

# *A Study on the Accessibility of Public Transit to Scenic Spots in Guilin based on Transfer Times*

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**Abstract:** In this paper, taking Guilin, a traditional tourist city, as an example, based on the data of public transport lines, bus stations and scenic spots, the convenience of the public transport is studied by using the indexes of transfer times and accessibility. The following findings were obtained: (1) Transfer times and accessibility index can be very intuitive and simple to measure a region's tourism public transportation convenience; (2) There is a great imbalance of Guilin tourism public transport, the majority scenic areas accessibility are relatively concentrated, and the minority scenic areas accessibility are dispersed, which formed 3 aggregation group; (3) The accessibility of public transportation in scenic areas can be improved significantly by adjusting a few public transport lines and sites.

## 1. Introduction

Tour transport is one of the six major traditional elements of tourism and the base and pre-condition for the development of tourism. Tour transport not only connects the tourist-generating region with the destination, but also is the link between different supply elements at the place tourist destination. As an important part of tour transport, the convenience of public transit for tourism influences directly the activity efficiency and tour experiences of tourists at the destination of tour.

Hansen (1959) proposed initially the concept of accessibility and defined it as the opportunity for mutual effect between nodes of transport network. Ingram (1971) recommended to measure, with Gaussian curve as the base, the overall accessibility of given points. In his research with the multivariate regressive method, Danaher (1996) found that there is no significant relationship between the satisfaction of tourists visiting New Zealand to the destination of tour and the tour transport. By deploying the transport cost model expenditure, B Prideaux (2000) studied the dynamic relation between tourist-generating regions of tourists. Avgousits observed that of the 14 factors affecting the satisfaction with the destination of tour, the accessibility of public transit service is the fourth important factor. Lumsdon (2006) observed that transport coupon plays a remarkable role in promoting the one-day tour. Thompson (2007) observed that the influence of the accessibility of public transit on the satisfaction with destination is higher than that of efficiency and safety. Albalate (2008) pointed out that tourism is of the positive externality to the construction of urban public transit, but also caused the external cost to the local residents. His research on the

satisfaction of tourists to the public transit in Dubai, Parahoo (2014) found: availability and applicability enhanced the attraction of tourist destination. Zoghbi Manrique de Lara (2016) found that national benefit and public transit service can promote the loyalty of tourists to the destination. Gutiérrez (2016) observed that the ratio of tourists, flying the destination and choosing public transit at the destination for touring activities, is the highest. Yang (2015) studied the capacity of urban public transit in Melbourne, London, Paris and Singapore serving the international tourists and observed that they all have a great room for improvement. CHEN Xiao (2008) analyzed quantitatively the harmony between such two systems as urban transport and tourism in Dalian and it's found that the harmony between city-area transit and tourism is higher than the outskirts. CHEN Gang (2009) observed that with the dependence on the transport integration being gradually weakened, hotels above 3-star in the main city area of Guilin prefer to be away from the city center. WANG Zhaofeng (2014) observed the “convenience” of public transit in tourist cities is relatively influential on customer satisfaction and revisit desire. WU Pan (2016) found the public transit routes in Xi'an cannot meet completely the demand of tourists and the convenience of tour transport needs to be improved. CHEN Fang (2013) proposed the planning method for public transit system in new tourist districts based on TOD tactics.

All in all, the research workers at home and abroad are already aware that the convenient and fast public transit for tourism is an important factor affecting the service quality satisfaction at the destination of tour and have proposed such measuring methods as distance method, topological network connection method, gravity measurement method and accumulative opportunity method. However, the previous researched laid more stress on measuring the accessibility of road network and considered less the influence of public transit route and stop setup on the accessibility between tourist nodes.

As one of the traditional tourist destinations in China, Guilin has undertaken long-term exploration and innovation in the development of public transit for tour. Free buses started in 2002, sightseeing buses started in 2008, and public transit routes were adjusted on a large scale in 2015, but as for the tourists, the effect of public transit for tour was not ideal. With the development of Internet technology and modern transport modes, individual tourists became gradually the main group of tourist activities, setting forth high requirement for the construction of public transit for tour. According to the survey, it is observed that public transit is the transport mode individual tourists wish most to choose during the tour in Guilin, but due to such reasons as non-smooth information, not knowing the availability of public transit between scenic spots, inconvenient public transit, and complicated transfer, the ratio (17%) of individual tourists choosing public transit is not high in actual tour activities.

By collecting the data of public transit routes and stops between scenic spots in the city area of Guilin and with transfer times and accessibility research method, this paper measures the convenience of public transit for tour between scenic spots in the city area of Guilin and tries to propose the tactics for improving the accessibility of public transit for tour.

## 2. Research Method

According to the tourist survey, tourists are most concerned whether the direct public transit route is available between two scenic spots (73%), but relatively less concerned about the distance between two scenic spots, travel time, and number of public transit stops. When there is no direct public transit between two scenic spots, most (83%) of the tourists can accept 1 transfer time, and when the transfer times are more than 2, tourists prefer to take taxi, online-hired car and other personalized public transit. Therefore, in the research, such indicators as transfer times and accessibility are used for the study on the accessibility of public transit between scenic spot.

## 2.1 Transfer times

Assuming a tourist travels from Scenic Spot X to Scenic Spot Y, by comparing different public transit routes and transfer stops on the public transit network, search the possible paths from X to Y, and then compare the transfer times of different possible paths, before determining the optimal path. Set:

$C_{(i)}$  ( $i= 1,2,\dots,m$ ) is the public transit route set via Scenic Spot X;

$D_{(j)}$  ( $j= 1,2,\dots,n$ ) is the public transit route set via Scenic Spot Y;

$E_{(i,u)}$  ( $U= 1,2,\dots,p$ ) are the stops on Route  $C_{(i)}$ ;

$F_{(j,v)}$  ( $V= 1,2,\dots,q$ ) are the stops on Route  $D_{(j)}$ ;

Search steps are as follows:

1 Determine initial Scenic Spot X and target Scenic Spot Y by bus

2-1 Find all the routes set  $C_{(i)}$  via Scenic Spot X and all the routes set  $D_{(j)}$  via Scenic Spot Y;

2-2 Judge where there is  $C_{(i)}=D_{(j)}$ . If yes, search the direct route  $C_{(i)}$  from Scenic Spot X to Scenic Spot Y, i.e.,  $D_{(j)}$  (Figure 1-1); if not, go to next step;

3-1 Seek Top Stop  $E_{(i,u)}$  on Route  $C_{(i)}$  and Stop  $F_{(j,v)}$  on Route  $D_{(j)}$ ;

3-2 Judge whether there is the same stop, i.e.,  $E_{(i,u)}= F_{(j,v)}$ . If yes, Routes  $C_{(i)}$  and  $D_{(j)}$  are 1-time transfer routes (Figure 1-2),  $E_{(i,u)}$  (i.e.,  $F_{(j,v)}$ ) is the transfer stop, one transfer is required at  $E_{(i,u)}$  (i.e.  $F_{(j,v)}$ ) from Scenic Spot X to Scenic Spot Y; if not, it is considered as impossible to travel from Scenic Spot X to Scenic Spot Y by public transit (Figure 1-3).

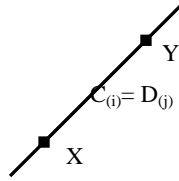


Fig. 1-1 Direct

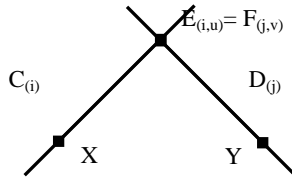


Fig. 1-2 1-time transfer

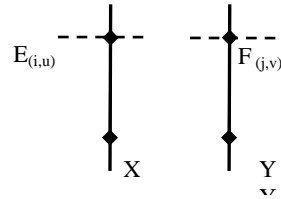


Fig. 1-3 2-times or more transfer

Fig.1 Public transport transfer model

## 2.2 Accessibility

Based on the transfer times, this paper proposes to measure quantitatively the accessibility between scenic spots, with the indicator accessibility. Accessibility and transfer times show a reciprocal relation.  $A_{(x,y)}$  is used to indicate the accessibility between Scenic Spot X and Scenic Spot Y,  $0 \leq A_{(x,y)} \leq 1$ . 1 indicates a high accessibility between Scenic Spot X and Scenic Spot Y, with the direct public transit bus available; 0 indicates a very low accessibility between Scenic Spot X and Scenic Spot Y, with no public transit buses available.

When it is possible to access between Scenic Spot X and Scenic Spot Y by taking one public transit bus,  $A_{(x,y)}=1$ ;

When it is only possible to access between Scenic Spot X and Scenic Spot Y by taking 2 public transit buses with 1 transfer,  $A_{(x,y)}=1/2$ ; when it is only possible to access between Scenic Spot X and Scenic Spot Y by taking 3 public transit buses with 2 transfers,  $A_{(x,y)}=1/3$ ; and so on.

In this paper, according to the transfer times acceptTab.to tourists, it is considered when it is only possible to access between Scenic Spot X and Scenic Spot Y with 2 or more transfers, i.e., by taking 2 or more public transit buses,  $A_{(x,y)}=0$ .

### 3. Scope of Study and Data Processing

#### 3.1 Scope of Study

The study selects the scenic spots in the city area of Guilin as the study objects, mainly based on the following two reasons: (1) Guilin is one relatively early traditional sightseeing city, with the city in scenes and scenes in the city, including 14 scenic spots of 3A and above in the city area, such as Elephant Hill, Seven stars Park, Diecai Hill scenic spots, etc. Since long, these scenic spots have been the important nodes of tour; (2) upon development for years, in the city area of Guilin, tourist resources and land resources have been basically developed completely and the spatial pattern of a landscape city has been basically established. With the urban functions for people’s daily life and work and tourism being increasingly improved and the public transit system becoming stable, it can reflect the rule of tourist public transit activities in Guilin.

#### 3.2 Data Source and Processing

With 57 (two-way 114) public transit routes and 890 stops, run by Guilin Communications Investment Holding Group Co., Ltd, the only public transit operation enterprise in the city area of Guilin, in 2016 as samples (Tab.1 and Tab.2), establish the database of Guilin public transit routes. The study method in Section 2.1 is used to search the public transit routes between 14 scenic spots of 3A and above in the city area of Guilin, Google map is deployed for online verification and field survey is undertaken to finally determine the public transit transfer paths between 14 scenic spots and obtain the transfer relation form (Tab.3) of public transit between different scenic spots for calculation of the accessibility of different scenic spots (Tab.4).

Tab.1: Urban Public Transit Routes in Guilin (Two-way Statistics)

Total PT Routes	Total PT Stops	PT Stops for Scenic Spots	PT Routes for Scenic Spots	Average Scenic Spots per Route	Average Stops per Scenic Spot
114	890	38	64	2.84	2.71

Tab.2: Public Transit Stops and Routes for Scenic Spots in the City Area of Guilin (Two-way Statistics)

Scenic Spot	PT Stops	PT Routes	Scenic Spot	PT Stops	PT Routes
Duxiu Hill	5	21	Fubo Hill	2	2
Seven stars Park	8	27	Nanxi Hill	2	4
Ludi Cave	3	3	Liu Sanjie Showplace	0	0
Elephant Hill	4	6	West Hill	2	12
Two rivers & Four lakes	5	23	Heliotrope Center	3	3
Chuanshan Hill	2	2	Zengpi Cave	2	9
Diecai Hill	2	3	Lujia Village	2	2

Tab.3: Transfer Relation of Public Transit between Scenic Spots in the City Area of Guilin

From \ To	Duxiu Hill	Seven stars Park	Ludi Cave	Elephant Hill	Two rivers & Four lakes	Chuanshan Hill	Diecai Hill	Fubo Hill	Nanxi Hill	Liu sanjie Showplace	West Hill	Heliotrope Centr	Zengpi Cave	Lujia Village
Duxiu Hill	-	11	203-3	Nil	11	28-214	Walk	Walk	11	Nil	14	203-3	11-5	14-213
Seven stars Park	11	-	14-3	25-16	11	28-214	11-2	11-2	11	Nil	14	14-3	28	14-213
Ludi Cave	3-203	3-14	-	3-2	3	Nil	3-203	3-203	3-11	Nil	213	Walk	3-5	213
Elephant Hill	Nil	16-25	2-3	-	Walk	16-214	2	2	16-11	Nil	23-25b	16-3	16-5	Nil
Two rivers & Four lakes	11	11	3	Walk	-	16-214	2	2	11	Nil	23-25b	3	5	3-213
Chuanshan Hill	214-28	214-28	Nil	214-16	214-16	-	Nil	Nil	Nil	Nil	214-25	Nil	214-28	Nil
Diecai Hill	Walk	2-11	203-3	2	2	Nil	-	2	203-11	Nil	89	203-3	2-28	Nil
Fubo Hill	Walk	2-11	203-3	2	2	Nil	2	-	203-11	Nil	203-25	203-3	203-5	Nil
Nanxi Hill	11	11	11-3	11-16	11	Nil	11-203	11-203	-	Nil	11-25b	11-3	11-86	11-213
Liu Sanjie Showplace	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-	Nil	Nil	Nil	Nil
West Hill	14	14	213	25b-23	25b-23	25-214	89	25-203	25b-11	Nil	-	213	25b-5	213
Heliotrope Center	3-203	3-14	Walk	3-16	3	Nil	3-203	3-203	3-11	Nil	213	-	3-5	213
Zengpi Cave	5-11	28	5-3	5-16	5	28-214	28-2	5-203	86-11	Nil	5-25b	5-3	-	Nil
Lujia Village	213-14	213-14	213	Nil	213-3	Nil	Nil	Nil	213-11	Nil	213	213	Nil	-

Tab.4: Accessibility of Public Transit between Scenic Spots in the City Area of Guilin

From \ To	Duxiu Hill	Seven stars Park	Ludi Cave	Elephant Hill	Two rivers & Four lakes	Chuanshan Hill	Diecai Hill	Fubo Hill	Nanxi Hill	Liu Sanjie Showplace	West Hill	Heliotrope Centre	Zengpi Cave	Lujia Village	Total
Duxiu Hill	-	1.0	0.5	0.0	1.0	0.5	1.0	1.0	1.0	0.0	1.0	0.5	0.5	0.5	8.5
Seven stars Park	1.0	-	0.5	0.5	1.0	0.5	0.5	0.5	1.0	0.0	1.0	0.5	1.0	0.5	8.5
Ludi Cave	0.5	0.5	-	0.5	1.0	0.0	0.5	0.5	0.5	0.0	1.0	1.0	0.5	1.0	7.5
Elephant Hill	0.0	0.5	0.5	-	1.0	0.5	1.0	1.0	0.5	0.0	0.5	0.5	0.5	0.0	6.5
Two rivers & Four lakes	1.0	1.0	1.0	1.0	-	0.5	1.0	1.0	1.0	0.0	0.5	1.0	1.0	0.5	10.5
Chuanshan Hill	0.5	0.5	0.0	0.5	0.5	-	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	3.0
Diecai Hill	1.0	0.5	0.5	1.0	1.0	0.0	-	1.0	0.5	0.0	1.0	0.5	0.5	0.0	7.5
Fubo Hill	1.0	0.5	0.5	1.0	1.0	0.0	1.0	-	0.5	0.0	0.5	0.5	0.5	0.0	7.0
Nanxi Hill	1.0	1.0	0.5	0.5	1.0	0.0	0.5	0.5	-	0.0	0.5	0.5	0.5	0.5	7.0
Liu Sanjie Showplace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
West Hill	1.0	1.0	1.0	0.5	0.5	0.5	1.0	0.5	0.5	0.0	-	1.0	0.5	1.0	9.0
Heliotrope Center	0.5	0.5	1.0	0.5	1.0	0.0	0.5	0.5	0.5	0.0	1.0	-	0.5	1.0	7.5
Zengpi Cave	0.5	1.0	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.0	0.5	0.5	-	0.0	6.5
Lujia Village	0.5	0.5	1.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	1.0	1.0	0.0	-	5.0

## 4. Data Analysis

### 4.1 Analysis of Public Transit Routes

14 scenic spots in the city area of Guilin are linked two by two to form 182 routes, of which 8 are walk routes, 46 straight routes, 80 routes with one transfer and 48 routes without public transit, involving No. 11 and other 14 public transit routes (two-way 30). Since the distance is relatively

close for such four pairs of scenic spots as Duxiu Hill-Diecai Hill, Duxiu Hill-Fubo Hill, Elephant Hill-Two rivers & Four lakes, and Ludi Cave-Heliotrope Center, they are accessible by walk. The mode of transport such three scenic spots as Seven stars Park, Two rivers & Four lakes and West Hill with other scenic spots is relatively convenient and it is possible to access other scenic spots by walk, direct route or route with one transfer. Liu Sanjie Showplace has no direct public transit or public transit with one transfer to other scenic spots. Between other scenic spots, public transit, direct or with one transfer, is available or not available to different extents.

126 direct routes and routes with one transfer involve 15 public transit routes in 206 times, including mostly No. 11 and No. 3, up to 34 times respectively; No. 203 and No. 2, No. 213 20 times and 18 times, respectively. The number of scenic spots linked by these 5 routes is 3-4, respectively. No. 89 and No. 86 are least involved, with only two routes. No. 86 links to Zengpi Cave only, while No. 89 links to West Hill and Diecai Hill only.

## 4.2 Accessibility Analysis

According to the statistical analysis of the accessibility of scenic spots in Tab.4, it is concluded: the average accessibility value of 14 scenic spots is 6.7, with the standard difference as 6.42, the range as 10.5, and the coefficient of variation as 0.96. It indicates an extremely high measures-of-dispersion of accessibility between scenic spots in the city area of Guilin. By analyzing further the accessibility of different scenic spots, it may be observed that the accessibility of scenic spots shows a feature of being mostly centralized and individually different to a great extent: the accessibility between most of the scenic spots (71%) is mainly 6.5-9; the highest is Two rivers & Four lakes, with the accessibility of 10.5, and the lowest is Liu Sanjie Showplace, with the accessibility of 0, next to which is Chuanshan Hill, with the accessibility of 3 (Figure 2). As a whole, the accessibility of scenic spots is in the positive correlation with the number of public transit routes ( $\gamma=0.64$ ) and the number of public transit stops ( $\gamma=0.63$ ) of the scenic spots.

By carrying out the field survey on the scenic spots with relatively low accessibility, Liu Sanjie Showplace and Chuanshan Hill, it is observed: since Liu Sanjie Showplace is located relatively far away, with No. 213 public transit route passing by, but without a bus stop and with the nearby bus stop being relatively far away, it is impossible to form the effective public transit access to other scenic spots. Chuanshan Hill has around Lijiang Road, Chuanshan Hill East Road and urban trunk roads, with numerous public transit routes, but due to such man-flow-intensive areas as Jiatianxia Square and gymnasium, the bus stops and routes of No. 16, No. 23 and so on are mostly arranged for Jiatianxia Square and the gymnasium, resulting in a blind area and Chuanshan Hill becomes an isolated island in the urban public transit system.

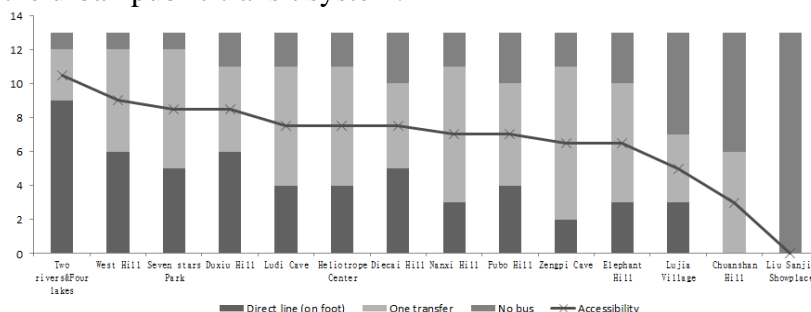


Figure2: Distribution of Scenic Spots Accessibility in the city area of Guilin(before adjustment)

## 4.3 Grouping of Scenic Spots

By analyzing the public transit routes and accessibility between scenic spots, it is observed

scenic spots form the obvious clustered groups: (1) Ludi Cave—West Hill Group, including such four scenic spots as Ludi Cave, Heliotrope Center, West Hill and Lujia Village, which linked together by Bus No. 213; (2) Elephant Hill-Diecai Hill Group, including such four scenic spots as Elephant Hill, Two rivers & Four lakes, Fubo Hill and Diecai Hill, which are linked by Bus No. 2 and by walk; (3) Seven stars Park-Duxiu Hill Group, including such four scenic spots as Seven stars Park, Duxiu Hill, Two rivers & Four lakes and Nanxi Hill, which are linked by Bus No. 11. The accessibility is 1 between the scenic spots within the three groups.

#### 4.4 Measures for Adjustment

In the circumstance of keeping the overall arrangement of public transit routes stable, by adjusting slightly the a few number of public transit routes, it is possible to improve remarkably connection of public transit between scenic spots and promote the public transit accessibility of the scenic spots.

(1) Add Liu Sanjie Showplace Stop. Liu Sanjie Showplace neighbors with West Hill, with No. 213 and No. 25 passing by and with two bus stops, Shengli Bridge and Jiashan, about 400m away before and after it. By adding Liu Sanjie Showplace Stop, without changing the route of No. 213 and No. 25, Liu Sanjie Showplace can be effectively included in the urban public transit system, forming a scenic spot group with such four scenic spots as Ludi Cave, Heliotrope Center, West Hill and Lujia Village.

(2) The terminal of No. 25 is adjusted to Chuanshan Hill. The downward terminal of No. 25 is Shijiayuan, about 900m away from Chuanshan Hill, with Lijiang Road in between. If the terminal of No. 25 is extended to Chuanshan Hill scenic spots, with the original route unchanged, Chuanshan Hill can be linked with such scenic spots as Seven stars Park, Duxiu Hill and West Hill.

(3) Seven stars Park Park Stop is added to No. 2. Since the Lijiang River runs through the city area of Guilin, dividing the city area into two parts, East and West, the scenic spots nearby can hardly be linked even though facing each other across the river. Bus No. 2 runs along the river on the west bank of the Lijiang Rivers and is the link of Elephant Hill—Diecai Hill Group. By extending No. 2 to the east bank of the Lijiang River, it is possible to link Seven stars Park-Duxiu Hill closely with Elephant Hill—Diecai Hill Group.

Upon adjusting with the foregoing measures: of the 182 routes, there are still 8 walk routes, the number of direct routes increases to 72, the number of routes with one transfer increases to 92 and the number of routes without public transit decreases to 10. The average accessibility of scenic spots increases to 9.0, standard difference decreases to 2.03, the range reduces to 5.0, and the coefficient of variation is lowered to 0.23. The accessibility of public transit between scenic spots is promoted sharply and the difference of accessibility between different scenic spots is remarkably reduced (Figure 3).

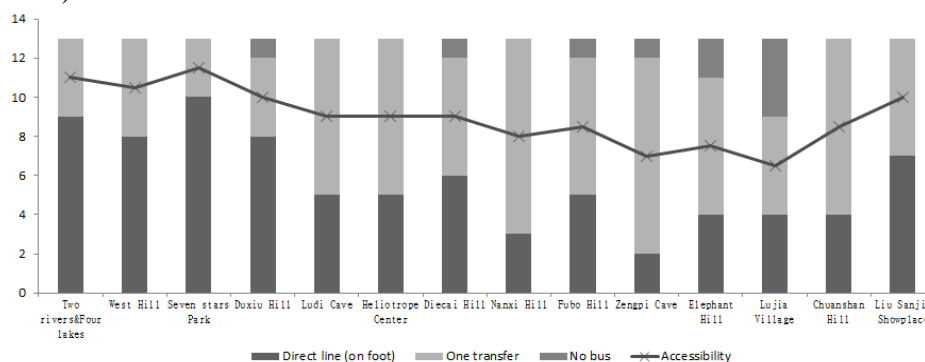


Figure 3: Distribution of Scenic Spots Accessibility in the city area of Guilin (after adjustment)

## 5. Conclusion and Discussion

By analyzing the transfer of public transit between different scenic spots, this paper finds a tour route accessible to most of the scenic spots by public transit and without transfer: Zengpi Cave-No.28-Seven Stars Park-No.11-Duxiu Hill- No.14-West Hill- No.213-Lujia Village- No.213-Ludi Cave (Heliotrope Center)- No.3 -Two rivers & Four lakes-Walk-Elephant Hill- No.2-Fubo Hill-No.2-Diecai Hill. This links 12 scenic spot except for Chuanshan Hill and Liu Sanjie Showplace.

54% of the public transit routes run by scenic spots, but most of the scenic spots (13) can linked together only with 30 (two-way) public transit routes, indicating that overlapping of public transit routes is relatively series in the city area of Guilin. Such indicators as range and coefficient of variation indicate the public transit for tour in Guilin is observed with a non-equilibrium problem, and the accessibility of scenic spots is much different.

With the method of calculating the transfer times, the indicators can visually explain the public transit relationship between scenic spots and the indicator of accessibility can measure, in a simple way, the accessibility of public transit between scenic spots. When integrated, the two can better explain the convenience of public transit for tour in one region.

According to the results of tourist survey, this paper studies emphatically the major factors influencing tourists in choosing the public transit routes: transfer times. When multiple transfer modes are available, the route with least stops is chosen, without studying the route of shortest distance between two scenic spots. In the field survey, it is also observed that it is accessible between scenic spots by public transit, directly or with one transfer, but it is not necessarily the shortest route. The quantitative relation between transfer times and shortest distance shall be further studied.

The extent of developed public transit represents the level of public service for tourism in a tourist city. Since the land resources are tight in the city area, it is hard to have a large scale of land available for constructing such facilities mainly for tourist services as car parks in the scenic spots. The tourist cities should include the public transit for tourism into the urban public transit for general planning and construction, increase the supply of public transit for tourism and reduce the pressure on urban public transport due to the choice of tourists for personalized transport modes.

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