourism planning, the definition of local characteristic tourism resources, the classification of tourism resources, and the quality evaluation of local characteristic resources, analyzing and selecting the quality factors of tourism resources somewhere, and the final conclusion is based on the development of local characteristic resources, planning tourism practice, and proposals for the development of tourism resources in tourism planning. Considering the value and characteristics of tourism resources, the value of tourism resources is higher than the characteristics of tourism resources. In the value of tourism resources, first attach importance to the value of tourism experience and then focus on the tourism value of this area. In the current construction of rural tourism

planning, in addition to creating pleasing landscapes, planning should pay more attention to the experience and participation of tourists. The implementation of macro-planning and design into details and perception has become the focus of current tourism planning. In the research of this article, because the research object of local characteristic tourism resources is relatively complicated, although the analysis and evaluation system has been established, it still needs more information, a larger range of research, and more comprehensive methods to make it more useful. In future research, more appropriate samples should be studied. The number of investigations can be increased, and the amount of investigation and data collection can be expanded to make the research more comprehensive.

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IoT Architecture for a Sustainable Tourism Application in a Smart City Environment

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Academic Editor: Claudio Agostino Ardagna

In the past few years, the Smart Cities concept has become one of the main driving forces for the urban transition towards a low carbon environment, sustainable economy, and mobility. Tourism, as one of the fastest growing industries, is also an important generator of carbon emissions; therefore, the recently emerging sustainable tourism concept is envisioned as an important part of the Smart Cities paradigm. Within this context, the Internet-of-Things (IoT) concept is the key technological point for the development of smart urban environments through the use of aggregated data, integrated in a single decisional platform. This paper performs the first analysis on the feasibility of the use of an IoT approach and proposes a specific architecture for a sustainable tourism application. The architecture is tailored for the optimisation of the movement of cruise ship tourists in the city of Cagliari (Italy), by taking into consideration factors such as transport information and queue waiting times. A first set of simulations is performed using 67-point of interest, real transportation data, and an optimisation algorithm.

1. Introduction

IoT leads a sweeping cultural change as a huge number of machines, devices, sensors, actuators, and other objects become interconnected to each other and to higher-level systems. Due to the enormous amount of variety of connectable devices and automatically collected data, entirely new services and features can arise, to form the basis of, among other concepts, Smart Cities. IoT and big data are both technology-driven developments leading to scenarios such as the one for the Smart Cities, having the potential to generate enormous market opportunities as well as make citizen lives smarter and more sustainable.

The Smart Cities architectures envisioned or implemented up to date deal mostly with use cases from the following categories: energy, waste disposal, environmental management, and transport. All these use cases can have their needs covered by means of an IoT platform connecting heterogeneous sensing systems with the upper layers dedicated to services and interfaces [1].

Tourism is not only the largest growing industry in the world but it also accounts for 5 to 12% of global greenhouse gas emissions [2]. Therefore, in the context of the passage towards a low carbon environment and sustainable economy, the term sustainable tourism was recently coined and begins to gain acceptance from both sides: tourists on one side and tour operators and the interested territory on the other side.

Without travel there is no tourism, so the concept of sustainable tourism is tightly linked to the concept of sustainable mobility which, for the specific case of an urban environment, can be included in the frame of the Smart Cities paradigm.

Based on these aforementioned concepts, this paper proposes an IoT architecture for a sustainable tourism application in a Smart City scenario. The proposed architecture is tailored for a specific use case: sustainable movement of tourists in the city of Cagliari in Sardinia, Italy.

The paper is structured as follows: Section 2 analyses briefly the key requirements for an IoT architecture operating in a Smart City environment for the specific implementation purpose; Section 3 presents the proposed architecture, while Section 4 is dedicated to the use case description

and model, tested in Section 5 through a first series of simulations. Section 6 presents the conclusions and the future work.

2. Key Requirements for an IoT Platform in a Smart City Environment

The emerging Smart City concept has many definitions and implementation approaches. However, as pointed out in the Introduction, from an infrastructural point of view, all Smart Cities have at their core a highly capable ICT system (IoT platform) connected to network of sensors, wired and wireless broadband connectivity, and advanced data analytics that settle the basis for developing intelligent applications and services for citizens [3].

Due to the current lack of fully defined standards for IoT architectures, the key requirements for their usage in a Smart Cities scenario are rather difficult to be defined. The first steps in this direction have been done by the PROBE IT EU-financed project which aimed, among others, at benchmarking IoT deployments and setting guidelines for IoT rollouts for Smart Cities [4]. Based on some of these guidelines, considering other surveys [5–9] and also the requirements fulfilled by some of the existing commercial IoT architectures and platforms [10, 11], we extracted a set of key requirements for IoT platforms operating in a Smart City environment.

The compliance of the architecture proposed in Section 3 with the identified requirements, considering also the first implementation steps, is discussed individually for each one of the requirements.

2.1. Security Requirements. There are already more connected devices than people on the planet, with the estimation that, by 2020, there will be 50 billion connected devices [11]. The inclusion of these devices in IoT platforms means that they will be readable and controllable over the Internet. Poor or misconfigured networks are potentially vulnerable to attacks and IoT environments are no different at all, as they are always connected to the Internet. Therefore, an IoT platform must have strong built in security, which, specifically for the Smart Cities environment and for the chosen application, should have the following key requirements.

(1) End-to-End Security Mechanisms and Data Encryption. Standard-based encryption from the hardware devices to the IoT platform is arguably one of the best deterrents of data theft. Many services encrypt data once it gets to their data centre, but in many ways data is more vulnerable when it is in transit. The challenge for the developer with doing this from end to end is making the entire authentication happen without the user's intervention, so the data is encrypted automatically. For the specific case of the proposed architecture, the critical links are between the real-world objects and the related virtual objects. To ensure a secured connection, the real-world objects exchange keys and IDs with the virtual objects at the association phase, avoiding any other further connection to. All the subsequent connections between the virtual objects and the upper layers are inside the cloud environment that avoids unauthorized access to the users' data.

(2) Flexible, Configurable Access and Authorization Control. Different user types need different levels of access to the data, especially for the specific scenario of live environmental data monitoring such as temperature and humidity. Therefore, an IoT platform should be able to grant to the users of the Smart City environment different access profiles in terms of ownership, security level, visibility, data polling frequency, etc. The virtual objects used in the proposed architecture can have three types of permissions: if "public," the resource can be accessible to everyone without the use of any keys; if "private," the resource can be accessed to the owner key only; if "friend," the resource can be accessed by providing the friend-key known by the friend virtual object.

All the other security requirements can be covered by the cloud environment which will be used to implement the proposed architecture.

2.2. Flexibility. The market for IoT-enabled devices, although in full extension, is still in the early stages of adoption. Developers of the next generation of connected devices and products need to rely on certain flexibility from their software counterparts aggregating their products. For these reasons, an IoT platform should comply with the following flexibility rules.

(1) Networking and Device Agnosticism. Configuration changes should not be limited to writing/changing the driver and data format when a device is added or updated, giving the freedom to hardware developers to constantly develop their products without being limited by predefined settings or compatibility issues.

(2) Device Manageability. Since a large number of smart devices and sensors can be placed geographically at large distances in a Smart Cities environment, the IoT platform must incorporate means to allow the remote management of these devices. This may include remote delivery of operating system patches, profiles, new analytics algorithms, and key management of parameters.

(3) Usage of Open APIs. Smart Cities inherently can generate large data sets originating mainly from networks of devices and sensors. Much of this data remains stored and not analysed mostly because of its unavailability to third party users other than the one intended for the original application. Therefore, as a quintessential element for the Smart Cities environment, the IoT platforms underneath should allow access to common shareable data and as such to become a motor for the development of innovative applications.

The proposed cloud-based architectural approach using virtual objects decoupled from the actual real-world objects allows for the flexibility requirements to be fully implemented.

2.3. Data Requirements. IoT data comes mainly from things but also from users in the form of metadata. Smart Cities

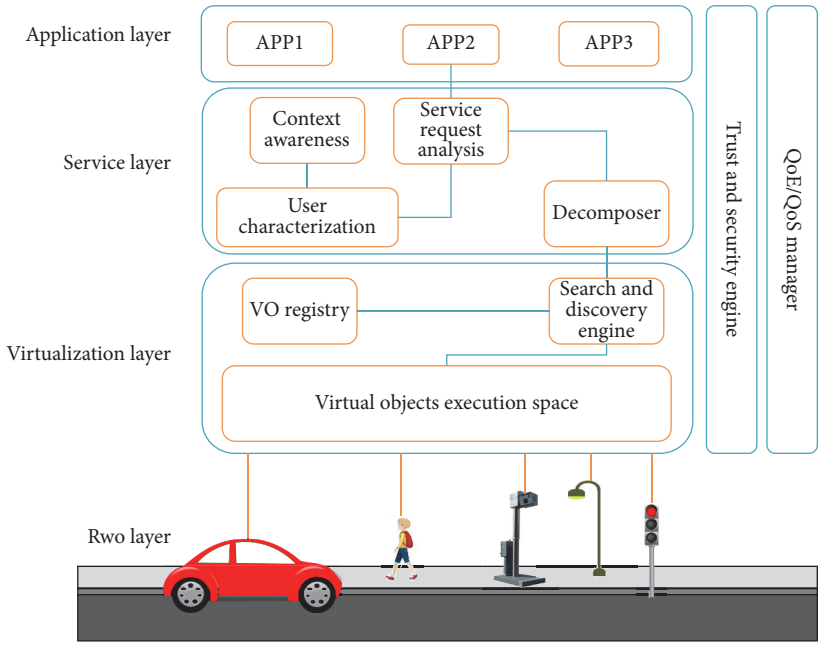

Figure 1: Cloud-based IoT architectural solution.

and IoT are more than a remote monitor of incoming data, with the key concept being data intelligence which implies some strict requirements in terms of data [10, 11]:

(1) Flexible Data Definition Tools, Data Virtualization, and Non-SQL Databases. New devices on an IoT platform need to be implicitly easy to define and set up, with no limit on the type of devices. As a consequence, there is no room for the inherent rigidity of SQL databases and the development lag to change the database schemes. The cloud platform to be used for the implementation of the proposed architectures relies on nonrigid SQL databases and flexibility in terms of data definition.

(2) Data Scalability. The data set of an IoT platform in a Smart City environment is predestined to grow on a fast pace, especially when monitoring environmental data, so the platform should have the ability to manage the warehouse of data using culling and archiviation methods, preferably in a fully automated manner. Data scalability for the proposed IoT platform is achieved by using cloud-based implementation.

(3) Component Reusability. In a Smart City environment, even though the incoming data may come from a variety of sources depending on the various application scenarios, the usage of this data is often very similar. Therefore, an IoT platform should allow at a large extent the reuse of the created components with minor adaptations. The proposed solution, through its layered architecture, gives the developers the possibility of building templates of objects and services available also to other uses different from the current one.

3. IoT Architecture for a Sustainable Tourism Application

As mentioned in the Introduction, the goal of our work is to present an IoT architecture for the specific Smart City scenario dedicated to the sustainable management of the tourist flow in the urban environment of Cagliari. To support the deployment of major applications, such as the efficiency of urban operations and services and the sustainable tourism, and to satisfy their quality requirements, an IoT architecture and its implementation as an IoT platform need to be able to address the previously listed requirements. To deal with these stringent requirements, we envision that, through the use of virtualization technologies, every real-world object participating to the Smart City, from smartphones to traffic lights and sensors, is associated with its virtual counterpart in the cloud. Associating a digital counterpart to physical objects is a common practice in the latest IoT research activities [12, 13], since through virtualization the physical devices gain augmented capabilities and are able to [12] (i) fully describe their characteristics with semantic technologies and then be able to interact with other virtual objects; (ii) identify, analyse, and manage the context related to an object surroundings and take decision accordingly; (iii) simplify the search and discovery of services and devices, which continuously join, move, and leave the network.

3.1. Proposed Architecture. The main purpose behind the proposed architecture, shown in Figure 1, is to activate the data-stream from IoT objects when needed. These data-streams are continuously processed to support end-users/ICT applications, with a set of procedures monitoring the context and producing alerts when particular conditions are met.

The proposed IoT platform foresees a four-level architecture: the highest level is the *Application Layer* in which user-oriented macroservices are deployed; the *Service Layer* is responsible for receiving the service requests and mapping them to the atomic services available in the lower layer; this layer is the *Virtualization Layer*, which interfaces directly with the real world and enhances objects' functionalities; the last level is the *Real-World Layer*, containing the real physical devices of the Smart City. Two additional cross-layers are needed to manage the quality requirements of the applications and to ensure that every communication takes place in a trustworthy and secure way, according to the previously listed requirements.

Even if this architecture is at the beginning of its implementation, we are moving towards implementation using Platform as a Service (PaaS) features, since they provide the tools needed to develop, run, and manage web applications, such as the execution containers of web services and related databases for data storage (see the Virtualization Layer subsection).

This approach has manifold motivations: (i) it enables objects to "speak" the same language at virtual level; (ii) it enhances the search and service discovery; (iii) it decouples the service requests and the actual IoT objects which satisfy the request; and (iv) it offers personalized experience to users based on their own needs and traits.

In the following paragraphs, we describe in detail the layers proposed for the architecture.

(1) Application Layer. At this level, user applications are responsible for final processing and presentation of the results. Deployment and execution of application make use of one or more services. An application at this level shows a back-end interface to the underlying layers. Additionally, applications can show a front-end interface so that requests can be triggered by users or by the objects themselves. A user interface is provided for the interaction with the system; however, in this case, the requests need to be translated in a language understandable by the platform.

(2) Service Layer. This layer is responsible for the analysis of the service requests generated by the application in the above layer and to enhance this request with a range of facts concerning the human user, including user context, profile, preferences, and policies. Each service request contains a semantic description of the input and of the desired output.

In particular, the *Service Request Analysis* (SRA) receives the query and asks for the retrieval of the current situation in which the query is performed. Moreover, it must be able to reuse the output of a previous request to respond to requests that present the same inputs and similar user information in order to reduce the burden on the Virtualization Layer and save redundant data requests.

The *user characterization* provides all the information associated with the user or the user's object which made the query. This block comprises cognitive functionalities to build user-related knowledge and act on behalf of the user when needed. This is an important component in our platform because many applications in a Smart City scenario, such as the one for sustainable tourism, are characterized by personal choices: requests coming from different users can have different solutions.

However, user characterization is only related to static user information, so a *Context Awareness* block is needed to detect, recognize, classify, and act upon the particular situation the user is involved in. A tourist looking for a museum to visit can receive different recommendations based on the time of day, the distance from different museums, or the number of people in the queue waiting to visit it.

All the collected information is then forwarded to the *Decomposer*. This block has to decide which atomic tasks (sensing, actuation, and computational) compose the query in order for the Virtualization Layer to be able to search for the right objects through the activation of subqueries.

(3) Virtualization Layer. The Virtualization Layer is where the virtual counterpart of the physical objects, namely, the *virtual objects* (VOs), reside. VOs are digital representations of the service(s) of any entity in the IoT, which are usually described in terms of semantics. VOs are implemented as web services and each of them as a related database for the data storage of the information sent by the physical counterpart.

Moreover, at this layer, the physical objects are enhanced with capabilities which enable them to perform operations otherwise hampered on real objects. Traffic lights, proximity sensors, and road cameras can communicate without any problem at this level even if they all use different communication technologies: simple technologies, such as RFID tags and NFC, can be attached to Points of Interest (POIs) to enhance the visiting experience of tourists by interpreting information about the environment and making choices accordingly, in order to push information to users via smartphones or tablets when necessary [14].

The core of this layer is represented by the *Virtual Object Execution Space* (VOES), where all the instances of VOs run. In fact, whenever a new object is detected, based on the information it provides about its resources and functionalities, it is associated with a new virtual object instance in the VOES. This instance is chosen among the possible VO models from a template repository which matches the physical device information. The VO model includes objects' characteristics; objects' location; resources, services, and quality parameters provided by objects.

Every VO is composed of two parts: on one side, it interfaces with the physical object it is associated with. This way it is possible to introduce a standardized communication procedure between the platform and the extremely variegate set of physical devices, so that the VO can switch among multiple communication channels, such as HTTP (Hypertext Transfer Protocol) or CoAP (Constrained Application Protocol) based on the situations. On the other side, the VO is able to communicate with the other VOs in the VOES through the use of a common semantic.

Thanks to this, heterogeneous objects become interoperable at the virtual level, even if they are not at the real-world level, since all the VOs "speak" the same language regardless

of the properties of their physical counterparts. Moreover, since all the data provided by objects are indexed making use of a common language, the discovery of services is simplified.

The metadata about each of the active VOs is maintained in the VO registry, which stores the semantically enriched data that are used for the description of the VOs, in order for them to be available anytime from anywhere.

Whenever the *Search and Discovery Engine* receives a request from the upper layer to find one or more services, this request is matched into VO template names for which VO instances are searched. This module then performs a search in the VO registry in order to discover potentially available and relevant VO instances of the requested VO template names.

(4) Real-World Object Layer. The lowest level of the proposed architecture is made up of real-world objects (RWOs). A RWO can be any entity in the physical domain, human or lifeless, static or mobile, solid or intangible, which is represented in the virtual world through the use of ICT objects. The capabilities and functions of these devices are then described in the Virtualization Layer in terms of sensors, actuators, and resources exposed to the other VOs in the system.

(5) Trust and Security Engine. This layer focuses on the implementation of appropriate security procedures to guarantee reliable communication at every layer. For example, at the Application Layer, it determines the level of access of the apps that generated the requests and grant access accordingly; at the Virtualization Layer, it has to understand how the information provided by the VOs has to be processed in order to ensure that the resources obtained are trustworthy.

(6) QoE/QoS Manager. Quality management is particularly problematic in IoT scenarios due to heterogeneity and mobility issues. The proposed architecture addresses these issues due to the adoption of the VOs; however, a quality manager is still needed to assure that the overall acceptability of applications and services is guaranteed, considering both end-to-end communication requirements (QoS) and the users' expectations (QoE).

4. Use Case

In this section, we analyse how the IoT platform previously described can be used to implement a Smart City scenario specific for the sustainable movement of tourists in the city of Cagliari. The scenario considered in this paper is that of cruise tourists that arrive in Cagliari and have just a few hours to visit the city. The tourists wish to visit some of the city's POIs, in the limited time available before the cruise leaves. For this purpose, we suppose tourists are provided with a smartphone/tablet app where they are able to specify which POIs they wish to visit. The objective is to visit all the desired POIs in the shortest time possible. We detected two main elements that can cause delays to the tourists: (i) choosing the wrong mode of transport to get to the POI and (ii) getting to the POI at the wrong time, when a longer queue time is expected.

For this specific use case, we assume to have sensors placed at each POI's entrance (for those that have one, excluding, e.g., statues, squares), to measure queue waiting time. These sensors, to be physically implemented in the next phase of this work, are virtualized by the Virtualization Layer, so that they are easily interoperable with all the objects that participate to the proposed architecture. Data gathered by the queue sensors is sent to the Service Layer and processed to infer a queue model that associates times of the day to queue waiting times, for the POI under examination. This association is necessary in order to have an estimate queue waiting time at the beginning of the route planning operations.

In our use case, we consider a model based on the mean value of queue waiting times with reference to each time of the day and POI.

Based on the current and expected queue waiting time and on the time needed to get to the POI either by public transport or walking, the optimal route to visit all the selected POIs will be recommended to the tourist.

(1) The Tourist Route Planning Problem. The optimisation problem solved by the application is a typical Travelling Salesman Problem (TSP) [12]: the tourist is given an optimal route where he/she visits each POI only once, minimizing a cost that, in this use case, is considered to be the sum of the time wasted to get to the POI and on the queue.

Given a complete digraph $\mathcal{G}(N, E)$ where N is the set of nodes and E is the set of edges, we associate node $i = 0$ to the tourist starting point and node $i = \{1, \ldots, n\}$ to each POI that the tourist wants to visit. For each edge, we introduce a logical variable $x_{ijk} = \{0, 1\}$ that equals 1 if the tourist goes from POI i to POI j at time step k. Analogously, we introduce a logical variable $y_{ik} = \{0, 1\}$ that equals 1 if the tourist is visiting POI i at time step k.

The cost to get from POI i to POI j at time step k is defined as

$$c_{ijk} = c_{ijk}^{\text{path}} + c_{jk}^{\text{queue}}, \tag{1}$$

where c_{ijk}^{path} is the time needed to go from POI i to POI j at time step k and depends on the mode of transport used; c_{jk}^{queue} is the time spent on the queue at POI j at time step k.

The tourist starts from the starting point $i = 0$. Therefore, it is necessary that

$$y_{00} = 1. \tag{2}$$

Furthermore, the tourist visits each POI exactly once. This is expressed as

$$\sum_{k=1}^{K} y_{ik} = 1 \quad \forall i \in N \setminus \{0\}. \tag{3}$$

Finally, if the tourist visits POI i at time step k, then he/she has to leave it at time step $(k+1)$:

$$\sum_{j\in N} x_{jik} = y_{ik} \quad \forall i \in N \setminus \{0\},\ k \in \{1,\dots,K\},$$
$$\sum_{j\in N} x_{ij(k+1)} = y_{ik} \quad \forall i \in N,\ k \in \{0,\dots,K-1\}. \tag{4}$$

Summarizing, the problem to be solved can be formalized as follows:

$$\begin{aligned}
\min \quad & \sum_{i\in N}\sum_{j\in N\setminus\{0\}}\sum_{k=1}^{K} c_{ijk}x_{ijk} \\
\text{s.t.} \quad & y_{00} = 1 \\
& \sum_{k=1}^{K} y_{ik} = 1 \quad \forall i \in N \setminus \{0\} \\
& \sum_{j\in N} x_{jik} = y_{ik} \quad \forall i \in N \setminus \{0\},\ k \in \{1,\dots,K\} \\
& \sum_{j\in N} x_{ij(k+1)} = y_{ik} \quad \forall i \in N,\ k \in \{0,\dots,K-1\}.
\end{aligned} \tag{5}$$

The problem described by (5) is a binary programming problem, which can be solved using a branch-and-bound algorithm. This type of problem is NP-hard; that is, its complexity scales exponentially with the number of variables [14]. In our case, the number of variables is given by $|x_{ijk}| + |y_{ik}|$, with $i, j \in N$ and $k = \{1,\dots,K\}$. Considering that at each time step the tourist visits one of the POIs, $K = N$ time steps are needed to visit all the POIs. Therefore, problem (5) complexity is proportional to $2^{(N^3+N^2)}$. Although it can appear high demanding for the computational resources involved, it has to be noted that this is just an upper bound that is rarely reached. Furthermore, it needs to be considered that the tourist has a limited amount of time to spend in the city, so he/she can only visit a low number of POIs. Nevertheless, should the problem still be considered too complex, heuristic techniques such as genetic algorithms or swarm intelligence may be used for the subsequent implementation of the entire system, planned in the next phase of this work.

The pseudocode of the Tourist Route Planning Problem described in this subsection is provided by Algorithm 1.

```
For i in POI_list then
    For j in POI_list then
        For k in range(1, POI_number) then
            For m in transp_mode_list then
                Retrieve path_time_ijk[m]
            End For
            path_cost[i, j, k] = min(path_time_ijk)
            queue_cost[j, k] = retrieve queue_time_jk
            Compute cost[i, j, k] according to eq. (1)
        End For
    End For
End For
Find all opt_route that solve eq. (5)
If there is more than 1 opt_route then
    Assign opt_route to the one that corresponds to
    the shortest path
End If
```

Algorithm 1: Tourist route planning problem.

5. Simulations

The use case described in Section 4 has been tested by means of a Python code implemented in the Service Layer of the previously presented architecture. We opted for our own implementation using Python and not for the free tools offered by Google Maps and Bing Maps APIs because of the usage limitations of these solutions.

We considered 67 of the main POIs belonging to the city of Cagliari, including churches, museums, monuments, gardens, towers, and historic buildings. Each tourist can select from 2 to 8 POIs, which can be reached either by bus or walking: each transportation mode represents a different cost, expressed in number of minutes.

To test the behaviour of the application, the POIs have been selected randomly from the map. The starting point is set to the port of Cagliari. In order to evaluate the cost to get from one POI to the other, the Google Maps APIs have been used in an initial phase. The queue waiting times c_{ik}^{queue} have been set randomly from 0 to 30 minutes. To compute the right time step k at which the cost value c_{ijk} has to be computed, we also considered the time spent by users at each POI, supposing that they need an average of 45 minutes to visit each POI. The results obtained using the proposed application, called TRAPP hereinafter, have been compared to the following approaches:

(i) Minimization of the time spent to reach the POIs (called MIN PATH), without taking into consideration the time spent on the queue: this is the typical behaviour of common route planning apps that are not enhanced by an IoT platform.

(ii) Moving to the next closest POI using the bus whenever possible (called ONLY BUS): this is the typical behaviour of a tourist who does not feel like walking.

(iii) Walking to the next closest POI (called ONLY WALK): this is the typical behaviour of a tourist who does not feel like wasting time either waiting for the bus or on the wrong bus line or finding the right bus stop.

Figure 2 shows the mean time values of the overall time spent to get to the POIs and on the queue, the only time spent to get to POIs, and the only time spent on the queue, for the four approaches described above, for different numbers of POIs. Focusing on the overall wasted time, TRAPP outperforms all the compared approaches, enabling to save up to 21% with respect to MIN PATH, up to 44% with respect to ONLY BUS, and up to 55% with respect to ONLY WALK.

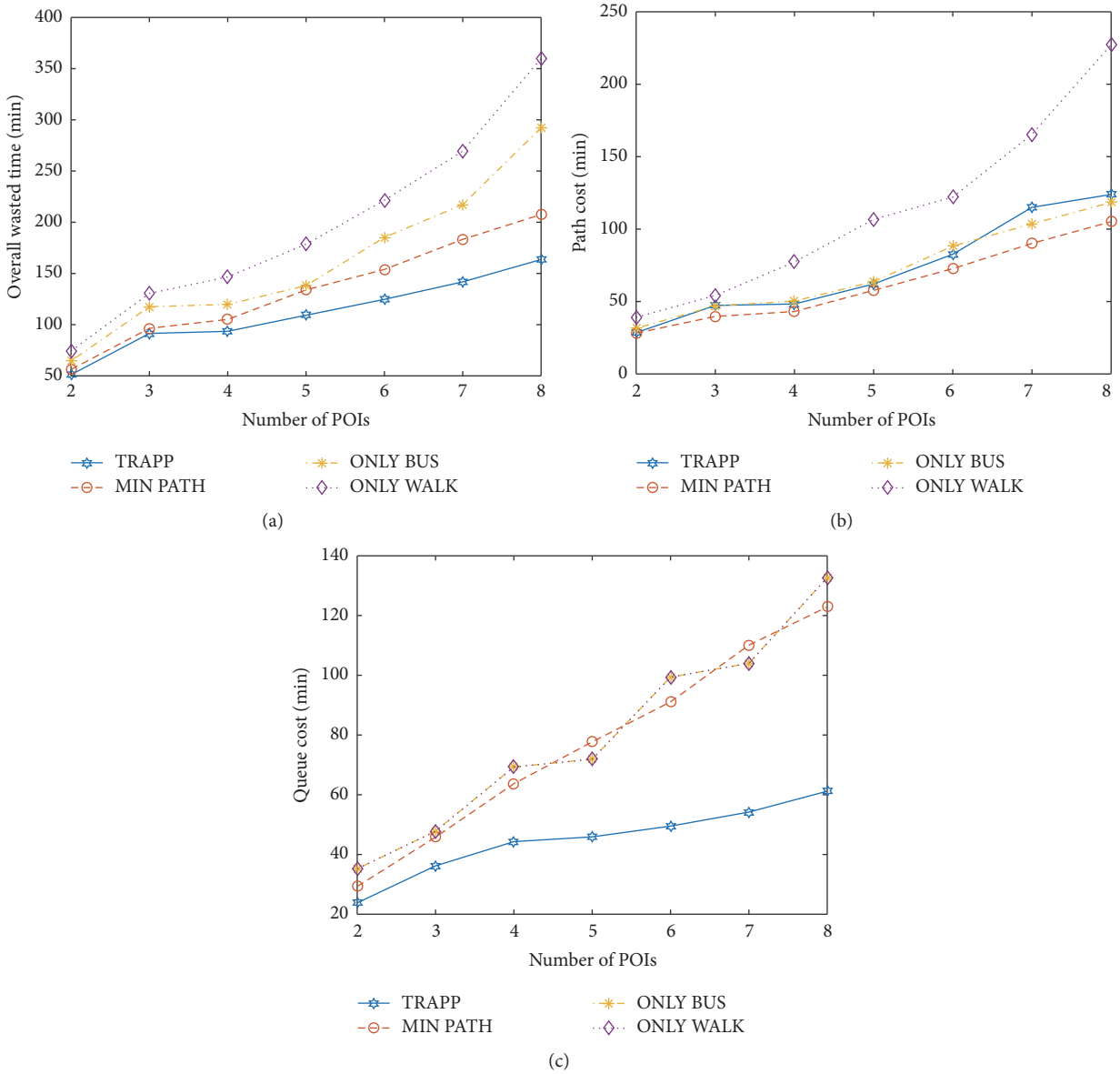

Figure 2: Mean time values for the overall wasted time, path cost, and queue cost for different numbers of POIs.

It has to be noted that, with reference to the queue cost, ONLY BUS and ONLY WALK approaches have the exact same values. This is because in both cases tourists' sequence of visited POIs is the same, as they are moving from one POI to the closest one, but using a different way to reach it.

It is interesting to note that, according to Figure 3, using TRAPP, the tourists' ratio between the distance covered by bus and the total distance is similar to that of MIN PATH when the number of POIs is low, but it gets closer to that of ONLY BUS when the number of POIs considered gets higher. Recall that ONLY BUS ratio is not 100% because it takes into account the distance covered by the tourist to get to bus stops and, in addition to that, sometimes there is no bus line between two POIs. On average, by using TRAPP, the tourist walks 44% of the time.

Cruise tourists usually spend from 6 to 9 hours in Cagliari. Considering this limited amount of time, tourists' satisfaction is higher if they are able to visit all the POIs they have planned to see. Accordingly, we define a satisfaction level given by the ratio between the number of POIs actually visited and the number of POIs that was planned to visit. Figure 4 shows the average tourist satisfaction level of visiting 8 POIs, considering an overall available time of 9 hours, supposing that they spend, on average, 45 minutes to visit each POI.

6. Conclusions

This paper proposes an IoT architecture for a sustainable tourism application in a Smart City scenario. The proposed architecture is tailored for the use case of an application for sustainable tourism. The presented IoT architecture is based

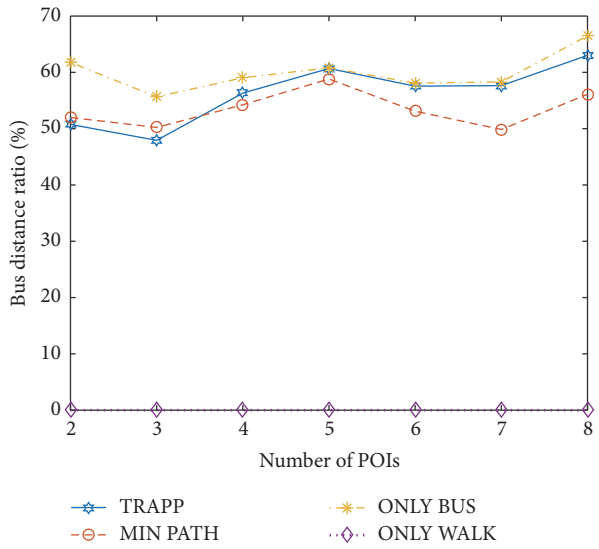

Figure 3: Mean percentage of distance covered by bus, with respect to the overall distance covered either by bus or walking.

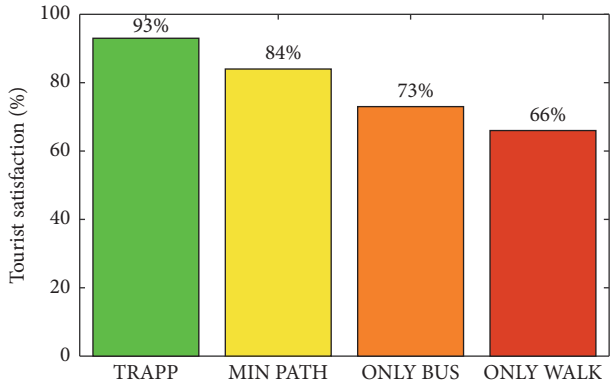

Figure 4: Average tourist satisfaction level to visit 8 POIs, for an overall available time of 9 hours.

on a specific set of requirements and can be implemented using a cloud-based IoT platform. The actual implementation is ongoing and is preceded by the proposed implementation of a specific use case for sustainable movement of cruise tourists that arrive by sea in the city of Cagliari, Italy, and have just a few hours to visit the city. The simulation of the presented use case includes a set of 67 POIs, information about the waiting times at the POIs, and transport information (walking and bus times and distances).

The simulation results evaluate the mean time values of the overall wasted time, the time wasted to get to POIs, the time wasted waiting on the queue, the distances covered by bus or walking, and the average tourist satisfaction level. The results showed that, with reference to other approaches, the proposed application enables tourists to save up to 55% of their time, with a satisfaction level up to 27% higher. Furthermore, the distance covered by bus rather than walking is comparable to that of the approach where tourists chose to use bus whenever possible, particularly for higher number of POIs.

Based on these encouraging first results, we already started the implementation of the proposed IoT architecture on a cloud-based IoT platform. The future work includes the completion of the implementation activities, the deployment of the virtual objects, including the queue and traffic sensors, and the introduction of new constraints to improve the Tourist Route Planning Problem (e.g., considering other modes of transport, user profiling, clustering techniques, and different weights of the cost elements of the problem, based on user preferences).

Acknowledgments

The research activities described in this paper have been conducted within the Research Project "Cagliari Port 2020" of the Italian Research Ministry Project Call "Quadro Strategico Nazionale 2007–2013, Programma Operativo Nazionale Smart Cities."

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Evolving MCDM Applications Using Hybrid Expert-Based ISM and DEMATEL Models: An Example of Sustainable Ecotourism

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Academic Editors: B. Niu and J. Pavón

Ecological degradation is an escalating global threat. Increasingly, people are expressing awareness and priority for concerns about environmental problems surrounding them. Environmental protection issues are highlighted. An appropriate information technology tool, the growing popular social network system (virtual community, VC), facilitates public education and engagement with applications for existent problems effectively. Particularly, the exploration of related involvement behavior of VC member engagement is an interesting topic. Nevertheless, member engagement processes comprise interrelated sub-processes that reflect an interactive experience within VCs as well as the value co-creation model. To address the top-focused ecotourism VCs, this study presents an application of a hybrid expert-based ISM model and DEMATEL model based on multi-criteria decision making tools to investigate the complex multidimensional and dynamic nature of member engagement. Our research findings provide insightful managerial implications and suggest that the viral marketing of ecotourism protection is concerned with practitioners and academicians alike.

1. Introduction

This section includes the engagement behavior for a virtual community, the importance of environmental concerns, and our research objectives and problems.

As information technology (IT) advances, the words "community" and "network" are commonly referred to as "virtual community, VC." VC sites formed by the internet offer users the ability to interact with others and exchange information and knowledge of the environment. Various social networking sites are emerging to attract a large number of users to participate in discussions on current issues and trends. Previous studies that indicate the factors that will affect user interest to use social networking sites are mainly focused on their initial beliefs (perceived usefulness and ease of use) as well as the attitudes to explore ideas for their use. Chen [1] claimed that the concept of community network originated from Barnes [2]: an anthropologist discovered the concept from an investigation of the social structure of a Norwegian fishing village. One cannot clearly explain the actual operations of a fishing village by looking at the formal role of social structure, such as identity or status. Instead, one can explain the interactions in a fishing village from looking at the informal role of social structure, such as friends and relatives and how they organize and impact an internal social network. Mitchell [3] argued that social networks show the interrelationship among individuals of a particular society. Pattison [4] believed that social networks are a social organization that collectively gather from the interrelationship among individuals and organizations. Chan et al. [5] claimed that individual behavior and attitudes demonstrate that a particular environment was influenced

by the interconnections with other individuals in that social environment. The network connects nodes and nodes together form the structure. The nodes can be individuals, teams, or organizations [6], and its overall structure describes social behavior.

In recent years, development of VC websites has grown rapidly. The use of social networking and their fast growth have become an important trend. According to the Business Next [7] survey of the top 100 Taiwan websites, 25 community sites were selected among to represent 25% of the overall list. After the financial crises of 2008, the VC website development seems to be the most promising and popular business model or trend. This trend is buttressed by social networking sites and microblogs, such as Facebook, Twitter, and Plurk. Users from US President Barack Obama, former GE chief executive Jack Welch, to Dell Computer and Starbucks Coffee, are utilizing this trend [8]. According to a survey by ComScore [9], the number of VC websites has grown at an amazing rate.

How will social networking sites grow to replace other types of sites, such as shopping sites and search engine websites, as users actively become more involved with these activities? Here are some important reasons. (1) Social networking sites bring interpersonal relationships into virtual situations; (2) they create more opportunities for human interaction and real-time sharing of personal information such as pictures, videos, and interactive games; and (3) users can create their own program to share many features that will meet their social, leisure, and entertainment needs. Thus, social networking sites successfully win user interest, which makes it a popular site type. They attract many users in VCs to share information and emotional communication. This free, open yet with hidden features communication platform has led various "internet communities" to spread [10]. Ecotourism and environmental concern communities have sprung up as a result.

Increasingly, the ecological degradation problems are highlighted and environmental protection issues have emerged from social networking sites to express awareness and priority concerns. One of the greatest challenges for sustainable ecotourism is to encourage visitors to act in ways that minimize environmental and experiential impact. This is the case for protected areas where the environment is often fragile and mindful and engaging experiences are sought. Previous research shows that all types of recreational activities can cause environmental damage, even at low use levels [11, 12] and visitor behavior and density levels influence the quality of visitor experiences [13].

Protected area managers employ a suite of strategies to address visitor problems, though for reasons of expediency, cost, and efficiency, education is the preferred and dominant visitor management worldwide [14–16]. As Ham and Weiler [17] pointed out, interpretation is ultimately aimed at communicating messages about a place and, in some instances, the persuasion of people to behave in ways that are consistent with the protected values. Therefore, a better understanding for how visitors think and what factors determine their behavior could contribute to better achieve managerial goals. Given these reasons, we explore the behaviors that are amenable to persuasive influence and how to tap into the relevant thoughts held by visitors about particular actions.

This study is aimed at the most popular social networking sites related to ecotourism issues (ecotourism VCs). We use the technology acceptance model (TAM) proposed by Davis et al. [18] to study IT user intention and behavior to investigate the participation of members of a virtual environmental protection community. Simultaneously, the quality of information and system from the virtual sites to achieve user information and system satisfaction are explored as well as the correlation between user attitude and willingness. In summary, information and system quality, satisfaction, perceived usefulness, and ease of use are discussed. The aforementioned factors affect VC member attitudes, intentions, and participation results. The four research objectives of this study are as follows: (1) integrate two major IT successes related research streams, namely, technology acceptance and user satisfaction; (2) explore the dynamics among object-oriented beliefs and attitudes, behavioral beliefs and attitudes, as well as engagement behavior; (3) investigate the interactive and co-creation value behavior of environmental protection VC; and (4) suggest effective strategies for the promotion of environmental protection issues.

This study determines the motivations and objectives. The remainder of this paper is organized as follows: Section 2 looks at related literature on VC marketing of ecotourism concerns. Section 3 looks at techniques used and establishes our study framework and decisions for the appropriate research methodology. Section 4 looks at our online questionnaires for an empirical case study that was distributed and analyzed with statistical software and a series of techniques. Section 5 shows our findings and the managerial implications are described. Section 6 is our conclusions and future research directions offered.

2. Literature Review

This section describes the relevant literature, including sustainable ecotourism, social network sites and VCs, and related technology acceptance.

The first mention of ecotourism in the English-language academic literature was by Romeril [19]. In the 1990s, the tourism industry realized the profit potential of ecotourism and the suffix "eco" was used by travel agents for marketing. Eventually, ecotourism organizations, such as the International Ecotourism Society (TIES) and the Ecotourism Society (TES), were formed [20]. While some may use the term "ecotourism" as being synonymous with "nature tourism," "adventure tourism," "responsible tourism," "ethical tourism," and "green tourism;" ecotourism does have specific characteristics that differentiate it from these other segments in the tourism industry. A subset of sustainable tourism (tourism that actively reduces the negative impact of tourism), ecotourism is defined by TIES as "responsible travel to natural areas that conserves the environment and improves the welfare of local people" [21, 22]. Additionally, ecotourism should build a constituency to promote conservation and provide an impetus for private conservation efforts.

Under these circumstances, conservation benefits can extend beyond the immediate experience of an ecotourism venture, as ecotourists become active advocates for conservation in the area visited as well as at home [23].

Ecotourism has been identified as a growing niche market for years. According to the World Resources Institute, while tourism grew by 4% in the early 1990s, "nature travel" grew at a rate between 10 and 30% [24]. World Tourism Organization estimates show global spending on the more narrowly defined ecotourism market increasing at a rate of 20% per year, about five times the rate for tourism [24]. However, more striking than this growth is the identification of ecotourism by its advocates as part of an ethical lifestyle (a form of life politics). Particularly, the idea, ecological degradation, is an escalating global threat. Increasingly, the worldwide awareness and concern expressed regarding the environmental problems that surround them. The concern for environmental issues focuses on education as to improve environmental behavior [25] and to study behavior as it relates to remediation of environmental issues. Thus, one way experts can promote environmental improvement through mediators is to examine the link between educational intervention and responsible behavioral change [25]. It is believed that environmental education is linked to environmental behavior. From this, environmental education leads to greater awareness and attitude change that improves environmental protection behavior. Such behavior was successful to change pro-environmental intention and actions that presented as credible environmental information as well as to become actively involved participants in sustainable ecotourism. Sustainable ecotourism has been widely researched in various fields, such as the related literature [26–32].

Some of the latest research on ecotourism, such as analyses on the relationships among tourism [33]; the measurement of sustainable tourism development indicators and developing standards associated [34]; and issues regarding zoos as a morally acceptable form of ecotourism [35]. Our study explores related ecotourism involvement behavior for VC members.

Social networking sites have gained important and vigorous development, most notably Facebook, MySpace, Plurk, and Twitter. The formation of virtual communities from the related literature [36] is an important research area. There were prior studies done regarding social networks. First, House et al. [37] had pointed out that social networks can be divided into two parts: structure and process. As for the structure, they may include social integration and network structure. Yeh and Luo [38] indicated that online dating patterns were similar to the real world. Existent real social networks influenced the formation and development of online communities. Boyd and Ellison [39] claimed that social network sites provided the following functional characteristics: (1) construct a public or semipublic profile within a bounded system; (2) articulated a list of other users with whom they share a connection; and (3) view and traverse their list of connections and those made by others within the system. Xia and Bu [40] described the topic in social network analysis; community detection can help us discover the network properties shared by its members. The VC was widely used for purposes of collaborative recommendation [41], knowledge sharing [42–44], and online market research [45, 46]. Although the nature and nomenclature of these connections may vary from site to site, professional VCs provide spaces that allow domain experts to interact, to assist in the creation, and to share tacit knowledge with the goal of becoming an intelligent enterprise [47–49].

The related technology acceptance literature includes the theory of reasoned action (TRA), theory of planned behavior (TPB), and the technology acceptance model (TAM). TRA was improved by Fishbein and Ajzen [50] and was based on social psychology theory that was widely and successfully applied in various disciplines. TRA states that behavioral intentions to perform a specific behavior predict, explain, or influence actual performance of the said behavior. TPB predicts deliberate behavior based on the assumption that behavior is deliberative and planned [51]. TPB suggests that behavior is determined by intention to perform the behavior and that this intention is, in turn, a function of attitude toward the behavior and subjective norm. TAM proposed by Davis et al. [18] studied the idea of IT user intention and behavior. This model is one of the most acceptable models in the investigation of IT related behaviors. It encompassed Web 2.0 technology focused subjects [52] and recognized two primary principles: "Perceived Usefulness" and "Perceived Ease of Use," which are major predictors of user attitude and complete emotional reaction for usage.

3. Methods and Materials

3.1. Information System Success Model. In the system management area, a crucial topic is to successfully implement an information system (IS) into an organization. An IS was used to enhance a business to create competitive advantage [53]; however, IS of IT will result in failure if it not accepted by its users. Therefore, the evaluation of success of an IS success model (ISSM) has been an important subject to organizations.

DeLone and McLean [54] proposed a successful IS model that indicated the factors that influenced successful IS is comprised of six parts: (1) system quality, (2) information quality, (3) use, (4) user satisfaction, (5) individual impact, and (6) organizational impact. They showed that system and information quality affects the level of use and user satisfaction as well as the level of use to positively or negatively affect user satisfaction. In additional, use level and user satisfaction will affect individuals and organizations. Pitt et al. [55] has added another factor "service quality" in addition to the six listed above. They demonstrate that service quality along with system quality and information quality together affected the use and user satisfaction levels. DeLone and McLean [56] later augmented this revised successful IS model. The revised model additionally added service quality as well as including system quality, information quality, service quality, user intention, user satisfaction, and net benefit.

The literature on user satisfaction indicates that IS characters were core factors, such as system quality, information quality, and service quality in a successful IS model as well as

higher order and overall expectancy disconfirmation in the post-acceptance model (PAM) [54, 57]. Bhattacherjee [57] proposed that PAM should be combined with expectancy disconfirmation theory (EDT) and TAM to better investigate user intentions for continual use IS. Furthermore, user satisfaction was regarded as the attitude toward a particular IS, whereas, it should be considered as an object-oriented attitude [58, 59]. This opinion is indicated by various satisfaction correspondence measurements that have adopted system character-oriented measures [60–62].

System characters affect the beliefs and attitudes toward the system itself. Along with behavior beliefs and attitudes as media, they manipulated final use behavior of the system. For example, the perceived reliability of an e-commerce website cannot directly control the use of that website. Nevertheless, it can affect his/her attitude (satisfaction) toward that website and, then, buttress the beliefs (i.e., ease of use) and attitude to use it, and, eventually, the use behavior. Wixom and Todd [59] effectively partitioned and empirically supported the relationship of object-oriented beliefs, object-oriented attitude, behavior beliefs, and behavior attitude based on the expectancy-value theory and the correspondence principle.

3.2. The Delphi Method. The Delphi method is a research technique that is used to address complex problems by using a structured communication process of a panel of experts [63] to forecast, make decisions, and solve complex problems. With objective application of the Delphi method, we explore creative ideas and produce valuable information. Knowledge collected during the Delphi study is synthesized and distilled from the use of a series of questionnaires. Responses to questionnaires were collected on site and were reviewed directly [64]. A few of the features of the Delphi method include: (1) rapid consensus, (2) participants can reside anywhere, (3) coverage of wide range of expertise, and (4) avoid groupthink. The limitations of the Delphi method include: (1) cross impact neglected in the original form, (2) does not cope well with paradigm shifts, and (3) success of the method depends on the quality of the participants. Delphi has been applied to various issues, such as to forecast a specific and single-dimension future issue, consensus building, and avoidance of groupthink and to generate creative ideas [63]. The features of the Delphi method provide comprehensive expert opinion and much needed objective consensus.

The latest research on ecotourism uses the Delphi method. For example, they analyze the relationships among tourism [33] and developed a point evaluation system for ecotourism destinations [65]. This study thus uses the Delphi method to analyze VC for eco-travel expert consensus.

In the standard Delphi method, several experts are consulted for estimations of a project or to prognosticate it. The process of Delphi method is described as follows.

(1) A project manager prepares a description of the project, in that the individual partial products are listed and prepared on a job form.

(2) The project manager presents the goals of the overall project and distributes copies of the job form to each expert; however, it does not take place of a discussion of the estimations.

(3) Each expert estimates the work packages contained in the job form; there is no cooperation between experts.

(4) All job forms are collected and evaluated by the project manager.

(5) If serious discrepancies result, then these are commented on by the project manager uniformly on all job forms as regard to the deviation. Each job form is then returned to its original editor,

(6) The experts consider their estimations as a function of the comments.

(7) The described loop repeats itself until the estimations independently (in a range of tolerance) consent to adjustment.

(8) The average values are calculated and presented by all estimations as the final estimation.

3.3. The ISM Method. Warfield [66, 67] first proposed interpretive structural modeling (ISM) to analyze complex socioeconomic systems. It is a process that helps individuals or groups to structure domain knowledge into a model of interrelationships to enhance the understanding of its complexity. The result of the ISM process is represented by a graph that shows the directed relationships as well as hierarchical levels of elements within the system under consideration. A few features of the ISM method include: (1) incorporating the subjective judgments and the knowledge base of experts systematically, (2) to provide ample opportunity for revision of judgments, and (3) computational efforts involved are far less for criteria ranging from 10 to 15 numbers as well as used as a handy tool for real-life applications [68]. The limitations of the ISM method include: (1) the contextual relation among the variables always depends on user knowledge and familiarity with the firm, its operations, and its industry; (2) the bias of the judgment variables influence the final result; (3) ISM acts as a tool to impose order and direction on the complexity of relationships among the variables; and (4) there is no weight associated with the variables [69]. ISM has been widely applied in various fields, such as supply chains [70], balanced scorecard [71], success factors [72], product design [73], and risk analysis [74]. The ISM method can transform nebulous thoughts and ideas into an intuitive model of structural relationships to understand the relationship between the variables.

The computational processes in the ISM method are described in the following steps.

(1) Identification of elements through research (e.g., literature review) or expert opinion (e.g., Delphi or brainstorming).

(2) Specification of contextual relationship depends on the objective and nature of the case.

(3) Construction of a structural self-interaction matrix (SSIM) in four types of possible relationships between the elements (a & b).

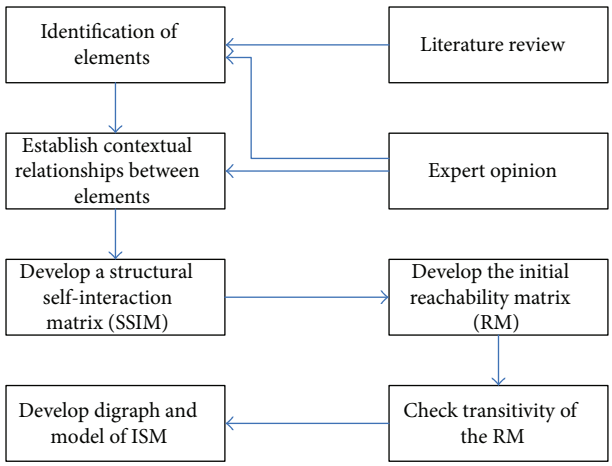

Figure 1: Flow diagram for implementing ISM.

(4) Transformation of SSIM into an initial reachability matrix (RM) in the rules for the substitution of 1s and 0s.

(5) Checking the initial RM for transitivity.

(6) Partitioning levels of the final RM.

(7) Building ISM digraph and model.

The ISM is generated by replacing all element numbers with the actual element description. Finally, the ISM gives a clear picture of the relationships among the system of elements. Conclusively, Figure 1 shows the above steps of the ISM method. Furthermore, the details of ISM method can be referred to the Warfield [66, 67] for the limited space.

3.4. The DEMATEL Method. The decision making trail and evaluation laboratory (DEMATEL) method is a mathematical procedure originated from the Geneva Research Centre of the Battelle Memorial Institute designed to deal with important issues of world societies [75, 76]. The DEMATEL possesses some excellent features. For example, it is based on matrices that represent the contextual relation as well as strength of influence of the elements for the target system. It converts the cause-effect relationship of elements into visible structural models. With its practical benefits, the DEMATEL has been widely applied in various fields, such as marketing [77, 78], education [79, 80], investment [81], supply chain management [82, 83], smart phone [84], and influential factors [85]. The DEMATEL method has advantages that help researchers better understand the nature of the problem.

Mathematically, the procedures of DEMATEL are narrated step-by-step as follows.

Step 1. Generate the initial direct-relation matrix. Acquire the assessments about direct affect between each pair of elements from experts. The pair-wise comparison designated by four levels: 0, 1, 2, and 3 to represent "No influence," "Low influence," "High influence," and "Very high influence," respectively. The initial direct-relation matrix A is a $n \times n$ matrix, in which a_{ij} is denoted as the degree to which the element i affects the element j is formatted as $A = [a_{ij}]_{n\times n}$.

Step 2. Normalize the initial direct-relation matrix. The normalized direct-relation matrix $X = [x_{ij}]$ can be obtained from (1) and (2).

$$s = \max\left[\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}, \max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\right], \quad i, j \in \{1, 2, \ldots n\}, \tag{1}$$

$$X = \frac{1}{s}A, \tag{2}$$

where (1) represents the maximum values of the sums of all the rows and the sums of all the columns and (2) represents the normalized initial direct-relation matrix. All elements in matrix X comply with $0 \le x_{ij} \le 1$ and all principal diagonal elements are equal to 0.

Step 3. Compute the total relation matrix. After Step 2, the total relation matrix, T, is obtained by using the following numerical calculation:

$$T = X + X^2 + \cdots + X^p = X \times (I - X)^{-1} = \left[x_{ij}\right]_{n\times n} p \longrightarrow \infty, \tag{3}$$

where p represents the power. Hence, when p tends to infinity, the matrix X will converge. Furthermore, I is the identity matrix.

Step 4. Calculate the sum of rows and columns of matrix T. The sum of rows and the sum of columns are separately denoted as vector D and vector R as follows:

$$T = \left[t_{ij}\right]_{n\times n}, \quad i, j = \{1, 2 \ldots, n\}, \quad D = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = \left[t_{ij}\right]_{n\times 1}, \quad R = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = \left[t_{ij}\right]_{1\times n}. \tag{4}$$

Step 5. Construct a cause-effect diagram. The cause-effect diagram is drawn by mapping the data set of the $(D+R, D-R)$. The horizontal axis vector $(D + R)$ named "prominence" is made by adding D to R, which shows the importance of the element. Similarly, the vertical axis $(D-R)$ named "relation" is made by subtracting D from R. When $(D - R)$ is positive, the element belongs to the cause group; otherwise, the element belongs to the effect group [86, 87].

After calculating the means of $(D + R)$ and $(D - R)$, the causal-effect diagram is divided into four quadrants, I to IV. Elements in quadrant I have high prominence and relation which indicates the highest interaction influence level with other elements. Thus, they are identified as driving factors; elements in quadrant II have low prominence but high relation, are identified as voluntariness; elements in quadrant III have low prominence and relation. They are relatively disconnected from the system. The elements in quadrant IV

have high prominence and low relation, which indicates their importance as impacted by other elements [88]. From this diagram, the complex interrelationship among elements is visualized to provide valuable insight for decision making. Especially, the DEMATEL method needs experts to decide on a threshold value to concentrate on most important effects from consideration in matrix T.

3.5. Research Methodology. This section introduces the study procedures, including research framework, research design, and data collection.

3.5.1. Research Framework. Based on the above related literature review, this study organizes ISSM, TAM, TPB, and TRA models to propose a research framework for exploring member engagement behavior as shown in Figure 2 with 12 major dimensions. In this framework, information quality, system quality, information satisfaction, and system satisfaction are based on ISSM; usefulness, ease of use, and attitude are related to TAM; subjective norms, perceived behavior control, environmentally conscious behavior are constructed from TRA; and engagement behavior, as well as engagement consequences are involved in TRA. These dimension will be measured by expert opinion through Delphi technique as described later.

3.5.2. Research Design. Since members of environmental protection VCs exert a multi-function dynamic, complex, and value co-creation behavior, multi-criteria decision making (MCDM) is employed to gain insights when concerned with the relationships. This study presents ISM and DEMATEL methods to solve real-life applications of MCDM problems, which provide a complete understanding of the procedures of MCDM tools. Figure 3 shows a flowchart of our proposed method of study.

3.5.3. Data Collection. This subsection briefly elucidates the computational processes using an empirical case study, including case introduction, research subject definition, and instrument development.

(1) Case Introduction. Two most popular ecotourism VCs in Taiwan, EZTravel and LulalaTravel, are committed to ecological and environmental protection.

First, for a constructed web site, http://eztravel.com/ was established in January 2000 to provide a full range service of online booking and online payments. It has total capital of NT$218 million with 460 employees and more than 2.2 million served members (many might be tourists). It has been the leader among domestic online travel agents in Taiwan. It maintained sustainable rapid growth in the revenue and has been ranked a top operating performer among domestic tourism websites. http://eztravel.com/ has aimed to aggressively develop differentiated fashionable products to satisfy various demands from consumers. It enhanced its core competitiveness to create profitability. EZTravel has originated the following specialized tours: environmental protection tourism, luxury tours on trains, million dollars around the world, tours of most of the world, international travelers, and a variety of tours with local themes. Particularly, environmental protection tourism has been welcomed and focused on.

Second, LulalaTravel Company was established on December 2005. The company has a mission to serve younger travelers, which has originated from the China Youth Corp. It has been expanding domestic tourist activities legally and professionally. In April 2006, the company established eight branch offices: Keelung City, New Taipei City, Taichung City, Changhua County, Yunlin County, Chiayi County, Tainan City, and Yilang County. LulalaTravel has 32 professional operators who handle all the business related to tourism as well as offers courses to educate professional tour guides, military instructors, and university staff. Thus, they created sequential training courses for the continual education of tourism professionals. LulalaTravel emphasizes ecotourism based on a mission from the China Youth Corp to provide a variety of services. They have originated many activities, such as educational group athletic activities, mountain training, casual weekends, holiday tours, potential development, upstream canoeing, and survival games. During summer and winter breaks, LulalaTravel offered various educational tasks to perform ecological leisure activities that had incorporated ecological themes for Taiwan.

(2) Research Subjects. Twelve professionally active members of ecotourist VCs were invited to engage in this study, mainly by contributing their opinions regarding the relationships among all research variables (Figure 2) through the Delphi process to find group consensus as input to all later related analyses.

(3) Instrument Development. Table 1 shows the instruments of this study as constituted by the components and their related elements.

4. Experiment and Data Analysis

We decomposed our study framework into three models, namely models 1–3 (Figures 4, 5, and 6) to thoroughly investigate the dynamics of the variables identified in our research model. Afterwards, we describe the profile of the experts that we have interviewed; and, then, conduct ISM and DEMATEL analyses for the three models.

4.1. Expert Profiles. We conducted a questionnaire to gather the opinions of experts. A total of 12 eco-travel experts participated in our questionnaire using the Delphi method. Thus, 12 surveys were received. The survey lasted from April 2012 until May 2012. The first round of surveys was received on April 16 2012. We compiled and summarized different opinions from the experts and then sent them a second round of questionnaires. After five rounds of opinion consolidation, we received a final consensus from the experts on May 25 2012. Table 2 summarizes the demographic profile of 12 experts.

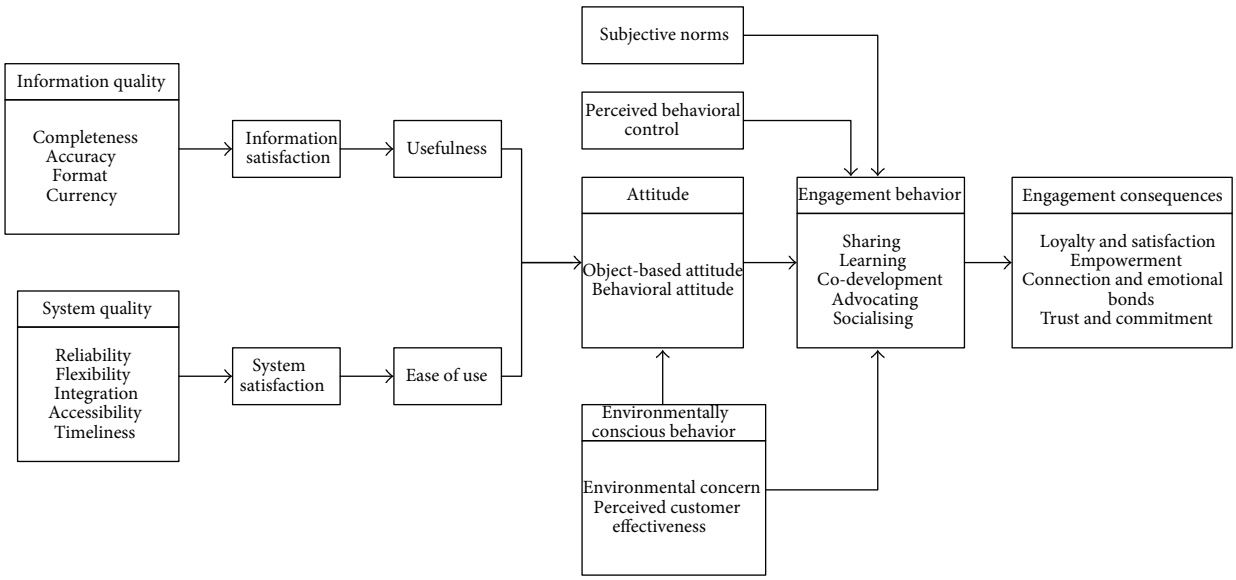

Figure 2: Research framework of this study.

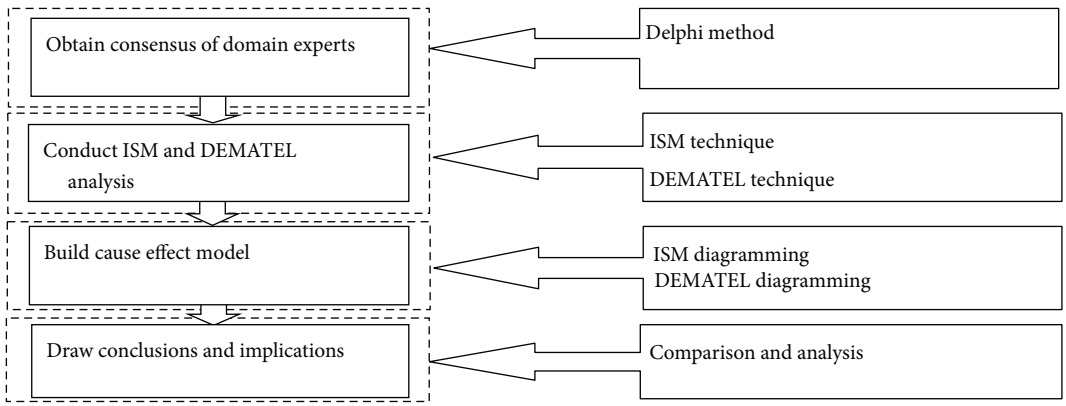

Figure 3: Flowchart of the proposed method of the study.

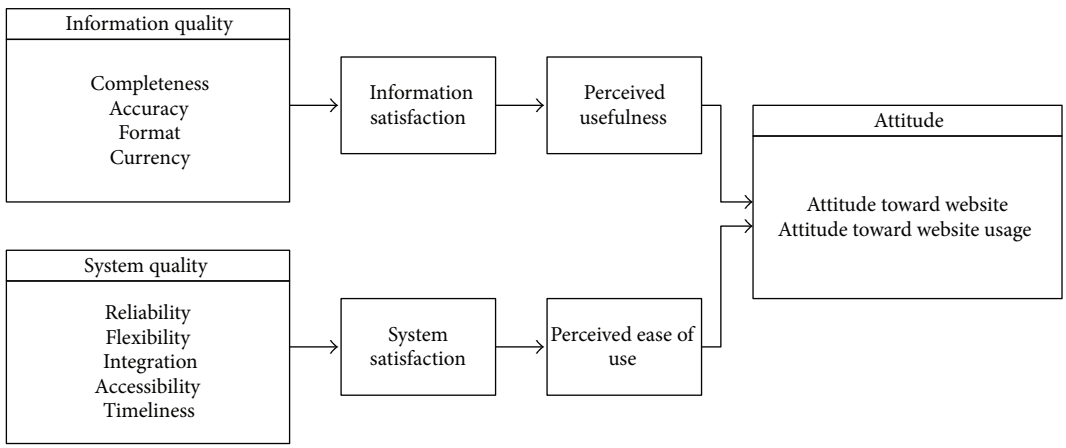

Figure 4: The structure of proposed model 1.

Table 1: System component definitions.

Components	Definitions	Elements	Reference
C1: engagement consequences	The desired results of engagement behavior	E11: loyalty and satisfaction E12: empowerment E13: connection and emotional bonds E14: trust and commitment	[89]
C2: engagement behavior	The interaction and value co-creation behavior of community members	E21: sharing E22: learning E23: co-development E24: advocating E25: socializing	[89]
C3: perceived behavioral control	An individual's perception on the ease or difficulty of conducting the behavior	—	[51, 90]
C4: attitude	A favorable or unfavorable evaluation of something	E41: object-based attitude E42: behavioral attitude	[59]
C5: environmentally Conscious Behavior	Recognizing the serious of environmental problems, people proactively engaged in recycling, saving electricity and water, and so forth	E51: environmental concern E52: perceived customer effectiveness	[91]
C6: subjective norms	An individual's estimate of the social pressure on him/her to engage or not engage in the target behavior	—	[51]
C7: perceived usefulness	Beliefs concerning instrumental outcomes associated with technology use	—	[92]
C8: perceived ease of use	Beliefs that technology use will be relatively free of cognitive burden	—	[92]
C9: information satisfaction	The degree of favorableness with respect to the information produced by the system	—	[59]
Ca: system satisfaction	The degree of favorableness with respect to the system and the mechanics of interaction	—	[59]
Cb: information quality	Desired features of the information produced by the system	Cb1: completeness Cb2: accuracy Cb3: format Cb4: currency	[59]
Cc: system quality	Desired features of the system and the mechanism of interaction	Cc1: reliability Cc2: flexibility Cc3: integration Cc4: accessibility Cc5: timeliness	[59]

4.2. ISM Analysis. In ISM analysis, a four-stage approach was used to systematically analyze. They are as follows: (1) construct structural self-interaction matrix, (2) generate reachability matrix, (3) partition the levels, and (4) building the ISM model.

4.2.1. Construct Structural Self-Interaction Matrix. The first step of ISM analysis was to perform analysis on the contextual relationship of variables. Based on the consensus from the expert panel, we captured the relationships in structural self-interaction matrixes (SSIM) for models 1–3.

4.2.2. Generate Reachability Matrix. Next, the SSIM is transformed into a binary matrix called initial reachability matrix by substituting the arrows by related 1 and 0.

4.2.3. Partition the Levels. From the final reachability matrix, the reachability set, and antecedent set for each variable were obtained. The reachability set includes variables themselves and others that help, while the antecedent set consists of variables and the other variables that help. Consequently, the intersection of these sets was derived for all variables. The variable for which its reachability was set to equal its intersection set is identified as the top-level variable in the ISM hierarchy. One important feature of the top-level variable in the hierarchy is that it does not help achieve any other variable above its own level. Therefore, once the top-level variable is identified, it is separated from the other variables. The same process is repeated to find out the next level until the level of each variable was found. Tables 3, 4 and 5 for models 1–3, respectively, show and summarize the results for the iteration process. Particularly, models 1, 2, and 3 show levels of 4, 3, and 2, respectively.

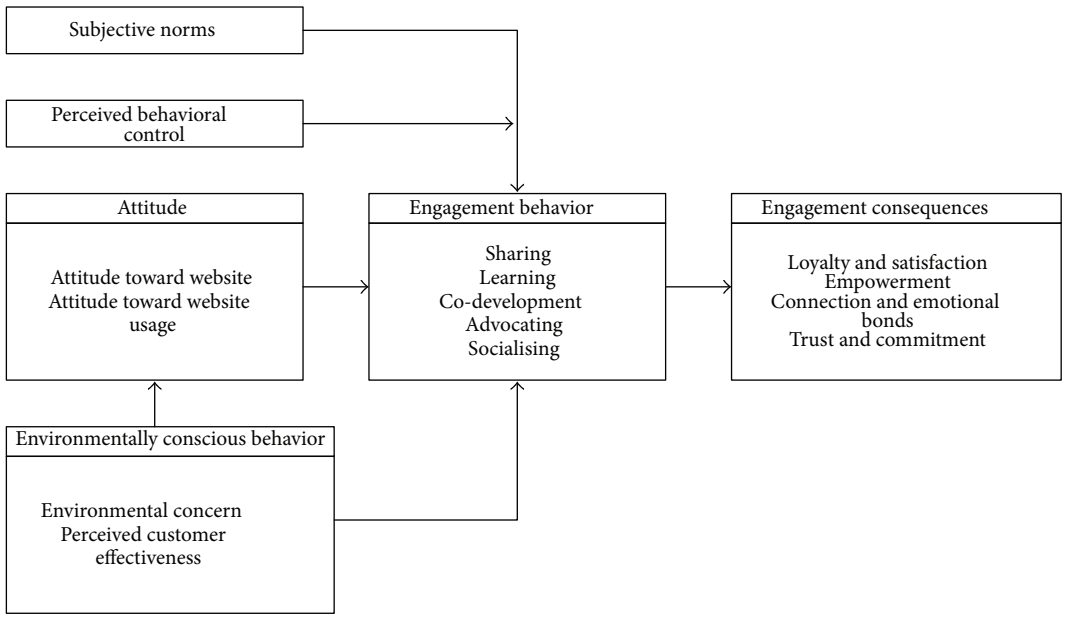

Figure 5: The structure of proposed model 2.

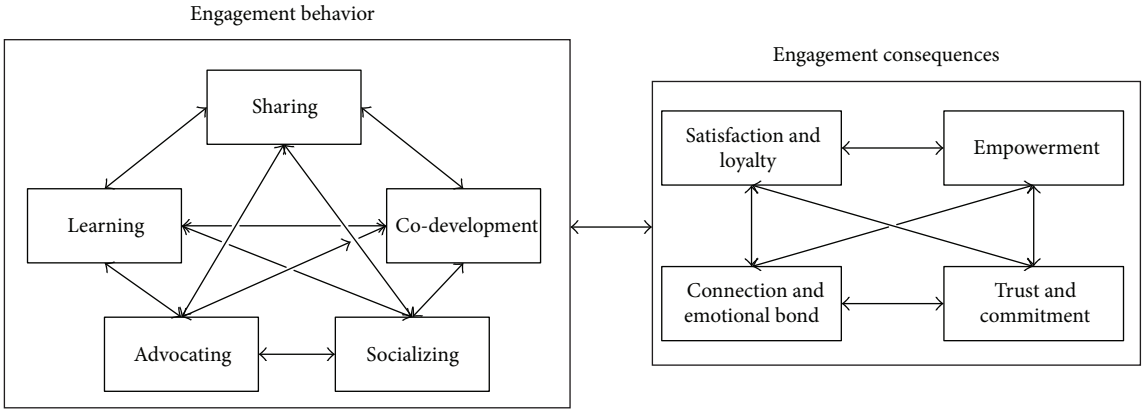

Figure 6: The structure of proposed model 3.

4.2.4. Building the ISM Model. Based on the final reachability matrix, the structural model of the proposed three models can be generated. If there is a relationship between variable i and j, then an arrow is drawn to connect the two points. This graph is called a directed graph or digraph. After removing the transitivity, the digraph is finally transformed into the ISM-based model (Figures 7, 8, and 9) for model(s) 1–3, respectively.

4.3. DEMATEL Analysis. As for DEMATEL analysis, the five-stage approach was analyzed in detail and includes: (1) obtain average matrix from experts; (2) normalize the average matrix to get initial direct-relation matrix; (3) compute the total relation matrix; (4) calculate the sum of rows and columns of total relation matrix; and (5) construct the cause-effect diagram.

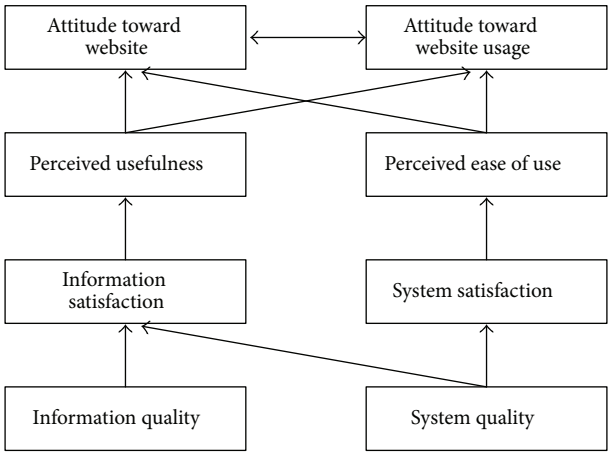

Figure 7: Four levels of structural model of model 1.

4.3.1. Obtain Average Matrix from Experts. First, the assessments of the direct affect between each pair of variables designated by the four levels, 0–4, are summarized as an average matrix of models 1–3 (Tables 6, 7 and 8).

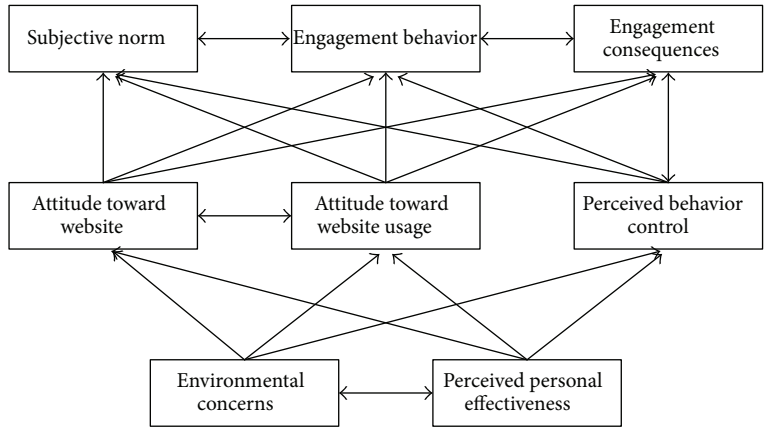

Figure 8: Three levels of structural model of model 2.

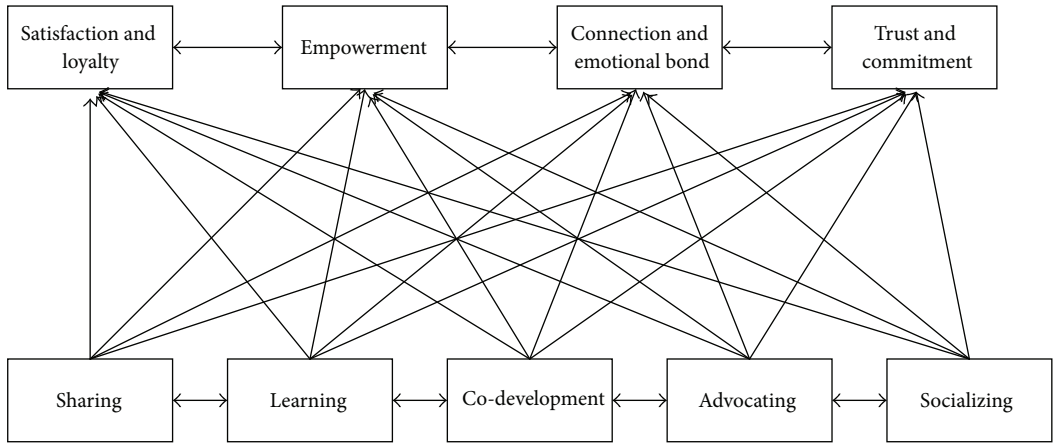

Figure 9: Two levels of structural model of model 3.

4.3.2. Normalize the Average Matrix to Get Initial Direct-Relation Matrix. The average matrix is normalized by dividing all elements by the maximum values from the sums of all rows as well as the sums of all columns. For the limited space, only Table 9 shows the above results on the initial direct-relation matrix of model 1.

4.3.3. Compute the Total Relation Matrix. The direct relation matrix has further raised its power to gain a convergent total relation matrix. For the limited space, only Table 10 shows the above results on the total relation matrix of model 1.

4.3.4. Calculate the Sum of Rows and Columns of Total Relation Matrix. Let vectors D and R denote the sum of rows and the sum of columns from total relation matrix, respectively, and then the values were obtained for models 1–3. Particularly, the average values of $(D + R)$ and $(D - R)$ were taken as the axial cross of Y $(D - R)$ and X $(D + R)$ in the next stage.

4.3.5. Construct the Cause-Effect Diagram. By mapping the data set of $(D + R, D - R)$, a casual diagram was drawn, where X of ($D + R$, prominence) was made by adding D to R, and Y of ($D - R$, relation) was made by subtracting D from R. Based on the means of $(D + R)$ and $(D - R)$, four quadrants were identified with their respective natures. Quadrants I and IV are defined as strong "cause" and "effect" factors of desired outcome, respectively. In contrast, Quadrants II and III are defined as weak "cause" and "effect" factors for desired outcomes, respectively. Thus, the cause-effect diagrams for the Models 1–3 can be drawn as Figures 10, 11, and 12.

5. Results and Discussion

We explored the analytical results to mine hidden information from our empirical case study for the research models. The following implied study findings and implications that suggest the management of engagement behavior that stem from the VC are compiled. They are of value to the academics and practitioners who focus on ecotourism community fields.

5.1. Findings

(1) Ecotourism Virtual Community Acceptance. Given its huge investments and great impact on businesses, the evaluation of information system success has gained wide attention

Table 2: The demographic variables of 12 experts.

Demographic variables	Number ($N = 12$)	Percentage
Gender		
Male	5	41.7%
Female	7	58.3%
Age		
Below 30 years old	3	25.0%
31~40	3	25.0%
41~50	4	33.3%
51 years old and above	2	16.7%
Educational		
Certificate	2	16.7%
Bachelor	7	58.3%
Master	2	16.7%
Doctoral	1	8.3%
Experience in online tourism		
Less than 5 years	2	16.7%
5–10	3	25.0%
11–15	1	8.3%
16–20	4	33.3%
21 years and above	2	16.7%
Ecotourism virtual communities (most frequently engaged)		
EZTravel	6	50.0%
LulalaTravel	6	50.0%

and involvement from academia. Traditionally, this area has been investigated within two primary research streams: the user satisfaction literature of ISSM (e.g., DeLone & McLean [54]) and the technology acceptance literature of TAM (e.g., Davis et al. [18]). These two approaches have been developed in parallel and have not been reconciled or integrated [59]. To bridge this gap, Wixom and Todd [59] have proposed an integrated research model that distinguishes between object-based beliefs and attitudes toward "the system" as well as behavioral beliefs and attitudes toward "using the system" and successfully links two dominant approaches. They also emphasized the correspondence principle for accurate predictions, beliefs, and attitudes must be specified in a manner that is consistent in time, target, and context with the behavior of interest [50]. Namely, to predict IS acceptance behavior, behavioral beliefs and attitudes performed better than object-based beliefs and attitudes. In our model 1 ISM model, all these propositions were supported well. Wixom and Todd [59] validated our study findings.

(2) Ecotourism Virtual Community Engagement Consequence. One important track of this study is customer engagement (CE). According to Brodie et al. [89], in the highly dynamic and interactive business environment, CE plays a role in co-creating customer experiences that values and receives increasing attention from business practitioners and academics alike. As salient evidence for this development, Marketing Science Institute (MSI) chose CE as a key research priority for 2010–2012. Even though most CE research is business-oriented, this study assumed the concept also applied to ecotourism VC context. The results of model 3 justified this point. Table 11 offers justification of the 5 fundamental propositions (FP) of CE summarized by Brodie et al. [89] as well as evidence from this study.

(3) Ecotourism Virtual Community Engagement Behavior. Kim and Han [91] have tested and modified the TPB by adding two important concepts: environmental concerns and perceived customer effectiveness, which contribute to environmentally conscious behavior that helps to critically predict eco-friendly consumer behaviors. This study follows this approach in Model 2 and verifies these two constructs exert critical driving power to impact users' attitude toward the website as well as its usage. Besides, they affect perceived behavioral control directly, then engagement behavior and engagement consequences. Compared with TPB, model 2 revealed an interesting finding that subjective norms play the role of an effect instead of a cause variable. This phenomenon indicates attitudes toward ecotourism VCs and perceived behavioral control work together to shape a social pressure that will encourage engagement.

(4) Summarization of Cause and Effect Factors. Salimifard et al. [93] has suggested a driving power-dependence diagram to help classify various decision factors into four clusters. The cluster in quadrant I include "linkage" elements that have strong driving power and dependence. The implication is that all the factors above this level are affected by them, while these elements are also dependent on lower level factors for the ISM model. The cluster in quadrant II consists of dependent factors that have weak driving power but strong dependencies. Factors in this cluster are the most important and influential ones. The cluster in quadrant III includes "autonomous" factors that have weak driving power and weak dependence. These factors are relatively disconnected from the system. Finally, the cluster in quadrant IV includes "dependent" factors that have weak driving power but strong dependence. These factors are representative of a desired system of outcomes. Figures 13, 14, and 15 show the driving power and dependence diagrams of this study.

(5) Overlapping Extension of Cause and Effect Factors. Afterwards, we compared cause and effect variables in models 1–3 identified by different ISM and DEMATEL algorithms. Tables 12 and 13 show the results. Obviously, great overlapping between them, which are highlighted in black-frame, was found. This phenomenon revealed that the performance of two intelligent methods provides similar analytical results toward an exploration of engagement behavior of ecotourism VC members to imply that the study results can be trusted.

Finally, the two methods are desirable for the following two reasons.

Reasons on Selected Used Techniques. First, ISM and DEMATEL under the MCDM condition are two major methodologies with the capability to clarify complex relationships

Table 3: Levels of model 1 elements.

Element	Reachability set	Antecedent set	Intersection set	Level
A1	A1A3A5A7A8	A1	A1	4
A2	A2A3A4A5A6A7A8	A2	A2	4
A3	A3A5A7A8	A1A2A3	A3	3
A4	A4A6A7A8	A2A4	A4	3
A5	A5A7A8	A1A2A3A5	A5	2
A6	A6A7A8	A2A4A6	A6	2
A7	A7A8	A1A2A3A4A5A6A7A8	A7A8	1
A8	A7A8	A1A2A3A4A5A6A7A8	A7A8	1

Table 4: Levels of model 2 elements.

Element	Reachability set	Antecedent set	Intersection set	Level
B1	B1B2B4B7B8	B1B2B5B6	B1B2	2
B2	B1B2B4B7B8	B1B2B5B6	B1B2	2
B3	B3B4B7B8	B3B5B6	B3	2
B4	B4B7B8	B1B2B3B4B5B6B7B8	B4B7B8	1
B5	B1B2B3B4B5B6B7B8	B5B6	B5B6	3
B6	B1B2B3B4B5B6B7B8	B5B6	B5B6	3
B7	B4B7B8	B1B2B3B4B5B6B7B8	B4B7B8	1
B8	B4B7B8	B1B2B3B4B5B6B7B8	B4B7B8	1

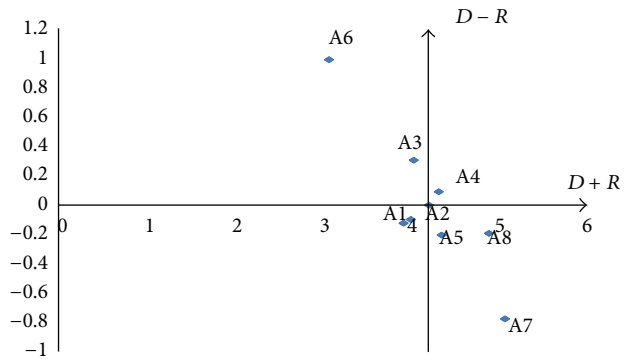

Figure 10: Cause-effect diagram of model 1.

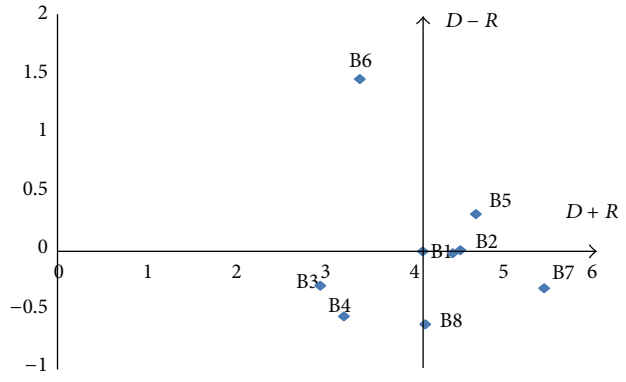

Figure 11: Cause-effect diagram of model 2.

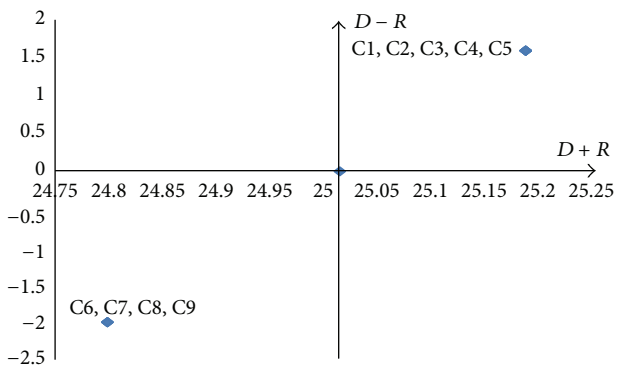

Figure 12: Cause-effect diagram of model 3.

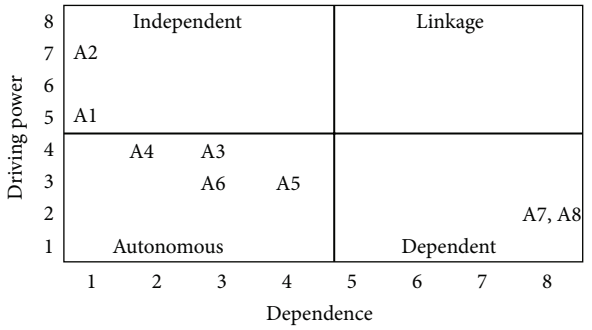

Figure 13: Driving power-dependence diagram of model 1.

between the elements involved in complex decision making. There are several similarities between them, such as they emphasize a cause-effect relationship among several decision elements (e.g., the driving power and dependence in ISM and the prominence and relation in DEMATEL) as well as present the relationships in easily understood diagrams.

Table 5: Levels of model 3 elements.

Element	Reachability set	Antecedent set	Intersection set	Level
C1	C1C2C3C4C5C6C7C8C9	C1C2C3C4C5	C1C2C3C4C5	2
C2	C1C2C3C4C5C6C7C8C9	C1C2C3C4C5	C1C2C3C4C5	2
C3	C1C2C3C4C5C6C7C8C9	C1C2C3C4C5	C1C2C3C4C5	2
C4	C1C2C3C4C5C6C7C8C9	C1C2C3C4C5	C1C2C3C4C5	2
C5	C1C2C3C4C5C6C7C8C9	C1C2C3C4C5	C1C2C3C4C5	2
C6	C6C7C8C9	C1C2C3C4C5C6C7C8C9	C6C7C8C9	1
C7	C6C7C8C9	C1C2C3C4C5C6C7C8C9	C6C7C8C9	1
C8	C6C7C8C9	C1C2C3C4C5C6C7C8C9	C6C7C8C9	1
C9	C6C7C8C9	C1C2C3C4C5C6C7C8C9	C6C7C8C9	1

Table 6: The average matrix of model 1.

	A1	A2	A3	A4	A5	A6	A7	A8	Row total
A1	0	1	4	1	3	1	2	2	14
A2	1	0	1	4	1	3	2	2	14
A3	3	1	0	1	4	1	3	3	16
A4	1	3	1	0	1	4	3	3	16
A5	2	1	3	1	0	1	4	4	16
A6	1	2	1	3	1	0	4	4	16
A7	1	1	2	2	3	3	0	4	16
A8	1	1	2	2	3	3	4	0	16
Column total	10	10	14	14	16	16	22	22	22

Table 7: The average matrix of model 2.

	B1	B2	B3	B4	B5	B6	B7	B8	Row total
B1	0	4	1	1	3	3	4	3	19
B2	4	0	1	1	3	3	4	3	19
B3	1	1	0	1	1	1	4	3	12
B4	1	1	1	0	1	1	4	3	12
B5	4	4	1	1	0	4	4	3	21
B6	4	4	1	1	4	0	4	3	21
B7	3	3	3	3	3	3	0	4	22
B8	2	2	2	2	2	2	2	0	14
Column total	19	19	10	10	17	17	26	22	26

Table 8: The average matrix of model 3.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	Row total
C1	0	4	4	4	4	4	4	4	4	32
C2	4	0	4	4	4	4	4	4	4	32
C3	4	4	0	4	4	4	4	4	4	32
C4	4	4	4	0	4	4	4	4	4	32
C5	4	4	4	4	0	4	4	4	4	32
C6	3	3	3	3	3	0	4	4	4	27
C7	3	3	3	3	3	4	0	4	4	27
C8	3	3	3	3	3	4	4	0	4	27
C9	3	3	3	3	3	4	4	4	0	27
Column total	28	28	28	28	28	32	32	32	32	32

Table 9: Initial direct-relation matrix of model 1.

	A1	A2	A3	A4	A5	A6	A7	A8
A1	0.000	0.045	0.182	0.045	0.136	0.045	0.091	0.091
A2	0.045	0.000	0.045	0.182	0.045	0.136	0.091	0.091
A3	0.136	0.045	0.000	0.045	0.182	0.045	0.136	0.136
A4	0.045	0.136	0.045	0.000	0.045	0.182	0.136	0.136
A5	0.091	0.045	0.136	0.045	0.000	0.045	0.182	0.182
A6	0.045	0.091	0.045	0.136	0.045	0.000	0.182	0.182
A7	0.045	0.045	0.091	0.091	0.136	0.136	0.000	0.182
A8	0.045	0.045	0.091	0.091	0.136	0.136	0.182	0.000

Nevertheless, ISM considered four possible relationships, while DEMATEL investigated the relationships deeper with a more sophisticated evaluation (from 0 to 4), as well as allowing different degrees of mutual influences. Therefore, ISM is more macro-oriented and DEMATEL more micro-oriented. They can complement each other to exert synergic benefits. As far as our limited knowledge, no research has adopted this approach. We also proved the adequacy of this approach.

5.2. Managerial Implications. The management implications in this study are based on the ISM and DEMATEL methods.

5.2.1. ISM Method

(1) Model 1. System and information quality are important factors in IS. Good quality systems bring community members a better site experience and good information quality makes them willing participants in ecotourism VCs for getting the latest ecotourism information.

(2) Model 2. Environmental concerns affect the attitude of the community members and ease of design of the system interface in the use of IS. Furthermore, the power of the

Table 10: Total relation matrix of model 1.

	A1	A2	A3	A4	A5	A6	A7	A8
A1	0.189	0.222	0.303	0.209	0.310	0.081	0.312	0.267
A2	0.223	0.197	0.192	0.344	0.229	0.169	0.319	0.273
A3	0.330	0.253	0.161	0.247	0.372	0.089	0.382	0.329
A4	0.252	0.338	0.218	0.206	0.245	0.220	0.386	0.333
A5	0.279	0.227	0.292	0.214	0.196	0.084	0.403	0.371
A6	0.221	0.277	0.189	0.298	0.235	0.040	0.398	0.366
A7	0.241	0.247	0.235	0.284	0.330	0.175	0.257	0.373
A8	0.279	0.283	0.269	0.303	0.352	0.178	0.457	0.221

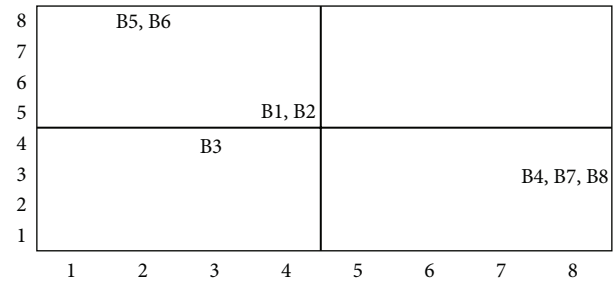

Figure 14: Driving power-dependence diagram of model 2.

community is a driving force to learn and share engagement behavior to promote environmental awareness. Ecotourism experiences share common topics of the natural environment through social networking sites.

(3) Model 3. The engagement on the public discussion that has enough emotion to form a network of human relationships with certain characteristics of social organization for the promotion of ecotourism VC issues is a positive relationship over time. Thus, common ecotourism virtual issues were developed through learning and sharing among the community members. Particularly, member loyalty enhanced the community and resulted in the real value of the community sites.

5.2.2. DEMATEL Method. (1) Model 1. System quality is a major driving power for other system components. Besides, system satisfaction and information satisfaction greatly influence system beliefs and attitude. Consequently, enhancing system infrastructure, such as hardware and software, as well as encouraging information sharing will be beneficial for community members' active and better engagement.

(2) Model 2. Environmental concerns and perceived personal effectiveness have strong influencing power on other system components. The emphasis on environmental protection was enhanced through the understanding of the importance of environmental issues. More importantly, the use of VCs to strengthen the basic concepts of international conservation and sustainable development are interesting issues that combine the power of the community members on the internet

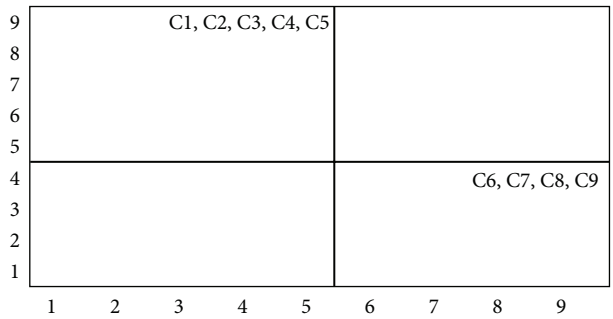

Figure 15: Driving power-dependence diagram of model 3.

and the awareness of environmental protection to every corner of the world.

(3) Model 3. Sharing, learning, co-development, advocating, and socializing have a strong relationship with other system components. Community members that share their ideas provide mutual understanding as well as contribute to the development of the community to achieve a vested emotion. The relationship and the sharing of member demands are to foster a sense of trust and commitment. The operation of the community website provides the members a centripetal force to achieve the maximum benefits of the community network.

6. Conclusions

The MCDM is a sub-disciplinet of operations research that explicitly considers multiple criteria in decision-making environments. However, there typically exist multiple conflicting criteria that need to be evaluated for making decisions. Therefore, structuring complex problems well and considering multiple criteria explicitly lead to more informed and better decisions. They are developed methods that transform such complex problem into essentially single criterion problems. They are used to solve MCDM problems by constructing value functions. Perhaps, a well-known method includes ISM and DEMATEL. Particularly, the two methods have seldom been seen in hybrid use to solve MCDM problems in ecotourism VCs.

Given the above reasons, this study focused on filling these knowledge gaps and conducting an intelligent hybrid model to solve a real life application problem that involves MCDM toward sustainable ecotourism. This study has proposed hybrid expert-based ISM and DEMATEL models that are suitable for those members of environmental protection VCs who intend to use intelligent systems. This study performs well and provides useful insight into the key characteristics that explores member engagement behavior in the VC industry and is critical with respect to responding to the rapidly changing environment under VC members that exert the multi-functions of dynamic, complex, and value co-creation behavior. The analytical results have important implications that are worthwhile for practitioners and academics that focus on environmental protection in VCs. Moreover, future research can be done in three directions as

Table 11: The justification of research results on FP of CE.

	Fundamental propositions	Justification
FP1	CE reflects a psychological state that occurs by virtue of interactive customer experiences with a focal agent/object within specific service relationships.	(i) The focal agent/object a customer interacts with may be a brand, product, or organization (i.e., the ecotourism VC). (ii) Focal CE behaviors that have a brand- or firm-focus extend beyond transactions/purchase (the environmental concern in ecotourism VC transcends over transactions). (iii) Two-way interactions generating CE may occur within a broader network of customers, stakeholders, and other actors in specific service relationships (there are different participating roles in ecotourism VC).
FP2	CE states occur within a dynamic, iterative process of a service relationship that co-creates value.	CE processes may range from short-term to long-term, relatively stable to highly variable processes typified by CE levels varying in complexity over time (there is different degrees of involvement in ecotourism VC).
FP3	CE plays a central role within a nomological network of service relationships.	(i) There is antecedent as well as consequence factors of ecotourism virtual community engagement behavior, as shown in our research framework. (ii) The mutual-influence and iterative nature of engagement behaviors imply that specific CE consequence may extend to be an antecedent in the next process.
FP4	CE is a multidimensional concept subject to a context and/or stakeholder-specific expression of relevant cognitive, emotional, and behavioral dimensions.	(i) Variables in this research framework include cognitive (e.g., information quality and system quality), emotional (e.g., attitude toward website itself and website usage), and behavioral (e.g., engagement behavior) dimensions in nature. (ii) Different situational conditions might generate distinct CE complexity levels.
FP5	CE occurs within a specific set of situational conditions generating differing CE levels.	Specific interaction between a customer and a focal agent/object and other actors within specific focal relationships may generate different levels of cognitive, emotional, and/or behavioral CE intensity, depending on specific CE stakeholder and contextual contingencies driving particular CE levels (the casual model acquired by ISM or DEMATEL analyses show this dynamic well).

Table 12: Cause and effect factors identified by ISM model.

Model	Dependent	Independent
1	A7 (attitude toward website)	A1 (information quality)
	A8 (Attitude toward website usage)	A2 (system quality)
2	B4 (subjective norm)	B1 (attitude toward website)
	B7 (engagement behavior)	B2 (attitude toward website usage)
	B8 (engagement consequences)	B5 (environmental concerns)
		B6 (perceived personal effectiveness)
3	C6 (satisfaction and loyalty)	C1 (sharing)
	C7 (empowerment)	C2 (learning)
	C8 (connection and emotional bond)	C3 (co-development)
	C9 (trust and commitment)	C4 (advocating)
		C5 (socializing)

Table 13: Cause and effect factors identified by DEMATEL model.

Model	Strong dependent variables	Strong independent variables
1	A5 (perceived usefulness)	A4 (system satisfaction)
	A7 (attitude toward website)	
	A8 (attitude toward website usage)	
2	B1 (attitude toward website)	B2 (attitude toward website usage)
	B7 (engagement behavior)	B5 (environmental concerns)
	B8 (engagement consequences)	
3	C6 (satisfaction and loyalty)	C1 (sharing)
	C7 (empowerment)	C2 (learning)
	C8 (connection and emotional bond),	C3 (co-development)
	C9 (trust and commitment)	C4 (advocating)
		C5 (socializing)

follows. (1) To screen and organize a domain expert panels with excellent experience in ecotourism virtual communities and apply procedures suggested by Delphi method and focus groups to find consensus efficiently and effectively from the use of larger samples to conduct structural equation modeling (SEM) to cross-verify the study results; (2) to investigate the dynamic nature decision elements more insightfully; analytical network process (ANP) can be applied especially for the engagement related variables; and (3) other qualitative research methods, such as interactive qualitative analysis (IQA) and means-ends chain (MEC) by laddering analysis can also be applied to gain more detailed responses from domain experts.

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Spatial Pattern Evaluation of Rural Tourism via the Multifactor-Weighted Neural Network Model in the Big Data Era

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Academic Editor: Syed Hassan Ahmed

The exploration of the evaluation effect of rural tourism spatial pattern based on the multifactor-weighted neural network model in the era of big data aims to optimize the spatial layout of rural tourist attractions. There are plenty of problems such as improper site selection, layout dispersion, and market competition disorder of rural tourism caused by insufficient consideration of planning and tourist market. Hence, the multifactor model after simple weighting is combined with the neural network to construct a spatiotemporal convolution neural network model based on multifactor weighting here to solve these problems. Moreover, the simulation experiment is conducted on the spatial pattern of rural tourism in the Ningxia Hui Autonomous Region to verify the evaluation performance of the constructed model. The results show that the prediction accuracy of the model is 97.69%, which is at least 2.13% higher than that of the deep learning algorithm used by other scholars. Through the evaluation and analysis of the spatial pattern of rural tourist attractions, the spatial distribution of scenic spots in Ningxia has strong stability from 2009 to 2019. Meanwhile, the number of scenic spots in the seven plates has increased and the time cost of scenic spot accessibility has changed significantly. Besides, the change rate of the one-hour isochronous cycle reaches 41.67%. This indicates that the neural network model has high prediction accuracy in evaluating the spatial pattern of rural tourist attractions, which can provide experimental reference for the digital development of the spatial pattern of rural tourism.

1. Introduction

Nowadays, with the close integration between information technology and the tourism industry, the Internet, big data, and artificial intelligence have rapidly become the hot technologies of industrial development. Especially, relevant incentive policies issued by the government and increased financial subsidies, which encourage the development of tourism and other projects in remote mountain villages, have injected new vitality into rural development and brought significant economic growth. However, some problems have appeared in rural tourism, such as improper site selection, layout dispersion, construction repetition and inefficiency, and market competition disorder, during the accelerated development as a result of improvident consideration of the planning basis and tourist market [1, 2]. Therefore, the application of artificial intelligence and big data analysis technology to the optimization of the spatial structure of rural tourism has become the focus of scholars in the current relevant fields.

The tour is a kind of sightseeing and entertainment activity on the premise of the coexistence of human society and natural environment. In recent years, the advocacy of "lucid waters and lush mountains are invaluable assets" and related documents on rural tourism have been proposed by the Chinese central government, which has become an important guiding force for the efficient and rapid development of rural tourism in China [3]. The Ningxia Hui Autonomous Region is one of the minority concentrated areas in northwest China. It puts ecological environment protection in the first place under the "The Belt and Road Initiative" policy and the economic protection strategy in the Yellow River Basin. Meanwhile, Ningxia is working hard to ensure ecological security in the middle and upper reaches of

the Yellow River and achieve the goal of building a beautiful China. Furthermore, due to the topography in Ningxia, more than 80% of the tourism resources are concentrated in rural areas, which have become the largest potential area for tourism development in the province with obvious advantages over the whole country [4]. The unique natural resources and geographical environment and other ecological advantages in Ningxia promote rural tourism into an important force progressing fast in the economic development of Ningxia. Meanwhile, a series of relevant policies issued by the government not only provide strong support for the development of rural tourism but also clarify the specific development direction and planning. This makes the number of rural tourism spots in Ningxia show rapid growth momentum in recent years.

With the rapid increase in rural tourist attractions, changes in economy, policy, and traffic changes have a deepening impact on rural tourism, resulting in the transformation of the spatial pattern of rural tourism. The rapid development in rural tourism also increases the demand for corresponding tourism space, which intensifies the contradiction between supply and demand of space in the region and leads to the imbalance of spatial utilization structure in the region [5]. In other words, the fast development of the economy and living standards of the people has also destroyed the original, pure, and natural environment artificially. In recent years, artificial intelligence technologies, such as big data analysis and artificial neural networks, have been widely used in various industries, such as machine translation, image recognition, and natural language processing. Deep learning, as one of the artificial intelligence algorithms, can learn multilevel features of data from raw data such as the spatial pattern of the original geographical environment without the participation of experts in related fields, which greatly saves the cost of labor, material and time [6, 7]. Meanwhile, the deep learning algorithm can classify tasks according to the important characteristics learned, which has far-reaching engineering practice value in the spatial pattern evaluation of rural tourism.

In summary, the evaluation and analysis of the spatial pattern of rural tourism are of great practical value for the development of tourism. The innovations of the existing research are as follows:

(i) Taking Ningxia Hui Autonomous Region in Northwest China as the research object, the research evaluates the spatial pattern of rural tourism.

(ii) The research analyzes the confusion of rural tourism location and scattered layout caused by insufficient consideration of various factors such as the planning basis of rural tourism.

(iii) Based on the simple weighting of the multifactor model, combined with neural network, the research constructs a spatiotemporal convolution neural network model based on multifactor weighting. Finally, the evaluation effect of rural tourism spatial pattern is analyzed through simulation.

The research is structured as follows: Section 1 is the introduction that mainly explains the current situation and background of rural tourism and the research purpose and significance. Section 2 is the related works, which mainly analyzes the research status of scholars related to rural tourism and algorithms. Section 3 mainly constructs and evaluates the model of rural tourism spatial pattern based on multifactor-weighted neural network algorithm. Section 4 is the results and discussion. After the simulation of the rural tourism spatial pattern model, its performance is analyzed and discussed more clearly. Section 5 is the conclusion that summarizes the research methods and results to provide basis for follow-up research. Section 6 is future work, which analyzes the shortcomings, and explains the follow-up research.

2. Related Works

2.1. Current Situation of Rural Tourism Development. At present, with the accelerating process of urbanization and the rapid improvement of people's living standards, people pay more attention to their spiritual needs while satisfying material needs. As one of the rural revitalization strategies advocated by the state, rural tourism has been studied by many scientific researchers. Su et al. [8] adopted a mixed methods research design, including quantitative questionnaires and qualitative semistructured interviews, to analyze tourism and rural sustenance at Hetu Town, Anhui Province, China. They found that the utilization of synergistic relationships between tourism and other sources of income could improve the overall livelihood sustainability. Meanwhile, they discussed the practical significance to enhance tourism participation and ensure appropriate benefit sharing with an emphasis on the roles of government [8]. Guaita Martínez et al. [9] demonstrated that tourism was a key sector in the sustainable development of rural environments. Hence, they proposed a more comprehensive and objective method to compare the level of seasonality of a group of rural destinations with that of coastal and urban destinations. Through the study, they found that the methodology enabled them to identify, which variables explained the differences in the level of seasonality of each destination to a large extent. Finally, the research results showed that the variables that do so are related to the internalization of the destination and changes in the availability of bed places [9]. Cunha et al. [10] explored the motivation, management practices, and consequences of rural tourism entrepreneurs considering data obtained from eight small tourism accommodation units, whose owners participated in semistructured interviews. The results revealed long-term planning and tend to form robust networks of entrepreneurs, which clearly contributed to not only the establishment of a dynamic but also more sustainable entrepreneurial ecosystem of tourism in rural areas [10]. Chi and Han [11] took Anji County as a case to comprehend the role of rural tourism destination performances in affecting destination image and predicting satisfaction and loyalty and verified the moderating effect of tourists' expectation [11]. These above works can provide certain guidance and reference for scholars and rural tourism practitioners to deepen the

research on tourism expectations, rural tourism performance, destination image, and the relationship between tourist satisfaction and loyalty.

2.2. Application Status of Neural Network Algorithms in Tourism. Today, neural networks are widely used in diverse industries, and many researchers have analyzed its application in emerging tourism. Lee et al. [12] analyzed the prediction performance of backpropagation neural networks (BPNNs), radial basis function networks (RBFNs), probabilistic neural networks (PNNs), and clustered probabilistic neural networks (CPNNs) in tourism. They found that PNNs performed best in all artificial neural networks, especially showing extreme accuracy in predicting underrepresented modes [12]. Petersen et al. [13] proposed a system for bus travel time prediction that leveraged the nonstatic spatiotemporal correlations present in urban bus networks, allowing the discovery of complex patterns not captured by traditional methods. Finally, they found that the multioutput, multitime step, deep neural network using a combination of convolutional and long short-term memory (LSTM) significantly outperformed all the other comparative methods [13]. Abdollahi et al. [14] proposed a multistep deep learning-based algorithm for predicting travel time. They found that feature extraction and clustering algorithms could be used to improve the feature space, which was robust [14]. Hu et al. [15] used artificial neural network (ANN) simulation to reveal the characteristics of human activity patterns and urban functions. They demonstrated that the proposed method, with relatively less loss and high accuracy, outperformed other comparative methods for classifying urban functions at the road segment level. Besides, they believed that their work contributed to the assessment of urban functional structure and further aid urban planners in designing better urbanization strategies with regard to traffic interaction and urban space structure [15].

Through the above scholars' research, most of the current research on rural tourism focuses on tourism resources, tourism development, tourism development mode, problems, and countermeasures, etc., while focusing little on the spatial structure of rural tourism and the spatial problems. Moreover, the application of applying deep learning to tourism is mainly in the prediction of travel time rather than in the design of tourism spatial pattern. Therefore, the neural network is introduced into the simply weighted multifactor model to construct a multifactor-weighted neural network model to evaluate the spatial pattern of rural tourism with the research object of rural tourist attractions in Ningxia.

3. Construction and Evaluation of Rural Tourism Spatial Pattern Based on Multifactor-Weighted Neural Network Algorithm

3.1. Overview of the Study Area. Ningxia Hui Autonomous Region is referred to as Ningxia, and Yinchuan is its provincial capital. Located in the northwest inland area of China, east of Shaanxi, west and north of Inner Mongolia, and south of Gansu, Ningxia occupies a total area of 66,400 square kilometers, located in the northwest of the four geographical divisions [16]. The terrain in Ningxia gradually tilts from southwest to northeast, with hills and ravines standing in numbers, consisting of three plates: the northern Yellow River irrigation area, the central arid zone, and the southern mountainous area. The autonomous region is located in the Yellow River water system, and the terrain is high in the south and low in the north, showing a ladder-like decline. The whole region is located in the continental arid and semiarid climate zone [17]. Ningxia Hui Autonomous Region administrates 5 prefecture-level cities (9 municipal districts, 2 county-level cities, and 11 counties), with two national AAAAA-level tourist attractions of the China Western Film Studio in Zhenbeibu and the Sand Lake, several 4A-level tourist attractions (including 96 A-level scenic spots), and numerous rural scenic spots [18]. There are mainly seven tourism plates in Ningxia: Great Sand Lake Holiday and Leisure Area, Xixia Cultural Tourism District, Saishang Hui Township Cultural Experience Plate, Frontier Cultural Tourism Plate, Great Shapotou Resort and Leisure Plate, Weizhou Historical and Cultural Tourism Plate, and Great Liupan Red Ecological Resort Plate [19]. Among them, the study area in Ningxia is shown in Figure 1.

3.2. Analysis on the Goal of Rural Tourism Pattern Construction. The spatial pattern of rural tourism not only affects the spread and flow of people, materials, and information in rural tourism activities but also guarantees the normal and orderly operation of various functions of rural tourism. Under the rapid development of the social economy, people's diversified spiritual needs have brought good opportunities for the development of rural tourism. However, mature rural tourism has cumulatively higher requirements for spatial patterns, which have an increasingly obvious impact on rural tourism. The requirements of rural tourism on the spatial pattern are mainly reflected in the rational utilization of resources, the correct guidance of the market, and the reasonable layout of products, as shown in Figure 2.

As shown in Figure 2, firstly, the rational development and utilization of rural tourism resources play an important role in the long-term and orderly development of rural tourism activities. Moreover, the construction of the spatial pattern can ensure the rational use of rural tourism resources and the maximum utilization of the developed parts. Secondly, the correct guidance of the rural tourism market requires the spatial pattern to ensure the accurate implementation of rural tourism market positioning and planning. Thirdly, the spatial pattern of multilayer structure can meet the multilayer structure of tourism products and ensure the priority of core products in rural tourism activities. Besides, the spatial pattern and multilevel system of tourism products can better meet the diversified needs of different tourists [20]. Similarly, the spatial pattern of rural tourism can affect the function and

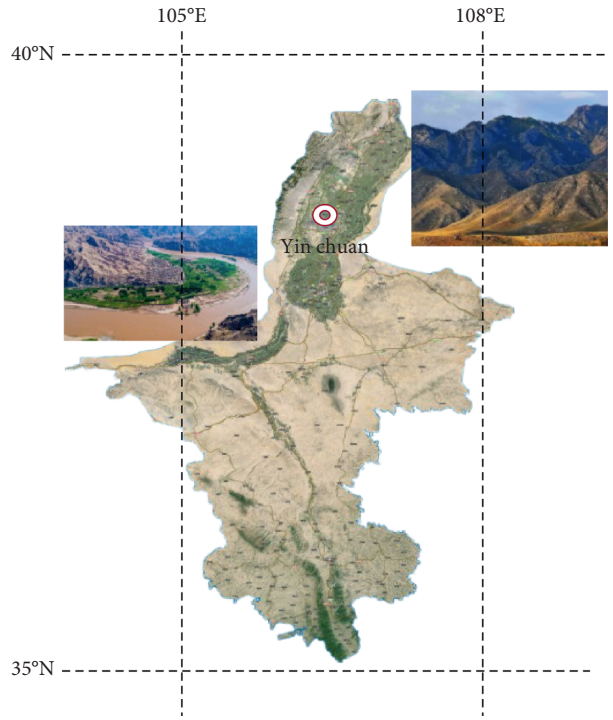

Figure 1: Diagram of the study area.

structure of rural tourism, which makes rural tourism a multifunctional leisure activity with different functions from different perspectives. Meanwhile, the integrity of tourists' rural experience is guaranteed.

The spatial structure of rural tourism is the organization rules of functional zoning, tourism resources pattern, and tourism product pattern, to ensure the orderly conduct of tourism activities. The construction of rural tourism spatial pattern is not only the planning and organization of rural tourism function and structure but also the dissection and integration of the spatial base. The construction of the spatial pattern here lies in the following three objectives: first, to ensure good development of rural tourism; second, to utilize and protect resources reasonably; and third, to allocate rural tourism products properly.

3.3. Construction and Analysis of the Multifactor-Weighted Neural Network Algorithm Model. It is necessary to select suitable factors and models to construct the multifactor model. If the process of building a multifactor model is likened to the production process of the factory, the factor will be the raw material, and the model will be the production line. With given raw materials, the choice of different production lines means different processing technology and different results correspondingly. Usually, the construction of multifactor model can be divided into the simple additive weight, linear regression method, and artificial intelligence approach. Although the simple additive weight can calculate the weighted average of each factor, it is impossible to predict the internal factors. Therefore, the multifactor model under simple additive weight is combined with neural network to construct a multifactor-weighted

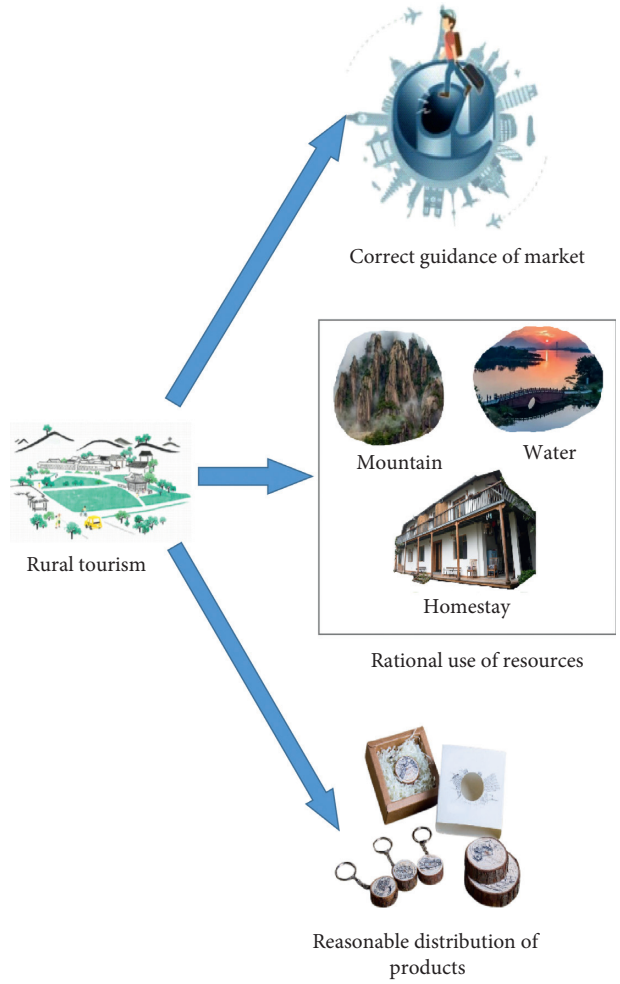

Figure 2: Requirements of rural tourism on the spatial pattern.

neural network model to evaluate the spatial pattern of rural tourism.

As the core algorithm of the model, neural network algorithm is very important to understand the role of data sources related to the spatial pattern of rural tourism. In the neural network algorithm system, CNN is the fastest growing feedforward neural network model with the best performance with the biggest advantage of local connection and weight sharing. Numerous neurons in CNN are organized in a certain way to respond to the overlapping areas in the vision field [21]. In CNNs, the first parameter of its operation is called the input and the second parameter (function w) is called the kernel function. The output is sometimes called the feature map [22]. Usually, CNNs perform convolution operations on multiple dimensions. Substitute a two-dimensional matrix I into the input and a two-dimensional kernel K, then the following equation is obtained:

$$S(i,j) = (I \cdot K)(i,j) = \sum_{m}\sum_{n} I(m,n)K(i-m, j-n), \quad (1)$$

where i, j, m, and n are fixed parameters, representing the dimension and order of the matrix. The exchange of convolutions can be equivalently written as

$$S(i,j) = (I \cdot K)(i,j) = \sum_m \sum_n I(i-m, j-n)K(m,n). \quad (2)$$

The exchangeability feature of convolution operation is caused by the kernel flip corresponding to the input. The index of kernel is decreasing with the increase of the index of input. The only purpose of kernel flip is to achieve exchangeability. Although exchangeability is useful in proving, it is not an important property in the application of neural networks. In contrast, many neural networks have a correlation function called cross-correlation function [23], which is almost identical to the convolution operation but cannot flip the kernel, as presented in

$$S(i,j) = (I \cdot K)(i,j) = \sum_m \sum_n I(i+m, j+n)K(m,n). \quad (3)$$

Any neural network algorithm that uses matrix multiplication but does not depend on the special properties of matrix structure is suitable for convolution operation without great modification. The working principle of CNN is to update the control weight w and bias b by continuously adjusting the learning rate γ and minimize the loss function, so as to obtain the predicted value closest to the real value [24]. Typical CNNs usually use three important ideas, namely, sparse interaction, parameter sharing, and equivariant representation, to improve the machine learning system, in order to deal with large-scale input more effectively.

The spatiotemporal graph convolution network (STGCN) is proposed after combining the spatial pattern and time characteristics of rural tourism. The spatial characteristics of rural structure can be extracted by graph convolution. In the time dimension, the one-dimensional convolution and the gating linear unit are used to extract the short-term evolution dependence of the spatial pattern. The two are alternately fused to form a spatiotemporal convolution block. Finally, the model structure is built on a stack of spatiotemporal convolution blocks. The feature extraction of rural tourism spatial pattern based on multifactor-weighted spatiotemporal CNN algorithm is illustrated in Figure 3.

The network structure of rural tourism spatial pattern is a general topological graph, where the weight of each factor may not be equal. Therefore, the two-dimensional convolution commonly used in CNNs is not applicable in the topological graph but more suitable for Euclidean structures with grid data. Here, similar convolution operations need to be defined in general graphs to extract spatial features. The graph convolution operator "$*G$" is introduced based on the definition of spectral graph convolution, that is, the transformation of the signal $x \in R^n$ by a kernel Θ, as shown in

$$\Theta_{*G}x = \Theta(L)x = \Theta\left(U \wedge U^T\right)x = U\Theta(\wedge)U^T x. \quad (4)$$

In equation (4), L refers to the normalized Laplacian matrix $L = I_n - D^{-1/2}WD^{1/2}$ of the network graph for the spatial pattern, where I_n denotes the n-order unit matrix, $D \in R^{n\times n}$ is the degree matrix of the network graph, $D_{ii} = \sum_j w_{ij}$, and $W \in R^{n\times n}$ represents the weight matrix of the network graph. Besides, $U \in R^{n\times n}$ is the Fourier basis, which is the matrix composed of the eigenvectors of L, that is, $L = U \wedge U^T$. Finally, $\wedge \in R^{n\times n}$ means the matrix is composed of the eigenvalues of L.

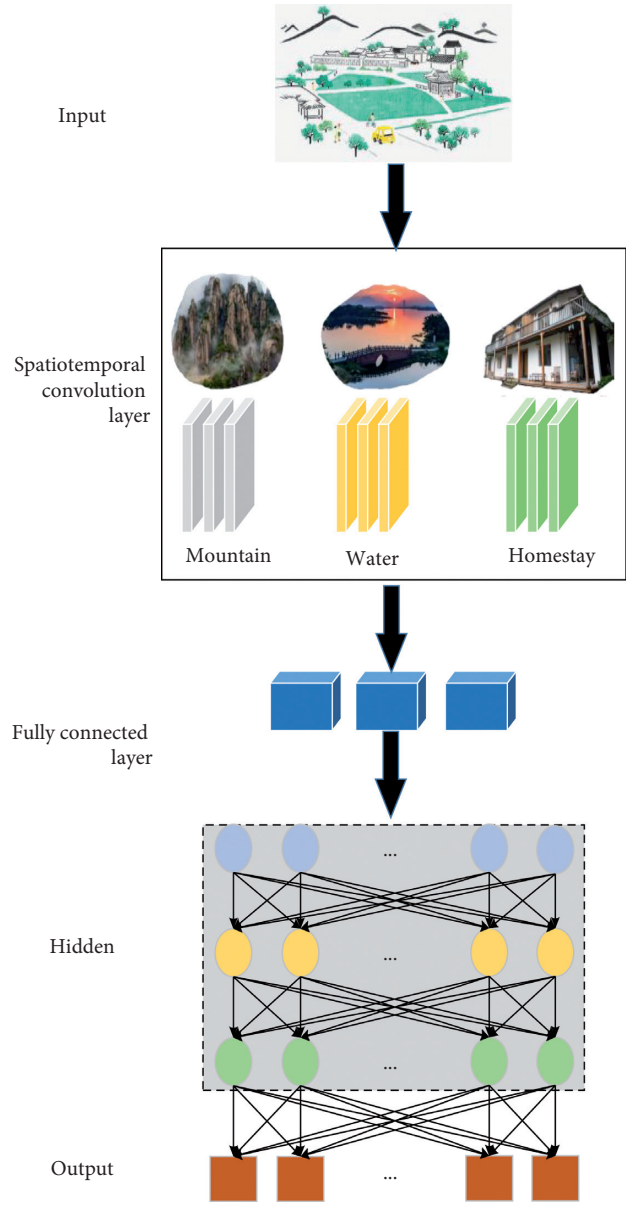

Figure 3: Process of feature extraction of rural tourism spatial pattern via the multifactor-weighted spatiotemporal CNN algorithm.

In the actual calculation, Chebyshev polynomials can be used to avoid matrix feature decomposition and reduce computational complexity. In the Chebyshev polynomials of $K-1$-order, the approximate kernel is Θ. K is the size of the convolution kernel (Kernel size) of the graph, similar to the size of the traditional convolution operation, which determines the maximum radius of the convolution starting from the center node [25]. Thus, graph convolution can be written as follows:

$$\Theta_{*G}x = \Theta(L)x \approx \sum_{k=0}^{K-1} \theta_k T_k(\tilde{L})x, \quad (5)$$

where $\tilde{L}$ represents a scaled Laplacian matrix $\tilde{L} = (2L/\lambda_{\max}) - I_n$ and θ_k is a network parameter to be learned.

T_k signifies a k-order Chebyshev polynomial determined by the following recursive relation expressions:

$$\begin{aligned} T_0(x) &= 1, \\ T_1(x) &= x, \\ T_{n+1}(x) &= 2xT_n(x) - T_{n-1}(x). \end{aligned} \tag{6}$$

The complexity of graph convolution calculation can be reduced from $O(n^2)$ to $O(K|\varepsilon|)$ through K approximation cores Θ of the Chebyshev polynomial.

Using the same convolution kernel Θ in M time steps in the rural tourism spatial pattern, the graph convolution can be used on the three-dimensional tensor of the rural tourism spatial pattern. The output of a single convolution kernel at each time step is an n-dimensional vector R^n. The output of C_o (o means output or the number of channels for the output vector, i.e., the extraction of features of different factors in the spatial pattern network) convolution kernels at each time step is $R^{n\times C_o}$, and the output at all time steps is $R^{M\times n\times C_o}$.

Then, the feature of rural spatial pattern is extracted by the STGCN. The input of the time convolution of each vertex can be regarded as a sequence of length M, with Ci channels (i denotes the input or the number of channels of the input vector), written as $Y \in R^{M\times C_i}$. Besides, the convolution kernel is $\Gamma \in R^{K_t\times 2C_0\times C_i}$, and Y is mapped to the result. Time-gated convolution can be defined as follows:

$$\begin{aligned} \Gamma_{*T}Y &= P \otimes \sigma(Q) \in R^{(M-K_t-1)\times C_o}, \\ P &= W_1Y + b_1 \in R^{(M-K_t-1)\times C_o}, \\ Q &= W_2Y + b_2 \in R^{(M-K_t-1)\times C_o}, \end{aligned} \tag{7}$$

where P and Q, respectively, refer to the input gates of GLU (gated linear unit), and each of them uses different C_o (o means output or the number of channels for the output vector, i.e., the extraction of features of different factors in the spatial pattern network) convolution kernel parameters to perform linear transformation on the input vector Y. Furthermore, W_i and b_i are the corresponding weight and bias parameter. $\otimes$ refers to the Hadamard product. σ represents the sigmoid activation function commonly used in neural networks, and the nonlinear gate σ (Q) controls the information entering the model in P. Compared with the activation function value directly using linear transformation, the structure can better excavate the complex time characteristics of rural spatial pattern [26]. The input and output of spatiotemporal convolution blocks are three-dimensional tensors. The input of the l-th spatiotemporal convolution block is $v^l \in R^{M\times n\times C^l}$, and its output is $v^{l+1} \in R^{(M-2(K_t-1))\times n\times C^{l+1}}$, which is gained by

$$v^{l+1} = \Gamma^l_{2*T}\mathrm{RELU}\left(\Theta^l_{*G}\left(\Gamma^l_{1*T}v^l\right)\right). \tag{8}$$

Here, Γ^l_{1*T} and Γ^l_{2*T} are the upper time convolution and lower time convolution in the l-th spatiotemporal convolution block. Moreover, Θ^l_{*G} is the graph convolution in the middle, and RELU stands for the activation function of the linear correction unit.

Data are mapped to the predicted flow to further extract the temporal and spatial characteristics in the rural spatial pattern. Meanwhile, the output of the last spatiotemporal convolution block is introduced into the output layer composed of two temporal convolutions and a fully connected layer. The output result of the output layer is the predicted value of the next step, combined with the original data to reconstruct $x = (x_2, \ldots, x_t, \hat{x}_{t+1})$. Then, the predicted value of the next step is obtained through the model until obtaining the predicted value of the future H-th step [27]. The optimization loss function of the whole model can be written as

$$L(\hat{v}; W_\theta) = \sum_t \left\|\hat{v}(v_{t-M+1}, \ldots, v_t, W_\theta) - v_{t+1}\right\|^2. \tag{9}$$

In equation (9), W_θ refers to the weight training parameters in the model, v_{t+1} denotes the real value of the future, and $\hat{v}(\cdot)$ shows the prediction of the model.

According to the convolution operation $\sigma(Wx + b)$ in CNNs, the graph convolution operation can be defined as $\sigma(\Theta Lx)$ below, where W and b in the former and Θ in the latter are the parameters to be learned, as follows:

$$\begin{aligned} \Theta_{*G}x &= \sigma\left(g_\theta(L)x\right) = \sigma\left(g_\theta\left(U \wedge U^T\right)x\right) = \sigma\left(Ug_\theta(\wedge)U^Tx\right), \\ g_\theta(\wedge) &= \begin{pmatrix} \theta_1 & & \\ & \ddots & \\ & & \theta_n \end{pmatrix}. \end{aligned} \tag{10}$$

To avoid matrix eigenvalue decomposition and reduce the number of parameters, $g_\theta(\wedge)$ can be improved as

$$g_\theta(\wedge) = \left(\sum_{j=0}^{K}\alpha_j\lambda_1^j \cdot \ldots \cdot \sum_{j=0}^{K}\alpha_j\lambda_n^j\right). \tag{11}$$

Thus, equation (12) can be obtained as

$$\Theta_{*G}x = \sigma\left(Ug_\theta(\wedge)U^Tx\right) = \sigma\left(\sum_{j=0}^{K}\alpha_jL^jx\right). \tag{12}$$

To avoid computing matrix multipliers, it is proved that equation (12) can be approximated by $k-1$–order Chebyshev polynomial, as shown in

$$\Theta_{*G}x = \sigma(L)x \approx \sum_{k=0}^{K-1}\theta_kT_k(\tilde{L})x. \tag{13}$$

Among them, θ_k is the network parameters to be learned. Equation (13) is used as the graph convolution operation of the first layer to integrate the information of k nodes around the node. Thus, the spatial pattern characteristics of multiple channels can be obtained through several groups of different parameters θ_k.

The square error is used as the loss function here, and the optimization objective can be expressed as

$$\min_\Theta \sum_{t\in\mathrm{Train}} \left\|y_t - \widehat{y}_t\right\|_F^2, \tag{14}$$

where Θ is the parameters to be learned in the graph convolution layer, whereas y_t is the real flow at time t and $\widehat{y}_t$

is the predicted flow. Meanwhile, the objective function is optimized by the Adam optimization algorithm to conduct the subsequent calculation and parameter solution.

The training of the proposed model mainly includes the learning rate updating strategy through the "Poly" learning rate adjustment method via the polynomial attenuation [28], as shown in

$$\text{init\_lr} \times \left(1 - \frac{\text{epoch}}{\max\_\text{epoch}}\right)^{\text{power}}. \tag{15}$$

In equation (15), the initial learning rate init_lr is 0.0005 ($5e^{-4}$) and the power is set as 0.9.

3.4. Data Sources of the Spatial Pattern of Rural Tourism in the Study Area. The research data of rural tourist attractions are from the list of rural tourist attractions published by the official website of the Department of Culture and Tourism of Ningxia Hui Autonomous Region (http://whhlyt.nx.gov.cn/) in 2009 and 2019. Besides, the basic road data comes from the 1 : 10,000,000 national basic geographic database released by the National Dynamic Atlas (http://www.webmap.cn). Finally, the administrative boundary data of the villages come from the standard map service website of the Department of Natural Resources of Ningxia Hui Autonomous Region (http://zrzyt.nx.gov.cn/).

3.5. Simulation Analysis. The MATLAB network simulation software is used for the simulation analysis of the performance of the multifactor-weighted spatiotemporal CNN algorithm. The data resource has been explained in the previous section. The obtained data are divided into the training set, verification set, and test set according to the proportion of 60%, 20%, and 20%, respectively.

The hyperparameters of the constructed neural network model are set as the following: the number of iterations is 60, the simulation time is 2000 s, and the batch size is 128. In the performance analysis of the proposed model, the prediction performance is compared with other algorithms applied by other scholars in related fields from the perspectives of accuracy, precision, recall, and $F1$ values (weighted harmonic mean of precision and recall). The comparative algorithms include LSTM [29], Bi-directional long short-term memory (BiLSTM) [30], the AlexNet improved by Visual Geometry Group (VGGNet) [31], AlexNet [32], and STGCN [33]. Furthermore, both hardware and software configurations are considered in the specific simulation experiment. The software is equipped with the Linux 64-bit operating system and Python 3.6.1, along with the PyCharm development platform. The CPU of the hardware is Intel core i7-7700 @ 4.2 GHz of 8 core, with the memory of Kingston ddr4 2400 MHz of 16G, and the GPU is Nvidia GeForce 1060 of 8G.

The following indicators are mainly taken into account in the use of the obtained data to evaluate the spatial pattern of rural tourism. Firstly, the nearest neighbor distance index (NNI). The calculation result of the average distance between the closet attractions is compared with that between nodes in the random distribution to analyze the degree of deviation from the random distribution, so as to obtain the distribution type of rural tourism attractions [34]. The calculation can be written as

$$\text{NNI} = \frac{\left[\sum_{i=1}^{N} \min\left(d_{ij}\right)/N\right]}{\sqrt[0.5]{A/N}} w_i. \tag{16}$$

In equation (16), min (d_{ij}) refers to the distance between any scenic spot i and its nearest scenic spot j; N is the total number of rural scenic spots; and A is the total area of the study area. NNI ≤ 0.5 is generally considered as aggregate, with 0.5 < NNI ≤ 0.8 as aggregate random, 0.8 < NNI ≤ 1.2 as random, 1.2 < NNI ≤ 1.5 as random discrete, and NNI > 1.5 as uniform.

Secondly, the standard deviation ellipse mainly reflects the moving direction of the centroid of the scenic spot space. Suppose a region has n subregions, (x_i, y_i) is the center coordinates of the i-th region and w_i is the attribute value and weight of the i-th subregion [35]. The standard deviation ellipse can be expressed as

$$M\left(\overline{X}, \overline{Y}\right) = \left[\frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} \times \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i}\right]. \tag{17}$$

Third, the time cost of accessibility of the scenic spot. The accessibility is quantitatively analyzed by the minimum time spent by tourists, and the small value demonstrates the good accessibility [36], which can be expressed as

$$T_i = \text{Exp}\left(i, j\right). \tag{18}$$

In equation (18), T_i represents the accessibility of site location i of the scenic spot j, whereas Exp (i, j) denotes the minimum time-consuming function to calculate the traffic between i and j. Among them, the isochronous circle is mainly divided into six parts: <1 h, 1-2 h, 2-3 h, 3-4 h, 4-5 h, and >5 h.

4. Results and Discussion

4.1. Comparative Analysis of Prediction Performance of Each Model Algorithm. The comparative analysis is conducted on the spatiotemporal convolution neural network algorithm based on multifactor weighting to study the prediction performance of the constructed model on the spatial pattern of rural tourism. The constructed model is compared with LSTM, BiLSTM, VGGNet, AlexNet, and STGCN from the perspective of accuracy, precision, recall, and $F1$ values, with the results shown from Figures 4 to 7.

According to the results presented from Figures 4 to 7, the accuracy of the constructed model reaches 97.69%, which is at least 2.13% higher than that of the deep learning algorithms (including LSTM, BiLSTM, VGGNet, AlexNet, and STGCN) used by other scholars. Besides, the neural network model has the highest precision, recall, and $F1$ value, and the $F1$ value may be smaller than the precision and recall rather than be between them. Therefore, compared with the deep learning algorithm adopted by other scholars, the spatiotemporal CNN algorithm based on multifactor weighting has better prediction accuracy and better performance in evaluating the spatial pattern of rural tourism.

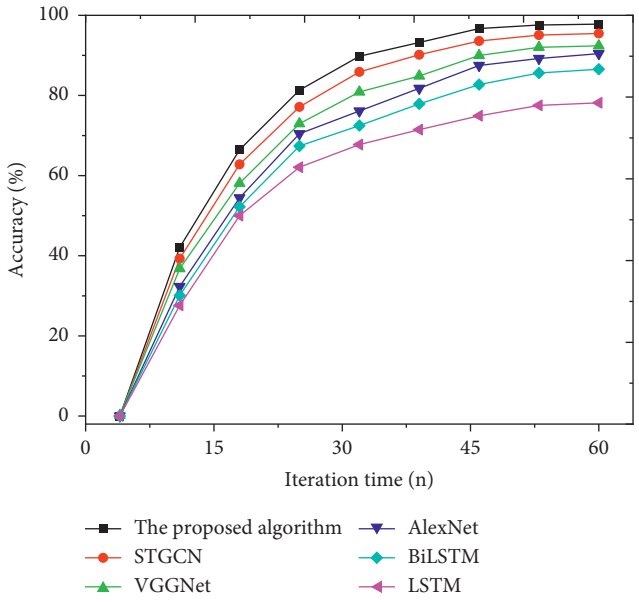

Figure 4: The comparison result of accuracy among the model and other deep learning algorithms.

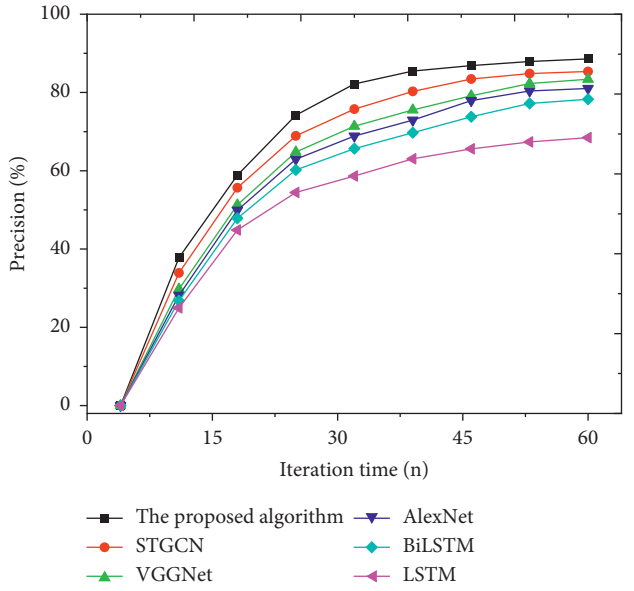

Figure 5: The comparison result of precision among the model and other deep learning algorithms.

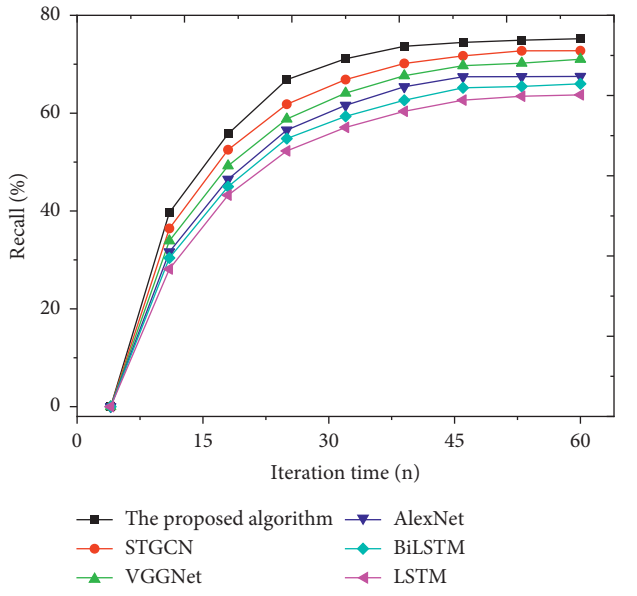

Figure 6: The comparison result of recall among the model and other deep learning algorithms.

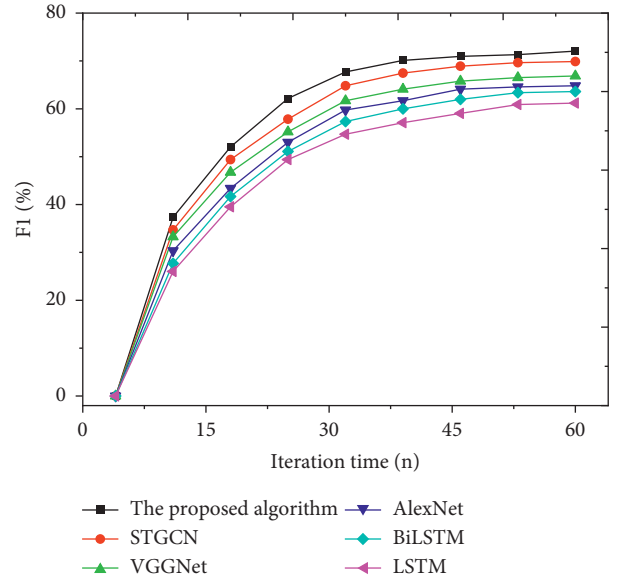

Figure 7: The comparison result of $F1$ value among the model and other deep learning algorithms.

4.2. Spatial Pattern Evaluation of Rural Tourist Attractions. In the spatial pattern evaluation of rural tourist attractions, the spatial pattern of rural tourist attractions in the seven tourism plates of Ningxia Hui Autonomous Region in 2019 is compared with that in 2009. The spatial distribution concentration, spatial centroid mobility, and spatial connection accessibility of rural tourist attractions are expatiated from Figures 8 to 10.

The NNI of the seven tourism plates is shown in Figure 8. It can be found that the spatial distribution concentration of rural attractions in Ningxia Hui Autonomous Region does not change significantly at the provincial level. The NNI in 2009 was 0.57, and the spatial structure type was aggregate-random. The NNI in 2019 was 0.69 increasing by 0.12. Meanwhile, the random distribution trend of attractions increases, but the spatial structure type was still aggregate-random, showing strong stability. The concentration of spatial distribution of scenic spots was analyzed from various tourism plates. Among them, the NNI of the Great Sand Lake Holiday and Leisure Area in 2009 was 0.67, with the aggregate-random distribution type, compared with the NNI of 0.48 and the aggregate distribution type in 2019. In 2009, the NNI of the Xixia Cultural Tourism District was 0.62 with the aggregate-random distribution type, compared with the NNI of 0.45. Besides, the agglomeration trend of

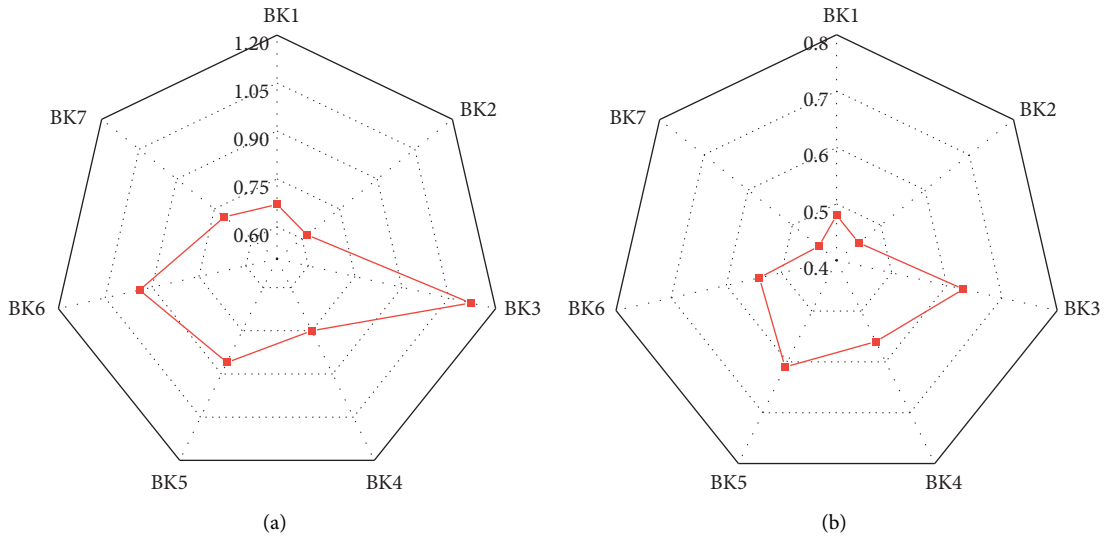

Figure 8: The comparison of NNI of the seven tourism plates in (a) 2009 and (b) 2019 (BK1: Great Sand Lake Holiday and Leisure Area; BK2: Xixia Cultural Tourism District; BK3: Saishang Hui Township Cultural Experience Plate; BK4: Frontier Cultural Tourism Plate; BK5: Great Shapotou Resort and Leisure Plate; BK6: Weizhou Historical and Cultural Tourism Plate; BK7: Great Liupan Red Ecological Resort Plate).

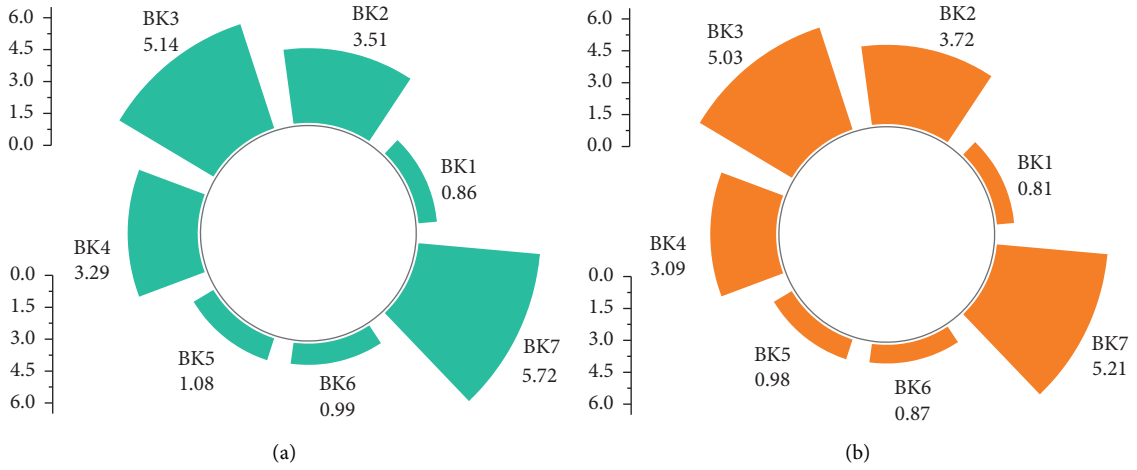

Figure 9: Change in the area of the standard deviation ellipse of A-level rural tourist attractions in the seven tourism plates in (a) 2009 and (b) 2019 (BK1: Great Sand Lake Holiday and Leisure Area; BK2: Xixia Cultural Tourism District; BK3: Saishang Hui Township Cultural Experience Plate; BK4: Frontier Cultural Tourism Plate; BK5: Great Shapotou Resort and Leisure Plate; BK6: Weizhou Historical and Cultural Tourism Plate; BK7: Great Liupan Red Ecological Resort Plate).

scenic spots increased and the spatial structure type changed from aggregate-random to aggregate. In 2009, the NNI of the Saishang Hui Township Cultural Experience was 1.12 with the random distribution type of scenic spots, compared with the NNI of 0.63 in 2019. Meanwhile, the agglomeration trend of scenic spots increased, changing into the aggregate-random distribution type. In 2009, the NNI of the Frontier Cultural Tourism Plate was 0.75 with the aggregate-random distribution type of scenic spots, compared with the NNI of 0.56 in 2019. The agglomeration trend of scenic spot distribution also increased, but the spatial structure type did not change. In 2009, the NNI of the Great Shapotou Resort and Leisure Plate was 0.86 with the random distribution type of scenic spots, compared with the NNI of 0.61 in 2019. Furthermore, the agglomeration trend of scenic spot distribution increased, and the spatial structure type changed from aggregate-random to aggregate-random. In 2009, the NNI of the Weizhou Historical and Cultural Tourism Plate was 0.94 with the random distribution type of scenic spots, compared with the NNI of 0.48 in 2019. Besides, the agglomeration trend of scenic spot distribution increased, changing into the aggregate spatial structure type. In 2009, the NNI of the Great Liupan Red Ecological Resort Plate was 0.71 with the aggregate-random distribution type of scenic spots, compared with the NNI of 0.44 in 2019. The trend of scenic spot aggregation distribution increased, and the

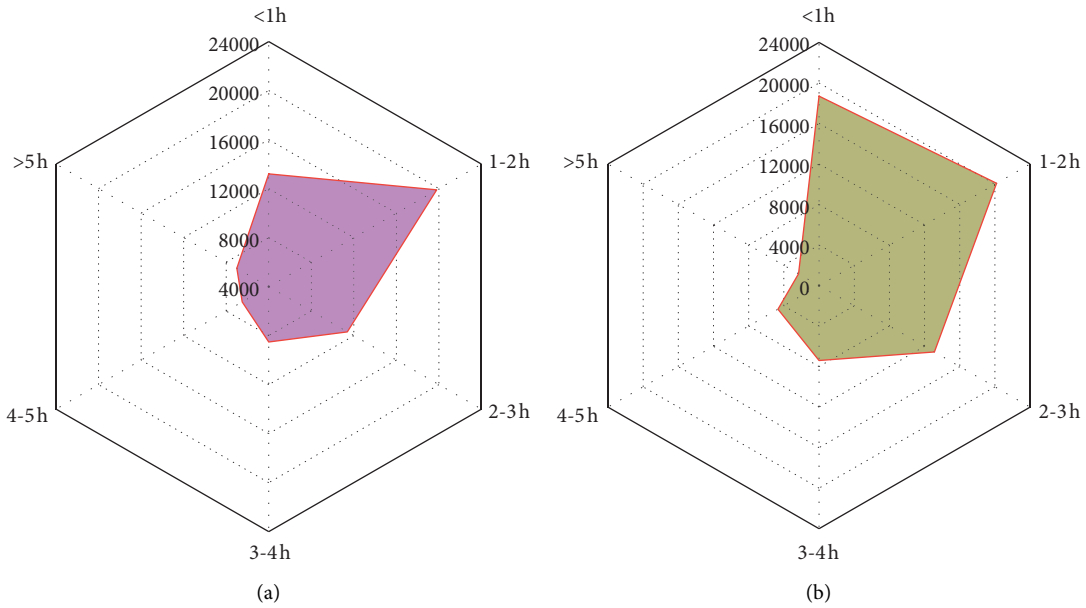

Figure 10: The change of time cost of spatial accessibility of rural tourist attractions in Ningxia in (a) 2009 and (b) 2019.

spatial structure type changed from random type to aggregate type.

The spatial centroid mobility of scenic spots indicates the degree of change of the overall layout direction of tourist attractions in the region. The analysis of the change of the standard deviation ellipse area of the distribution of A-level rural tourist attractions in the seven tourism plates from 2009 to 2019 is shown in Figure 9. The elliptical direction of each tourism plate is consistent with the distribution of the whole province. Under the influence of the "The Belt and Road Initiative," the number of plate attractions increases, but the centroid moves southwest.

Through the analysis of the spatial accessibility of rural tourist attractions in Ningxia, as shown in Figure 10, the time cost of scenic spot accessibility changed significantly at the provincial level from 2009 to 2019. The change rate of one-hour isochronous circle was 41.67%, the change rate of the isochronous circle of 1-2 hours was 1.95%, the change rate of the isochronous circle of 2-3 hours was 15.19%, and the change rate of three-hour isochronous circle was negative. Meanwhile, the spatial distribution of accessibility of scenic spots shows an increasing trend from the scenic spots along the main traffic arteries to the periphery. The areas with better accessibility are contiguously distributed around the traffic arteries and cities, while the rural scenic spots with poor accessibility are distributed in the rugged terrain of the provincial boundary.

5. Conclusion

The rural tourism attractions in Ningxia Hui Autonomous Region are selected as the research object to investigate the current situation of the spatial pattern of rural tourist attractions. Meanwhile, a spatiotemporal CNN model based on multifactor weighting is constructed to evaluate the spatial pattern of rural tourism. Through simulation, it is found that the constructed CNN model has high prediction accuracy of 97.69% and can effectively evaluate the spatial pattern, which can provide experimental basis for the digital development of rural tourism spatial pattern in the later stage.

6. Future Work

The evaluation and analysis of the spatial pattern of rural tourism reveal that although it can make a more accurate and effective evaluation, there are also some deficiencies. For example, in the spatial pattern analysis of scenic spot accessibility, only the impact of land transportation on rural tourism space in Ningxia is evaluated, and aviation is not included in the accessibility cost resistance model. In addition, the research only selects tourism destinations and transportation routes and lacks the relevant analysis of market factors.

In the future research direction, on the one hand, it is necessary to extend the research time limit, include market factors, explore the advantages and disadvantages of cluster development between plates, consider the impact of natural factors such as terrain and climate and human factors like social economy on accessibility, include aviation into the accessibility cost resistance model for evaluation, and minimize the calculation error of accessibility index value. On the other hand, in the future research, it is required to break the administrative boundaries and build a global tourism cooperation development model, to provide reference for the development of rural tourism economy and the improvement of spatial pattern.

Acknowledgments

NSFC project (18BGL161): phased achievements in the research on the interaction mechanism between characteristic towns and poverty alleviation and development in Ningxia; Ningxia University Science and Technology Research Support Project (NGY2018037): Research on sustainable development of Characteristic Towns in Ningxia under the strategy of Rural Revitalization.

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