# Research on Spatial Accessibility Measurement Algorithm for Sanya Tourist Attractions Based on Seasonal Factor Adjustment Analysis

Xiaodong Mao[1]*, Yan Zhuang[2]
School of Tourism and Health Industry, Sanya Institute of Technology, Sanya, Hainan, 572011, China[1]
University of Sanya, Sanya, Hainan, 572011, China[2]

***Abstract*—Seasonal factors will lead to changes in tourists' demand for scenic spots in different seasons, which will affect the traffic network and road conditions, and then affect the convenience and efficiency of tourists arriving at scenic spots. Based on the adjustment and analysis of seasonal factors, this study puts forward an algorithm for measuring the spatial accessibility of Sanya tourist attractions. Principal component analysis is used to denoise the data of Sanya tourist attractions in different seasons, and independent component analysis is used to extract the data characteristics of Sanya tourist attractions in different seasons after denoising. On this basis, the spatial accessibility index of Sanya tourist attractions is calculated by combining the spatial information of Sanya tourist attractions and GIS technology, and the spatial accessibility of Sanya tourist attractions is analyzed, and the spatial accessibility measurement model of Sanya tourist attractions is constructed to realize the spatial accessibility measurement of Sanya tourist attractions. The experimental results show that the spatial accessibility measurement method of Sanya tourist attractions is effective, which can effectively improve the accuracy of accessibility measurement and shorten the accessibility measurement time. It aims to help decision makers plan and optimize tourist routes and improve the efficiency and convenience of tourists arriving at their destinations.**

***Keywords*—Seasonal factors; adjustment analysis; Sanya Tourist Attractions; spatial accessibility measure; GIS technology**

## I. Introduction

As a famous seaside tourist city in China, Sanya has a unique natural environment and rich tourism resources. With the rapid development of tourism, the spatial accessibility of tourist attractions has become an important factor affecting the development of tourism. However, seasonal factors have a significant impact on the spatial accessibility of tourist attractions [1-3]. Therefore, it is of great practical significance to study the spatial accessibility measurement algorithm of Sanya tourist attractions based on seasonal factor adjustment analysis. Sanya has many famous tourist attractions, such as nansan, Yalong Bay Tropical Paradise Forest Park and Tianya Haijiao. With the development of tourism, the spatial accessibility of tourist attractions has become an important indicator to measure the development level of tourism in a region [4]. Tourist attractions with high spatial accessibility can attract more tourists, create more economic benefits and promote the sustainable development of tourism in Sanya.

Zhou Haitao [5] and others revealed the spatial distribution characteristics of red tourist attractions in Inner Mongolia by means of kernel density and geographical concentration index. Based on the road planning function of Gaode map, the road traffic conditions were obtained in real time, and the spatial accessibility measurement model of red tourist attractions was constructed. The influencing factors of accessibility differences were clarified by using geographical detectors. This method can comprehensively consider the spatial distribution characteristics of scenic spots, traffic network and road traffic conditions, and comprehensively evaluate the accessibility of scenic spots from multiple angles. However, depending on the path planning function and road traffic data provided by Gaode map may have a certain impact on the measurement results. Wang Hao [6] and others, based on the statistical yearbook of Xinjiang road network and the official data of Xinjiang Culture and Tourism Department, analyzed the spatial distribution characteristics of scenic spots of 4A level and above in Xinjiang by using the network analysis method, kernel density analysis method and geographical concentration index of GIS, and analyzed the spatial accessibility from two aspects: scenic accessibility and regional accessibility. This method can accurately calculate the shortest path and time between scenic spots, thus providing more accurate results of scenic accessibility analysis. However, the reliability of the data needs to be verified. Wei Liu [7] and others use the spatial grid method to divide the research scope, count the number of residents in the research scope, and use the API interface of the network map platform to obtain the expected travel time data of residents. On this basis, according to the accessibility model, the fairness of public transport accessibility in Xi 'an is analyzed by using fairness coefficient and Lorenz curve. This method can quickly obtain the calculation results, but the data source is limited. Ma Shuhong [8] and others calculate the travel cost of public transport according to the data planned by real-time routes. Arcgis is used to analyze the accessibility of urban agglomerations, and theil index and fairness coefficient are used to get the difference characteristics of public transport accessibility. The calculation results of accessibility and fairness of this method are accurate and the coverage is limited.

Based on this, this paper puts forward an algorithm for measuring the spatial accessibility of Sanya tourist attractions based on the adjustment and analysis of seasonal factors, aiming at exploring how to better eliminate the influence of seasonal factors, improve tourists' travel experience and promote the sustainable development of Sanya tourism through in-depth research on the spatial accessibility of Sanya tourist attractions. By extracting the data characteristics of Sanya tourist attractions in different seasons, this paper analyzes the spatial accessibility of Sanya tourist attractions, constructs a spatial accessibility measurement model of Sanya tourist attractions, and effectively adjusts and analyzes the spatial accessibility of Sanya tourist attractions due to seasonal factors. This method can effectively measure the spatial accessibility of Sanya tourist attractions, improve the measurement accuracy and shorten the measurement time. By studying the influencing factors of the spatial accessibility of Sanya tourist attractions, it provides scientific basis and decision support for the prosperity and development of Sanya tourism. The research contribution of this paper:

*1)* Denoising the data of Sanya tourist attractions in different seasons, extracting the data characteristics of Sanya tourist attractions in different seasons, considering the changes in seasonal demand, traffic network, and other factors, assisting decision makers in planning and optimizing tourist routes, improving the efficiency and convenience of tourists arriving at their destinations.

*2)* Based on the spatial information of Sanya tourist attractions and GIS technology, the spatial accessibility index of Sanya tourist attractions is calculated, so as to evaluate the spatial accessibility of Sanya tourist attractions, provide scientific basis and decision support for the development and planning of Sanya tourism, and make positive contributions to improving tourism efficiency and promoting economic development.

## II. Feature Extraction of Sanya Tourist Attractions Data in Different Seasons

Due to the fact that different seasons attract different types of tourists and have an impact on the number of tourists, transportation network, etc. By extracting data features of Sanya tourist attractions in different seasons, it is possible to analyze the changes in demand for Sanya tourist attractions and the operation of transportation and facilities during different seasons. Count the number of tourists to tourist attractions in Sanya during different seasons, understand the characteristics and travel preferences of the tourist group, help formulate more accurate Sanya tourism planning and marketing strategies, conduct seasonal factor adjustment analysis, optimize traffic management and resource allocation, and improve the spatial accessibility of Sanya tourist attractions. Therefore, in order to effectively measure the spatial accessibility of Sanya tourist attractions, first, principal component analysis is used to denoise the data of Sanya tourist attractions in different seasons. Then, independent component analysis is used to extract the features of the denoised data of Sanya tourist attractions in different seasons.

### *A. Sanya Tourist Attractions Data Noise Reduction in Different Seasons*

Based on the principle of constrained optimization, obtain abnormal data of tourist attractions in Sanya in different seasons and flexibly represent them.

The data of tourist attractions in Sanya for different seasons has $n$ dimensions, and each dimension includes a layer $d_{rj}$, which also has $l_r$ dimension layers. Set the value at position $i$ of the $r$ dimension $j$ layer in the data of Sanya tourist attractions in different seasons to $y_{i_1,i_2,\ldots,i_{rj}}$. The process of obtaining the expected value $\hat{y}_{i_1,i_2,\ldots,i_{rj}}$ of Sanya tourist attraction data in different seasons is as follows:

$$\hat{y}_{i_1,i_2,\ldots,i_{rj}} = y_{i_1,i_2,\ldots,i_{rj}}\left(\gamma^{G}_{i_{rj}|d_{rj}} \mid G \subset \left\{d_{rj} \mid 1 \le r \le n, 1 \le j \le l_r\right\}\right) \tag{1}$$

In Formula (1), $\gamma_{i_{rj}|d_{rj}}$ is the expected coefficient of Sanya tourist attraction data in different seasons, and $G$ is the constraint condition in Sanya tourist attraction data in different seasons. The abnormal data $s_{i_1,i_2,\cdots,i_{rj}}$ of tourist attractions in Sanya obtained from different seasons is as follows:

$$s_{i_1,i_2,\cdots,i_{rj}} = \frac{\left|y_{i_1,i_2,\ldots,i_{rj}} - \hat{y}_{i_1,i_2,\ldots,i_{rj}}\right|}{\sigma_{i_1,i_2,\cdots,i_{rj}}} \tag{2}$$

In Formula (2), $\sigma_{i_1,i_2,\cdots,i_{rj}}$ is the abnormal data index of Sanya tourist attractions in different seasons.

Based on the above calculation results, the abnormal data of Sanya tourist attractions in different seasons will be removed, and then the principal component analysis method [9-11] will be used to denoise the data in Sanya tourist attractions in different seasons. Principal component analysis (PCA) is a commonly used data denoising method, which transforms the original data into a new coordinate system by linear transformation, so that the largest variance appears on the first coordinate axis, the second largest variance appears on the second coordinate axis, and so on. The final principal components are linear combinations of original data changes, and these principal components are sorted according to their variance.

Construct a three-dimensional coordinate system using the component decomposition method in Sanya tourist attractions of different seasons, and the data vectors in Sanya tourist attractions of different seasons in the coordinates are:

$$Z(x) = \left[Z_1(x), Z_2(x), \cdots Z_p(x)\right]^T = S_p(x) + N_p(x) \tag{3}$$

In Formula (3), $S_p(x), N_p(x)$ represents the $p$-dimensional signal and noise vector of Sanya tourist attraction data in different seasons.

By using the minimum noise separation transformation method, the data from Sanya tourist attractions in different seasons are linearly transformed, and the process is as follows:

$$Y_i(x) = a_i^T Z(x), i = 1, 2, \cdots, p \tag{4}$$

In Formula (4), $a_i^T$ is the transformation coefficient of data from Sanya tourist attractions in different seasons, and $Y_i(x)$ is the transformed data from Sanya tourist attractions in different seasons. Through the above transformation, it can be seen that each band in $Y_i(x)$ exists independently of each other, and the obtained result is the maximum signal-to-noise ratio $SNR_{Y_i}$ of data from Sanya tourist attractions in different seasons. The acquisition process is as follows:

$$SNR_{Y_i} = \frac{\operatorname{var} Y_i(x)\left\{a_i^T S_p(x)\right\} V}{\operatorname{var} Y_i(x)\left\{a_i^T N_p(x)\right\} B} \tag{5}$$

In Formula (5), $V, B$ is the covariance matrix of signal and noise in the data of Sanya tourist attractions in different seasons. Based on the above results, complete the data denoising processing for Sanya tourist attractions in different seasons.

*B. Feature Extraction of Sanya Tourist Attractions Data in Different Seasons*

Independent component analysis (ICA) is a data analysis method applied in signal processing, neural network and other fields. Its core idea is to assume that the observed multidimensional signal is a linear mixture of multiple independent components, each of which has its own statistical distribution. The purpose of ICA is to decompose the mixed signal into independent components through certain linear transformation, so as to realize signal separation and feature extraction. When ICA is used to extract the data features of Sanya tourist attractions in different seasons, it is generally necessary to preprocess the data first, such as using PCA to denoise the data to eliminate the noise and interference information in the data. Then, ICA algorithm is used to linearly transform the preprocessed data to extract the independent components hidden in the data. Using independent component analysis method, extract the features of Sanya tourist attractions data in different seasons after denoising.

Set $Z(x)$ as the original data vector of Sanya tourist attractions in different seasons, and the data vector of Sanya tourist attractions in different seasons after minimum noise separation transformation is $Y(x)$. Retain the first $k$ term in $Y(x)$ and reset the other $p-k$ terms to zero, in order to obtain the dataset of Sanya tourist attractions in different seasons for the first $k$ term of $Y(x)$ and perform minimum noise separation inverse transformation on it. The process is as follows:

$$\begin{cases} Y^{(k)}(x) = \left[Y_1(x), Y_2(x), \cdots, Y_k(x), 0, \cdots, 0\right]^T \\ Q(x) = \left[1Q(x), 2Q(x), \cdots, pQ(x)\right]^T \\ Q_i(x) = SNR_{Y_i} \sum_{t=1}^{p} a_t Y_t \end{cases} \tag{6}$$

In Formula (6), $Y^{(k)}(x)$ is the dataset of Sanya tourist attractions in different seasons obtained from the first $k$ term of $Y(x)$, $Q(x)$ is the dataset of Sanya tourist attractions in different seasons obtained from the minimum noise separation inverse transformation, $a_t$ is the conversion amount during the transformation, and $p$ is a constant. Based on the above calculation results, construct an orthogonal matrix for the dataset of Sanya tourist attractions in different seasons, and the process is as follows:

$$W = Q_i(x) A = \left[1Q(x), 2Q(x), \cdots, pQ(x)\right]^T \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1p} \\ a_{21} & a_{22} & \cdots & a_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{p1} & a_{p2} & \cdots & a_{pp} \end{bmatrix} \tag{7}$$

In Formula (7), $A$ is a singular matrix with zero eigenvalues. Calculate the matrix based on the third-order center distance to obtain the independent component skewness of Sanya tourist attraction data for different seasons. The process is as follows:

$$\det(W) = \det(0)^{\circ} \det(A) = 0 \tag{8}$$

In Formula (8), $\det(A)$ is the independent component kurtosis of the obtained data of Sanya tourist attractions in different seasons. Sort the data of Sanya tourist attractions in different seasons based on the obtained independent component skewness, in order to obtain the characteristics of Sanya tourist attraction data in different seasons.

## III. Measurement of Spatial Accessibility of Tourist Attractions in Sanya

The measurement of spatial accessibility of Sanya tourist attractions is based on the data characteristics of Sanya tourist attractions in different seasons, combined with the spatial information of Sanya tourist attractions and GIS technology, to calculate the spatial accessibility index of Sanya tourist attractions, and evaluate the spatial accessibility of Sanya tourist attractions. These results can provide scientific basis for tourism planners in Sanya, helping them understand the changes in spatial accessibility of tourist attractions in Sanya, and carry out reasonable resource development and Sanya tourism route design.

*A. Analysis of Spatial Accessibility of Tourist Attractions in Sanya*

Assuming $SY_m$ represents the temporal accessibility of the spatial node $m$ of Sanya tourist attractions, it describes the shortest time average value of the spatial node $m$ of Sanya tourist attractions reaching other nodes. The mean temporal accessibility of all nodes is the temporal accessibility $SY$ of the entire Sanya tourist attraction space, and its calculation formula is as follows:

$$\begin{cases} SY_m^s = \det(W)\sum_{m=1,v\neq 1}^{\omega} SY_{mv}^s / (Y_{mv}^s - 1), m \in [1,\omega] \\ SY^s = \sum_{m=1}^{\omega} SY_m^s / Y_{mv}^s \end{cases} \quad (9)$$

In Formula (9), $\omega$ represents the number of nodes in the Sanya region, and $SY_m^s$ represents the time accessibility of node $m$ under travel mode $s$, $SY_{mv}^s$ represents the time barrier between node $m$ and node $v$ in the Sanya tourist attraction space using travel mode $s$, and $SY^s$ represents the time accessibility corresponding to travel mode $s$ in the study area.

Construct a set of travel modes $S$, which includes three types of travel modes: car travel, motorcycle travel, and bicycle travel. Assuming $Y_{mv}^s$ is the travel time generated by travel mode $s$ on the designated road section, it can be calculated using Formula (10):

$$Y_{mv}^s = \frac{r_{mv}}{b_{mv}^s} \quad (10)$$

In Formula (10), $r_{mv}$ is the distance between node $m$ and node $v$ in the space of Sanya tourist attractions, and $b_{mv}^s$ is the speed of the existing section $r_{mv}$ under travel mode $s$.

Assuming that $SV_m$ represents the economic cost distance corresponding to node $m$ in the Sanya tourist attraction space, it describes the minimum average cost of node $m$ to other nodes in the Sanya tourist attraction space. The average time accessibility corresponding to all nodes is the time accessibility $SV$ corresponding to the Sanya tourist attraction space, and its calculation formula is as follows:

$$\begin{cases} SV_m^s = \det(W)\sum_{m=1,v\neq 1}^{\omega} V_{mv}^s / (Y_{mv}^s - 1) \\ SV^s = \sum_{m=1}^{\omega} SV_m^s / Y_{mv}^s \end{cases} \quad (11)$$

In Formula (11), $SV_m^s$ represents the cost accessibility of node $m$ under travel mode $s$, $V_{mv}^s$ represents the cost of node $m$ using travel mode $s$ to reach node $v$ in the Sanya tourist attraction space, and $SV^s$ represents the cost accessibility of using travel mode $s$ in the study area.

The generalized travel cost usually includes the following types:

*1)* Parameter comprehensive cost $V_{mv}^z$:

$$V_{mv}^z = Y_{mv}^s + VOT \times \beta Y_{mv}^s \left(\frac{Y_{mv}^s}{Y_c}\right)^{\chi} \quad (12)$$

In Formula (12), $VOT$ is the unit time cost, $\beta$ and $\chi$ are adjustment coefficients, and $Y_c$ is the time threshold.

*2)* Parameter time cost $V_{mv}^S$:

$$V_{mv}^S = VOTY_{mv}^s + VOTY_{mv}^s \beta \left(\frac{Y_{mv}^s}{Y_c}\right)^{\chi} \quad (13)$$

*3)* Comprehensive cost $V_{mv}^{ZH}$ :

$$V_{mv}^{ZH} = VOTY_{mv}^s + \mathrm{Sin}_{mv}^s \quad (14)$$

In Formula (14), $\mathrm{Sin}_{mv}^s$ is the travel cost incurred from node $m$ using travel method $s$ to node $v$.

*4)* Travel cost $V_{mv}^{CX}$ :

$$V_{mv}^{CX} = \frac{VOTr_{mv}}{b_{mv}^s} + r_{mv}\omega_{mv}^s \quad (15)$$

In Formula (15), $\omega_{mv}^s$ is the fuel consumption generated by using travel mode $s$ on section $r_{mv}$.

Using the weighted shortest travel time method, calculate the time of the Sanya tourist attraction space at each node to reflect the spatial accessibility of Sanya tourist attractions. The calculation formula is:

$$\begin{cases} A_x = \sum_{y=1}^{\tau} \lambda_y \delta_{xy} / \sum_{y=1}^{\tau} \lambda_y \\ \lambda_y = \sqrt{p_x e_x} \end{cases} \quad (16)$$

In Formula (16), $A_x$ represents the weighted time for the shortest travel in Sanya's tourist attraction space, and $\delta_{xy}$ represents the minimum time that should be consumed for the shortest distance in Sanya's tourist attraction space, $\lambda_y$

represents the capacity of Sanya's tourist attraction space and the degree of connection with other cities, $p_x$ represents the number of people in Sanya's tourist attraction space, $e_x$ represents the gross economic product of Sanya's tourist attraction space, $y$ represents the location parameter, and $\tau$ represents the spatial range of Sanya's tourist attraction. The smaller the $A_x$ value, the higher the spatial accessibility of tourist attractions in Sanya is.

The comprehensive weighted average travel time is used to measure the accessibility of tourist attractions in Sanya, and the calculation formula is:

$$IA_x = \sum A_{xx_i} r_{x_i} \tag{17}$$

In Formula (17), $IA_x$ represents the spatially weighted shortest average travel time of tourist attractions in Sanya, $A_{xx_i}$ represents the shortest average travel time, and $r_{x_i}$ represents the travel weight.

Based on the above calculation formula and the urban spatial gravity model, the shortest spatial time of tourist attractions in Sanya is calculated using the following formula:

$$I_{mn} = IA_x \mu_m \mu_n / d_{mn}^b \tag{18}$$

In Formula (18), $I_{mn}$ represents the spatial interaction force between tourist attractions in Sanya, $d_{mn}^b$ represents the shortest time corresponding to the shortest spatial distance of tourist attractions in Sanya, $\mu_m$ and $\mu_n$ represent the spatial scale of tourist attractions in Sanya, and $b$ represents the spatial distance friction index of tourist attractions in Sanya.

Using the potential model, calculate the spatial interaction potential $J_x$ of tourist attractions in Sanya, and the calculation formula is:

$$J_x = \sum_{m=1}^{n} I_{mn} + \mu_m \mu_n / d_{mn}^b \tag{19}$$

Traffic impedance is related to factors such as residents' travel modes and transportation environment, and is a physical factor that measures the difficulty of travel. Combining traffic impedance with the spatial road characteristics of Sanya tourist attractions, taking into account both time and cost impedance factors, this paper introduces them into the spatial accessibility analysis of Sanya tourist attractions, and improves the spatial accessibility analysis of Sanya tourist attractions. The function expression is:

$$\xi_i = \frac{(\theta_1 T_i + \theta_2 F_i)}{w_j} J_x \tag{20}$$

In Formula (20), $\xi_i$ represents the traffic resistance value, $\theta_1$ and $\theta_2$ represent the coefficients to be labeled, $T_i$ represents the time resistance value, $F_i$ represents the cost resistance value, and $w_j$ represents the regional importance.

*B. Construction of Spatial Accessibility Measurement Model for Sanya Tourist Attractions*

Based on the analysis of spatial accessibility of tourist attractions in Sanya, a measurement model for spatial accessibility of tourist attractions in Sanya is constructed. According to the time schedule and various data obtained, there are four main types of models for measuring the spatial accessibility of tourist attractions in Sanya, namely physical accessibility evaluation models, comprehensive index models based on residents' spatial preferences for tourist attractions in Sanya, analysis models based on differences in residents' spatial motivations for choosing tourist attractions in Sanya, and analysis models based on temporal and spatial behavior, use these four models to measure the spatial accessibility of tourist attractions in Sanya.

*1) Physical accessibility evaluation model:* This type of model is often combined with shortest distance, coverage, gravity method, etc. to describe the spatial distribution of transportation vehicles in Sanya's tourist attractions. The most commonly used indicators for evaluating the supply and demand of transportation vehicles are the distance from residents' residential areas to the location of tourist attractions in Sanya, as well as the spatial scale, capacity, and construction quality of tourist attractions in Sanya.

Based on the two evaluation indicators of shortest distance and scale capacity, the calculation formula is:

$$\begin{cases} D_m = \min\limits_{v} d_{mv} \\ C_m = \dfrac{\xi_i \sum S_v}{P_m} \end{cases} \tag{21}$$

In Formula (21), $D_m$ represents the shortest distance from the starting point to the destination, and $C_m$ represents the spatial capacity of tourist attractions in Sanya, $d_{mv}$ represents the geometric centroid distance, $\min$ represents the minimum function value, $S_v$ represents the total area of spatial facilities construction in Sanya tourist attractions, and $P_m$ represents the total population of the city.

Due to the fact that physical evaluation models are more commonly applied to the same transportation vehicle and have certain limitations, the two evaluation indicators of shortest distance and scale capacity have been modified. The shortest distance from residents' residences to the location of Sanya tourist attractions is $D_{mm}$, and the effective coverage range of

Sanya tourist attractions is $C_{vv}$. The physical accessibility evaluation model is:

$$R = D_{mm} C_{vv} \xi_i \sum_{d_{mv} < K} E\rho \tag{22}$$

In Formula (22), $K$ represents the effective coverage area, $E$ represents the accessibility difference index for residents to access the spatial facilities of Sanya tourist attractions, and $\rho$ represents the population density of transportation users.

According to geographic information system (GIS) classification [12-13], differences in residents' age, income, and other factors are statistically analyzed. Combined with the distribution of population living space, the degree to which different residential areas are covered by the spatial facilities of Sanya tourist attractions is compared, and an evaluation of the physical accessibility of Sanya tourist attractions is completed.

*2) Comprehensive index model Based on residents' spatial preference for Sanya tourist attractions:* For residents, each type of Sanya tourist attraction spatial facility has its unique characteristics, which can meet the specific needs of specific subjects. At the same time, residents have various preferences for Sanya tourist attraction spatial facilities. Due to the fact that the audience level of tourist attractions in Sanya depends on multiple reasons, a comprehensive index model (IEI) is established using two indicators: attractiveness and separation to analyze residents' demand and preference for Sanya tourist attractions. The comprehensive index model takes residents' preference for Sanya tourist attractions as a weight coefficient and uses Likert scale scale to represent the spatial preference of Sanya tourist attractions. The expression of the comprehensive index model for Sanya tourist attractions is:

$$F_{ij(k)} = P_k \times W_{j(k)} \times s_{ij}^{-\alpha} \tag{23}$$

In Formula (23), $P_k$ represents the preference coefficient of different residents for the spatial facilities of different Sanya tourist attractions, $W_{j(k)}$ represents the indicator that attracts residents to choose, $s$ represents the measurement value of the spatial separation degree of Sanya tourist attractions, and $\alpha$ represents the spatial separation coefficient of Sanya tourist attractions.

Based on GIS output classification, a visual map with $F_{ij(k)}$ values is obtained to analyze the spatial distribution of tourist attractions in Sanya.

*3) Analysis model Based on spatial motivation differences of residents choosing Sanya tourist attractions:* This type of analysis model is based on the gravity model and presents the analysis results through GIS and spatial distribution models. Considering the behavioral ability of residents to choose spatial facilities in Sanya tourist attractions and the differences in simulated space, the selection motivation is divided into $\beta_k$ and $\alpha_k$. The calculation formula for the analysis model of spatial motivation differences in Sanya tourist attractions is:

$$G_{ij(r)} = \frac{M_{j(r)} \times D_{j(r)}}{\alpha_k \times \beta_k \times T_{kj}} \tag{24}$$

In Formula (24), $T_{kj}$ represents the spatial value of Sanya tourist attractions, $r$ represents the serial number of Sanya tourist attractions spatial facilities, $M_{j(r)}$ represents the scale of Sanya tourist attractions spatial facilities, and $D_{j(r)}$ represents the service range of Sanya tourist attractions spatial facilities.

*4) Analysis model based on temporal and spatial behavior:* This model mainly analyzes the actual travel schedules of residents and the spatial travel schedules of Sanya tourist attractions, and combines them with spatiotemporal variables to calculate the comprehensive service deprivation coefficient of Sanya tourist attractions. The model considers the matching degree between residents' personal schedules and the spatial schedules of Sanya tourist attractions. Analyze the accessibility of this model from three perspectives:

*a)* The calculation formula for measuring the spatiotemporal accessibility of tourist attractions in Sanya is:

$$\begin{cases} U_{AB}(z, t_1, t_2) = \max(z, t_1, t_2, f) \\ U_{T_\varepsilon T_\varepsilon}(z, t_1, t_2) = \min(z, f) U_{AB}(z, t_1, t_2) \end{cases} \tag{25}$$

In Formula (25), $t_1$ and $t_2$ represent the comprehensive time period, $z$ represents the location of spatial facilities for tourist attractions in Sanya, and $f$ represents the number of spatial facilities for tourist attractions in Sanya during opening hours, $U_{AB}(z, t_1, t_2)$ represents the accessibility ability of residents to reach $f$ in both time and airspace during the comprehensive time period, while $U_{T_\varepsilon T_\varepsilon}(z, t_1, t_2)$ represents the accessibility ability of residents to reach $f$ in the shortest travel time during the comprehensive time period.

*b)* The calculation formula for measuring the spatiotemporal needs of spatial facilities in tourist attractions in Sanya is:

$$H_t(z, t_1, t_2) = \int_{t_1}^{t_2} N_t(z) dz / a \tag{26}$$

In Formula (26), $N_t(z)$ represents the individual residents' demand for the space of tourist attractions in Sanya, and $a$ represents the demand cycle.

Combining the space accessibility of Sanya tourist attractions with the space requirements of Sanya tourist attractions, the analysis model based on time and space behavior is:

$$\eta(z,t_1,t_2)=\varpi\times\left[U_{T_\varepsilon T_\varepsilon}(z,t_1,t_2)\times H_t(z,t_1,t_2)\right] \quad (27)$$

In Formula (27), $\varpi$ represents the weights of time and spatial indicators.

By calculating the spatiotemporal accessibility of Sanya tourist attractions and the spatiotemporal needs of facilities in the model, combined with temporal and spatial indicators, the results are output through GIS.

In order to facilitate calculation and analysis by unifying various indicators, the range standardization method is used to obtain the calculation formula as follows:

$$\varpi_j=(\varpi'-\min\varpi')/(\max\varpi'-\min\varpi') \quad (28)$$

In Formula (28), $\varpi_j$ represents the standardized values of time-domain and spatial indicators, $\varpi'$ represents the original values of time-domain and spatial indicators, $\max\varpi'$ represent the maximum function, and $\min\varpi'$ represents the minimum function.

Due to the strong objectivity and high numerical accuracy of the entropy method, it can effectively reduce the weight of indicators and be affected by subjective factors. Therefore, using the entropy method [14-15] to determine the weight of each indicator can better reflect the impact of evaluation indicators on the evaluation results. The calculation formula is:

$$\begin{cases} R_j=\varpi'/\sum_{j=1}^{n}\varpi_j \\ e_j=\sum_{j=1}^{n}(R_j\times\ln R_j) \\ g_j=1-e_j \\ W_j=\sum_{j=1}^{n}g_j \end{cases} \quad (29)$$

In Formula (29), $R_j$ represents the proportion of indicators, $e_j$ represents entropy, $g_j$ represents the coefficient of difference, and $W_j$ represents the weight coefficient.

The comprehensive accessibility measurement results of the four models are:

$$Z=\sum_{j=1}^{n}W_j\left[G_{ij(r)}F_{ij(k)}C_{vv}D_{mm}\eta(z,t_1,t_2)\right] \quad (30)$$

Through the above steps, the spatial accessibility measurement of tourist attractions in Sanya can be achieved.

# IV. Experimental Analysis

## A. Experimental Environment and Data Sources

As a tourist destination in the tropics, Sanya has many natural landscapes, such as beautiful beaches, magnificent mountains and tropical rainforests. These natural landscapes not only attract many tourists, but also become an important feature of Sanya tourism. In order to verify the validity of the spatial accessibility measurement algorithm of Sanya tourist attractions based on seasonal factor adjustment analysis, the experiment is implemented in MATLAB simulation software environment. Taking Coconut Dream Corridor, Yalong Bay, Haitang Bay, Jiajing Island, wuzhizhou Tourist Scenic Area, Fenjiezhou Island and Nanwan Monkey Island as spatial nodes, the data set of Sanya tourist attractions is divided. Through questionnaires, interviews and other means to collect tourists' evaluation of scenic spots, tourism motivation, consumption behavior and other information. Collect relevant data from government departments, tourism websites, scenic spots management offices and other channels, such as the number of tourists, tourism income, ticket sales, etc. Using big data technology, through analyzing data sources such as online search, social media and travel booking websites, we can get information about tourists' attention and preferences to Sanya tourist attractions.

There may be some noises and missing values in the collected tourism data, which need to be preprocessed, including data cleaning, missing value processing, abnormal value processing and so on. For example, removing duplicate data, correcting erroneous data, filling in missing values, etc. Due to the seasonal factors in Sanya, the popularity and demand of scenic spots may be different in different seasons. Summer is the peak of tourism in Sanya, and many beaches and water sports attractions will become more popular. In winter, some hot springs and tropical botanical gardens may be favored by tourists. Therefore, it is necessary to consider the change of seasonal demand when analyzing the data of Sanya tourist attractions. According to the seasonal characteristics of Sanya tourist attractions, the data can be divided into different seasonal segments. Generally speaking, the tourist season in Sanya is mainly concentrated in winter and summer vacations and holidays, and the data can be divided into seasons according to the date. Based on the data collection, preprocessing and seasonal segmentation of Sanya tourist attractions, the accessibility of Sanya tourist attractions at each node is measured by using the spatial calculation method of Sanya tourist attractions.

## B. Analysis of the Measurement Effect of Spatial Accessibility of Tourist Attractions in Sanya

Accessibility can reflect the difficulty of interconnecting one region with other regions. In order to verify the effectiveness of the spatial accessibility measurement method for tourist attractions in Sanya, the accessibility of this study is understood as the average travel time from a tourist attraction in a certain administrative region of Sanya City to tourist attractions in other administrative regions. The average travel time $s_\tau$ of tourist attraction $\tau$ in Sanya is expressed as:

$$s_\tau = \sum_{\xi=1,\zeta=1}^{\psi} g_{\xi\zeta} / \psi \tag{31}$$

In Formula (31), $\psi$ is the number of tourist attractions in Sanya, and $g_{\xi\zeta}$ is the travel time from point $\xi$ in the region to point $\zeta$ through the shortest route in the transportation network.

Select Coconut Dream Corridor, Yalong Bay, Haitang Bay, Jiajing Island, wuzhizhou Tourist Scenic Area, Fenjiezhou Island and Nanwan Monkey Island as the evaluation index. The smaller the value, the better the spatial accessibility measurement effect of Sanya tourist attractions. The average travel time of tourist attractions in Sanya is shown in Table I.

TABLE I. AVERAGE TRAVEL TIME OF TOURIST ATTRACTIONS IN SANYA

| Sanya Tourist Attractions | $S_\tau$ /min |
|---|---|
| Coconut Dream Corridor | 151.35 |
| Yalong Bay | 120.86 |
| Haitang Bay | 101.65 |
| Jiajing Island | 125.42 |
| Wuzhizhou Tourist Scenic Area | 78.24 |
| Fenjiezhou Island | 81.24 |
| Nanwan Monkey Island Ecotourism Area | 74.43 |

According to the data in Table I, the average travel time of seven tourist attractions in Sanya is 74.43min-151.35min. Among them, the Nanwan Monkey Island Ecotourism Area, with the shortest average travel time of seven tourist attractions in Sanya, is about 74.43min, and this tourist attraction in Sanya has the best spatial accessibility. Followed by Wuzhizhou tourist Scenic Area, about 78.24min, the average travel time of Sanya tourist attractions is the Coconut Dream Corridor, about 151.35min, and the spatial accessibility of Sanya tourist attractions is the worst. Therefore, the method in this paper can effectively measure the spatial accessibility of Sanya tourist attractions, and has a good effect on measuring the spatial accessibility of Sanya tourist attractions.

## C. Precision Analysis of Spatial Accessibility Measurement for Sanya Tourist Attractions

In the process of calculating the spatial accessibility of tourist attractions in Sanya, the Lorentz curve and fairness coefficient are key indicators for judging fairness. Among them, the fairness coefficient is based on the Lorentz curve, and the fairness coefficient value can be calculated based on the area ratio in the Lorentz curve graph. Therefore, the fairness coefficient is used to calculate the fairness level of spatial accessibility of tourist attractions in Sanya. Randomly select 10 time periods as experimental data samples, calculate the fairness coefficients for 10 time periods, and compare the fairness calculation results of the method of reference [7], the method of reference [8], and this article with the actual results. The comparison results of fairness coefficients between different methods are shown in Fig. 1.

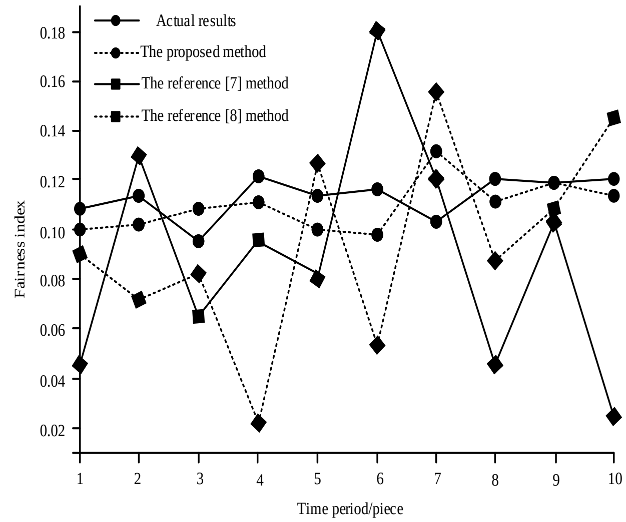


Fig. 1. Comparison results of fairness coefficients of different methods.

According to Fig. 1, the fairness coefficients calculated by different methods in different time periods are different. Comparing the actual results with the methods in this paper, literature [7] and literature [8], we can see that the methods in this paper are in good agreement with the actual results, while the methods in literature [7] and literature [8] are far from the actual results. This shows that the fairness calculation of this method is more accurate and can effectively improve the accuracy of spatial accessibility measurement of Sanya tourist attractions. This is because this method combines the advantages of principal component analysis and independent component analysis, and can consider the characteristics and problems of data more comprehensively. Principal component analysis can reduce the dimension of multivariate to a few principal components and extract the main features of data. Independent component analysis can extract the independent components from the data, further denoising and simplifying the data. By using these two methods comprehensively, the characteristics and problems of data can be considered more comprehensively, thus improving the accuracy of spatial accessibility measurement of tourist attractions.

## D. Time Analysis of Spatial Accessibility Measurement for Tourist Attractions in Sanya

On this basis, further validate the spatial accessibility measurement time of Sanya tourist attractions using the method proposed in this paper. Compare the method of reference [7] and the method of reference [8] with the method proposed in this paper, and obtain the spatial accessibility measurement time of Sanya tourist attractions using different methods, as shown in Fig. 2.

According to Fig. 2, with the increase of the number of time periods, the time for measuring the spatial accessibility of Sanya tourist attractions by different methods increases. When the time period reaches 10, the measurement time of the method in reference [7] is 14.7ms, that of the method in reference [8] is 17.6ms, and that of this method is 4.8 ms. Therefore, it takes a short time to measure the spatial accessibility of Sanya tourist attractions by this method. This is because, this method constructs physical accessibility evaluation model, comprehensive index model based on residents' spatial preference for Sanya tourist attractions, analysis model based on residents' spatial motivation differences in choosing Sanya tourist attractions, and analysis model based on time domain and spatial behavior. The physical accessibility evaluation model can transform complex spatial relations into simple distance and time calculations; The comprehensive index model based on residents' spatial preference for Sanya tourist attractions and the analysis model based on residents' spatial motivation differences in choosing Sanya tourist attractions can measure tourists' preferences and choices from different angles, thus avoiding complex spatial optimization algorithms. These models comprehensively consider the influencing factors of the spatial accessibility of Sanya tourist attractions from different angles, including physical accessibility, tourists' preferences, tourists' choices and spatio-temporal behaviors, so as to reduce repeated calculation and invalid calculation, thus saving calculation time.

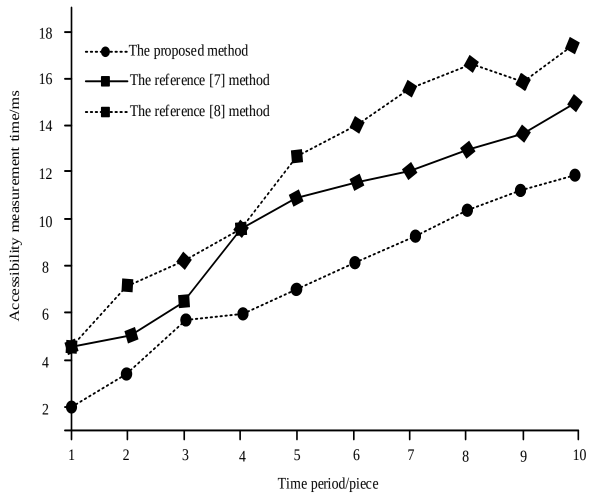


Fig. 2. Measurement time of spatial accessibility of tourist attractions in Sanya using different methods.

## V. Discussion

According to the experimental results, the spatial accessibility of Nanwan Monkey Island Ecotourism Area is the best, while the spatial accessibility of Coconut Dream Corridor is the worst. This shows that when planning tourist routes or promoting tourist attractions in Sanya, priority should be given to those scenic spots with good spatial accessibility, such as Nanwan Monkey Island Ecotourism Area and Wuzhizhou Tourist Scenic Area. For scenic spots with poor spatial accessibility, such as Coconut Dream Corridor, more resources need to be put into improvement, such as adding traffic lines and improving the service level of public transportation. The spatial accessibility measurement algorithm of Sanya tourist attractions based on seasonal factor adjustment analysis proposed in this paper has high accuracy and reliability. Therefore, in practical application, this method should be given priority to improve the accuracy and efficiency of spatial accessibility measurement of Sanya tourist attractions. With the increase of the number of time periods, the time for measuring the spatial accessibility of Sanya tourist attractions with different methods increases. This shows that in real-time monitoring or high frequency measurement, we need to pay more attention to computational efficiency and resource consumption. Therefore, in practical application, the appropriate number of time periods should be selected according to the specific situation to balance the calculation efficiency and measurement accuracy.

## VI. Conclusion

In this paper, the spatial accessibility measurement algorithm of Sanya tourist attractions based on seasonal factor adjustment analysis is proposed. Through the study of the spatial accessibility of Sanya tourist attractions, this paper puts forward the method of seasonal factor adjustment analysis. By extracting the data characteristics of Sanya tourist attractions in different seasons, combining with the spatial information of Sanya tourist attractions and GIS technology, this paper analyzes the spatial accessibility of Sanya tourist attractions, constructs the spatial accessibility measurement model of Sanya tourist attractions, and realizes the spatial accessibility measurement of Sanya tourist attractions. This method has a good effect of measuring the spatial accessibility of Sanya tourist attractions, which can effectively eliminate the influence of seasonal factors, improve the accuracy of accessibility measurement and shorten the time of accessibility measurement, so as to measure the spatial accessibility of tourist attractions more objectively and accurately. This not only provides a scientific basis for the development of tourism in Sanya, but also helps to improve the tourist experience.

However, there are still some limitations in this study. For example, there may be some deviation when collecting data, and the seasonal influencing factors of some scenic spots may be complicated. Therefore, future research can further expand the data sources and enhance the accuracy of data, and at the same time, deeply study the seasonal influencing factors of different scenic spots, so as to adjust the analysis methods more finely. In addition, we will explore more efficient and accurate measurement algorithms by combining research results in other fields, such as artificial intelligence and machine learning. At the same time, we can further expand the research scope and combine the development of Sanya tourism with environmental protection, cultural inheritance and other related fields to promote the sustainable development of Sanya tourism. Through continuous in-depth study and improvement of seasonal factor adjustment and analysis methods, we hope to provide more valuable scientific basis and decision support for the prosperity and development of Sanya tourism.

## Acknowledgment

This research was supported by 2021 Hainan Provincial Social Science Fund Project "Research on the Growth of Hainan Rural Tourism Micro-enterprises from the Perspective of Kinship" (Grant number HNSK（YB）21—13).

## References

[1] Tampubolon, F., & Sinulingga, J. (2021). Socialization of Efforts to Increase Environmental Awareness in Pangambatan Village as A Tourist Attraction in Karo Regency. ABDIMAS TALENTA: Jurnal Pengabdian Kepada Masyarakat, 6(1), 91-98. DOI: 10.32734/ ABDIMASTALENTA.V6I1.5395.

[2] Wang, Y. W., Wu, X. Y., Liu, Z. Z., Chen, H., & Zhao, Y. Y. (2022). Spatial Patterns of Tourist Attractions in the Yangtze River Delta Region. Land, 11(9): 1523. DOI: 10.3390/land11091523.

[3] Yuliviona, R., Azliyanti, E., Tasri, E. S., & Lindawati. (2021). The effect of tourist attraction, location and promotion toward local tourist decision visit to air manis beach in padang city in new normal policy. IOP Conference Series: Earth and Environmental Science, 747(1), 012085. DOI: 10.1088/1755-1315/747/1/012085.

[4] Kim, G. S., Chun, J., Kim, Y., & Kim, C. K. (2021). Coastal tourism spatial planning at the regional unit: Identifying coastal tourism hotspots based on social media data. ISPRS International Journal of Geo-Information, 10(3), 167-177. DOI: 10.3390/IJGI10030167.

[5] Zhou, H. T, Ma, Y. S., Fan, Y. Y., & Ning, X. L. (2023). Spatial distribution and accessibility analysis of red tourism resources in Inner Mongolia. Arid Land Geography, 46(5): 814-822. DOI: 10.12118/ j.issn.1000-6060.2022.423.

[6] Wang, H., & Yang, L. (2022). Study on Spatial Distribution Characteristics and Accessibility of 4 A Level and Above Scenic Spots in Xinjiang. Journal of Sichuan Normal University(Natural Science),45(6):817-829. DOI: 10.3969/j.issn.1001-8395.2022.06.017.

[7] Liu, W., Dong, A. R., Deng, L., Zhu, T., & Pi, Y. X. (2021). Research on Fairness Measurement of Urban Public Transportation Accessibility Based on Network Open Data. Journal of Wuhan University of Technology(Transportation Science & Engineering),45(06):1045-1050. DOI: 10.3963/j.issn.2095-3844.2021.06.008.

[8] Dong, L., Lv, Y., Sun, H., Zhi, D., & Chen, T. (2021). GPS Trajectory-Based Spatio-Temporal Variations of Traffic Accessibility under Public Health Emergency Consideration. Journal of Advanced Transportation,2021,(3):1-22. DOI: 10.1155/2021/8854451.

[9] Pilario, K. E., Tielemans, A., & Mojica, E. R. E. (2022). Geographical discrimination of propolis using dynamic time warping kernel principal components analysis. Expert Systems with Applications, 187, 115938. DOI: 10.1016/j.eswa.2021.115938.

[10] Zhao, L., Zhao, X., Zhou, H., Wang, X., & Xing, X. (2021). Prediction model for daily reference crop evapotranspiration based on hybrid algorithm and principal components analysis in Southwest China. Computers and Electronics in Agriculture, 190, 106424. DOI: 10.1016/j.compag.2021.106424.

[11] Geng, L., Li, H., & Liu, L. (2022). Mining method of fuzzy frequent item set based on principal component analysis. Computer Simulation, 39(02), 410-413. DOI: 10.3969/j.issn.1006-9348.2022.02.078.

[12] Amaro-Mellado, J. L., Melgar-García, L., Rubio-Escudero, C., & Gutiérrez-Avilés, D. (2021). Generating a seismogenic source zone model for the Pyrenees: A GIS-assisted triclustering approach. Computers & Geosciences, 150, 104736. DOI: 10.1016/ j.cageo.2021.104736.

[13] Zhou, Z., Qingshan, Z., Dongyi, L., & Weihong, T. (2021). Three-dimensional reconstruction of huizhou landscape combined with multimedia technology and geographic information system. Mobile Information Systems, 2021, 1-13. DOI: 10.1155/2021/9930692.

[14] Özer Genç, Ç., & Arıcak, B. (2022). Developing a Harvest Plan by Considering the Effects of Skidding Techniques on Forest Soil Using a Hybrid TOPSIS-Entropy Method. Forest Science, 68(3), 312-324. DOI: 10.1093/forsci/fxac010.

[15] Yan, X. F. (2022). Research on the action mechanism of circular economy development and green finance based on entropy method and big data. Journal of Enterprise Information Management, 35(4), 988-1010. DOI: 10.1108/jeim-01-2021-0024.