Chin. Geogra. Sci. 2012 Vol. 22 No. 4 pp. 496–506
doi: 10.1007/s11769-012-0552-y
www.springerlink.com/content/1002-0063

Karst Cave Tourism System in Zhejiang Province Based on Resource Regional Analysis

JIN Pingbin[1], FU Zhiwei[2], BAN Maosheng[3]

(*1. Department of Earth Sciences, Zhejiang University, Hangzhou 310027, China; 2. Beijing Tsinghua Urban Planning & Design Institute, Beijing 100085, China; 3. China Academy of West Region Development, Zhejiang University, Hangzhou 310028, China*)

Abstract: Karst cave tourism plays an important role in the overall tourism of Zhejiang Province, China. In analyzing the current status of karst cave tourism resources, it is crucial to develop a scientific system for optimizing resource exploitation and tourism development in the future. This study conducted an analysis of resource characteristics and regional structure in Zhejiang Province. Nearest neighbor index (NNI) method and accessibility index method were used for a comprehensive understanding of the effects of scale, strength, combination, and accessibility of karst cave tourism resources. Results indicated that karst cave tourism resources in Zhejiang Province have a significant regional influence, and that resource quality and exploitation are diverse in different regions. Among the regions, Jinhua had the highest exploitation proportion of over 60% and the lowest NNI value of 0.098. Furthermore, regional analysis inferred that different karst caves demonstrate diversity in accessibility to tourism markets, among which the Lingshan Cave, Fengshui Cave, and Xianqiao Cave reveal the highest accessibility index of 2.41. Finally, we put forward a karst cave tourism system in Zhejiang Province based on the Growth Pole Theory and set up an overall scheme for karst cave tourism development. From a regional perspective analysis, the study refined the methods for regional resource research and provided a strategic proposal for karst cave tourism in Zhejiang Province.

Keywords: regional analysis; karst cave tourism resource; karst cave tourism system; Zhejiang Province

Citation: Jin Pingbin, Fu Zhiwei, Ban Maosheng, 2012. Karst cave tourism system in Zhejiang Province based on resource regional analysis. *Chinese Geographical Science*, 22(4): 496–506. doi: 10.1007/s11769-012-0552-y

1 Introduction

According to The General Survey of China's Tourism Resources, karst cave tourism resources belong to the cave category. The features of karst cave tourism resources include sustainability, periodicity, non-substitutability in tourism function, and variability after exploitation (Yang, 1998). Owing to the landform factor, karst caves reveal similarities in landscapes and regional substitutability, and are typical regional tourism resources (Bao, 1995).

Studies on the exploitation of karst cave tourism resources are currently often found in a large volume of relevant literature. Most early researchers paid close attention to natural characteristic description and evaluation on karst caves in a region. With summarizations on the advantages and constraints of karst cave tourism resources, some development proposals were presented (Ming, 1997; Ye and Gan, 1999). Xu (1989) analyzed the basic situation of karst cave resources in Hunan Province, and put forward four karst cave resource regions for exploitation. Zhu and Dong (2007) also provided an overview of the karst cave resources in Zhejiang Province, and indicated the defects in karst cave tourism development. However, their studies did not contain a quantitative analysis, which may have made their findings more convincing. Xu (1990) investigated the karst caves in Jinhua City and pointed out some caves to be prioritized for use in the entire area, but his study was mainly based on geological conditions and neglected the regional background. Bao (1995) brought up some exploiting types for caves, including

Received date: 2011-12-11; accepted date: 2012-03-22
Foundation item: Under the auspices of National Natural Science Foundation of China (No. 30571524)
Corresponding author: BAN Maosheng. E-mail: banmsh@sohu.com

isolated caves, integrated caves, and caves in famous scenic spots. Furthermore, he promoted a concept of intervening opportunities in cave exploitation. Arrigo and Ezio (2000) claimed that environmental aspects should be considered before karst cave tourism resource exploitation takes place. From the perspectives of tourism, environment, and economy, the above-mentioned studies have been proven to be more scientific than before. However, they still focused on separate caves.

With the introduction of the life cycle theory, some researchers attempted to guide and regulate the exploitation of karst cave resources (Ding and Bao, 2000; Li *et al*., 2003; Li *et al*., 2004). Those studies succeeded in their time series analysis and explained the developing rules of karst cave tourism resources. In view of the life cycle of karst caves, some studies focused on mature karst caves. Wu and Zhuang (2007) studied the Jiushan Cave in Anhui Province, which had been exploited for more than 20 years, and pointed out two aspects of strategies for sustainable development. According to the questionnaire research on the Tianquan Cave, Xu and Chen (2009) upgraded five cave products and suggested that product upgrading should be systemic work. Comparisons among karst caves in different regions may help in reaching a more comprehensive conclusion because karst cave tourism resources generally function as complex systems involving various external factors.

In terms of tourism market factors, Yin (1999) analyzed the distribution of travelers to Zhijin Cave in Guizhou Province to recommend measures for exploiting karst cave tourism resources in poverty-stricken areas. Based on cluster analysis, Samuel *et al*. (2008) carried out a study on the characteristics of cave tourists in Samchuk City, Korea, and provided guidance for cave tourism development. Although progress in market studies have been made, these studies were limited in their further analysis of regional relationships among karst cave resources and neglected the karst caves that were unexploited.

A number of studies have applied economic theory on cave tourism development. In a study on tourism location, Wang and Wang (2000) indicated that the marginal utility of karst cave tourism resources affected their exploitation. From the perspective of competition among karst cave resources, Bao and Hou (2007) investigated the karst caves in Zhangjiajie City, and emphasized the roles management and policy played in karst cave resource exploitation. Long *et al*. (2007) advanced the effect of externality during karst tourism resource exploitation. Wang (2010) insisted that karst caves in Guilin must be developed in different ways to avoid a waste of resources. However, the qualitative economic analysis in the research failed to provide sufficient related data about the resources.

Although there has been a rapid accumulation of research results on karst cave resource exploitation, three aspects of limitations were apparent. First, little attention has been paid to the quantitative analysis on karst cave tourism resources because most existing studies mainly concentrated on qualitative rather than quantitative analysis, partly because of the difficulties in gathering materials. Second, most studies relied largely on local geographical information or theoretical research, not on furthering the understanding of background conditions of karst cave tourism resources. Third, system theories were seldom applied and most studies regarded karst caves as some isolated points (Ding and Bao, 2000; Wu and Zhuang, 2007). As a result, few studies have considered a systematic development of karst cave tourism resources.

Compared with previous studies, this study is not limited to a single cave development because an analysis is conducted of resource characteristics and regional structure. Based on regional conditions of karst cave tourism resources, we applied advanced methods including nearest neighbor index (NNI) and accessibility index to analyze the scale effect, strength effect, combined effect, and accessibility of karst cave tourism resources. We attempted to propose a tourism system that includes growth poles, tourism routes, and an integrated network. A karst cave tourism system was proposed for an overall scheme of karst cave tourism development in Zhejiang Province, as well as the proper way for karst cave tourism in Zhejiang Province to cooperate with other provinces. Specifically, the study provided quantitative methods for the research of karst cave tourism resources such as NNI and connected degree among others. This study also attempted to present a hierarchical and sequential exploitation of karst cave tourism resources.

2 Materials and Methods

2.1 Study area

This study chose Zhejiang as the study area because it has a long history of karst cave tourism development.

However, intense competition from other scenic spots and irrational exploitation of the karst caves have led to a decline in karst cave tourism (Zhu and Dong, 2007). Given its abundant karst cave tourism resources, Zhejiang Province has made significant achievements in karst cave tourism for the past 30 years. Five scenic spots of karst caves in Zhejiang Province attracted approximately 2×10^6 tourists and raised tourism revenues of 7.22×10^7 yuan (RMB) in 2009. Karst cave tourism has displayed its significance in the tourism industry of Zhejiang Province.

In Zhejiang Province, tourism has been developed into an aggregation of sightseeing, leisure vacation, convention and exhibition, shopping, and entertainment, and has been considered superior to most other industries in the area. Hence, tourism has been a significant economic growth stimulator in Zhejiang Province.

Climate factors play an important role in the formation of karst caves. Karst caves in China can be grouped into five categories: tropical, subtropical, temperate zone, arid region, and cold plateau. Karst caves in Zhejiang Province are categorized as subtropical karst. Compared with tropical karst regions such as Guangxi Zhuang Autonomous Region and Guizhou Province, Zhejiang Province has a lower density and scale of karst caves. As a forerunner of tourism, the boom of karst cave tourism resources has given impetus to the tourism of the eastern China. For instance, as early as the 1980s, the Yaolin Cave in Tonglu County, Zhejiang Province, was exploited as a kind of burgeoning tourism resource, leading to remarkable achievements in the tourism market.

Moreover, from the 1980s to the mid-1990s, a flood of extensive exploitation of karst caves occurred in Zhejiang Province. However, the karst cave scenic spots have since then experienced a decline and stepped into a dilemma. To date, the karst cave scenic spots still have not eliminated the depression of the tourism market, which apparently became a main obstacle to the sustainable development of karst cave tourism. Compared with the karst caves in Zhejiang Province, the karst caves in other regions have developed maturely in recent years. For example, Karst in South China has been a world heritage site since 2007. In terms of statistical analysis, this study defines the six sub-research regions or districts as Hangzhou, Quzhou, Jinhua, Huzhou, Lishui, and Shaoxing, all of which have relatively abundant karst cave tourism resources.

2.2 Data sources

This study is mainly based on quantitative datasets, including tourism resources grades and the spatial distribution of karst caves. Most data were obtained from the investigation of different grades of tourism resources in Zhejiang Province in 2004 (Zhejiang Tourism Resources Investigation Office, 2004). The tourism market information was mainly sourced from the General Survey of Zhejiang Tourism (Tourism Administration of Zhejiang Province, 2008; 2009). Data on transportation in Zhejiang Province were collected from the Bureau of Communications of Zhejiang Province. Other relevant data on Zhejiang Province, including maps and other fundamental information, were cited from the website of the Administrative Division of China. Some data were also collected from other research (Zhu and Dong, 2007).

2.3 Analysis methods

2.3.1 Characteristics analysis

The scale effect of resources does not only come into being along with exploitation, but also bring about cost savings and economic benefits. Strength effect is embodied in the grade and quality level of resources, to be referenced as an indicator for the evaluation of a resource. Meanwhile, combined effect does not only pertain to the economic effects resulting from the concentration of property and economic activities, but also pertain to the centripetal force to pull economic activities to certain regions. Generally, the combined effect of karst cave tourism resources consists of dispersed form, random form, and intensive form. Thus, according to previous research, it is reasonable to take Nearest Neighbor Distance (NND) and NNI as the quantitative measures of combined effect. The equation for NND can be expressed as

$$\overline{d} = \frac{1}{n_1}\sum_{i=1}^{n} d_{i1} \tag{1}$$

where $\overline{d}$ is NND; n_1 is the quantity of the points except the analyzed one; d_{i1} is the distance from the analyzed point to another point I; n is the amount of points except the analyzed one; and i is the number of the analyzed point, which ranges from 1 to n.

NND reflects the distribution pattern of the points in a certain area. A negative correlation also exists between NND and the intensive degree. Philip and Francis (1954)

utilized the *NNI* to explain the distribution of plant population, which was expressed as

$$NNI = \frac{\overline{d}}{E(\overline{d})} \tag{2}$$

where $E(\overline{d})$ is the ideal NND, which can be expressed as follows:

$$E(\overline{d}) = 0.5\sqrt{\frac{A}{n}} \tag{3}$$

where A is the area of the research region, and n is the amount of points in the research region.

When *NNI* ranges from 1 to 2.149, it emphasizes the dispersed form; when *NNI* is less than 1, it emphasizes the intensive form; when *NNI* is 0, it emphasizes the highly centralized form.

2.3.2 Regional analysis

An imbalance of tourism resources in a region universally exists; hence, this study will analyze the connectivity and market accessibility of karst cave tourism resources to describe the relationship among resources as well as the relationship between resources and the environment.

As an index describing the average number of lines connecting every two points, the index β is a measurement for the connected degree of resources network. It can be depicted as

$$\beta = L / P \tag{4}$$

where β is the connected degree of resources network; L is the number of lines; and P is the number of resource points to be analyzed; β is in direct ratio with the network connectivity.

Another index α is the ratio of the number of actual circuits to the ideal circuits. The formula is described as

$$\alpha = (L–P) / 2P \tag{5}$$

When the value of α is 0, there is no circuit in the network. On the contrary, the circuits in the network will be in maximum with α being 1.

Accessibility is the measurement of the mobility of individual participating in tourism activities (Miller, 1999). In the current study, the accessibility of karst cave tourism resources to the market is expressed as the average of the nearest distance to the market.

$$A_j = \sum D_{ij} / n \tag{6}$$

where A_j is the accessibility index of the analyzed point j; D_{ij} is the nearest distance between the analyzed point j to another point i; and n is the quantity of points in the network except the point being analyzed. The accessibility index is in an inverse ratio with the accessibility to market. Market accessibility embodies the time for tourists to reach the karst cave resources instead of the actual distance.

2.3.3 Growth pole theory

The Growth Pole Theory, brought forward by Perroux in 1950, theoretically generalize the positional relationship and the regional structure relationship belonging to geographical space. The growth poles influence two aspects: the polarization effect, which plays the leading role in the primary stage; and the diffusion effect, which thrives progressively in the later stages.

3 Results and Discussion

3.1 Regional resource characteristics

3.1.1 Scale effect

The investigation of tourism resources indicates that the karst cave tourism resources are generally abundant with 80 sites located in six cities.

The locations of main karst caves are shown in Fig. 1, with the names of karst caves above grade three listed. Therefore, karst cave tourism resources are mainly distributed in the northwestern region of Zhejiang Province, including Changshan, Jinhua, Lanxi, Jiande, Chun′an, Tonglu, Lin'an, Fuyang, Xihuqu, and parts of Lishui and Shaoxing.

As indicated in Table 1, Hangzhou, Quzhou, and Jinhua show remarkable scale effect. Under the influence of geological factors, Hangzhou takes the first position in the scale effect of physiographic tourism resources and all tourism resources. With prominent attractions and regional influence, the karst cave tourism resources in Zhejiang Province provided the foundation for integrated development.

3.1.2 Strength effect

Figure 2 shows the exploitation levels of karst cave resources for tourism in different regions based on the statistics of resource exploration in Zhejiang Province (Zhejiang Tourism Resources Investigation Office, 2004). Jinhua obviously has the highest utilization ratio of karst cave tourism resources while Shaoxing and Lishui have the lowest. In brief, the karst caves in the northern Zhejiang Province are mostly exploited and those in the southwestern Zhejiang Province are generally unexploited. The exploitation of karst cave resources are clearly unbalanced, which may obstruct their further exploitation.

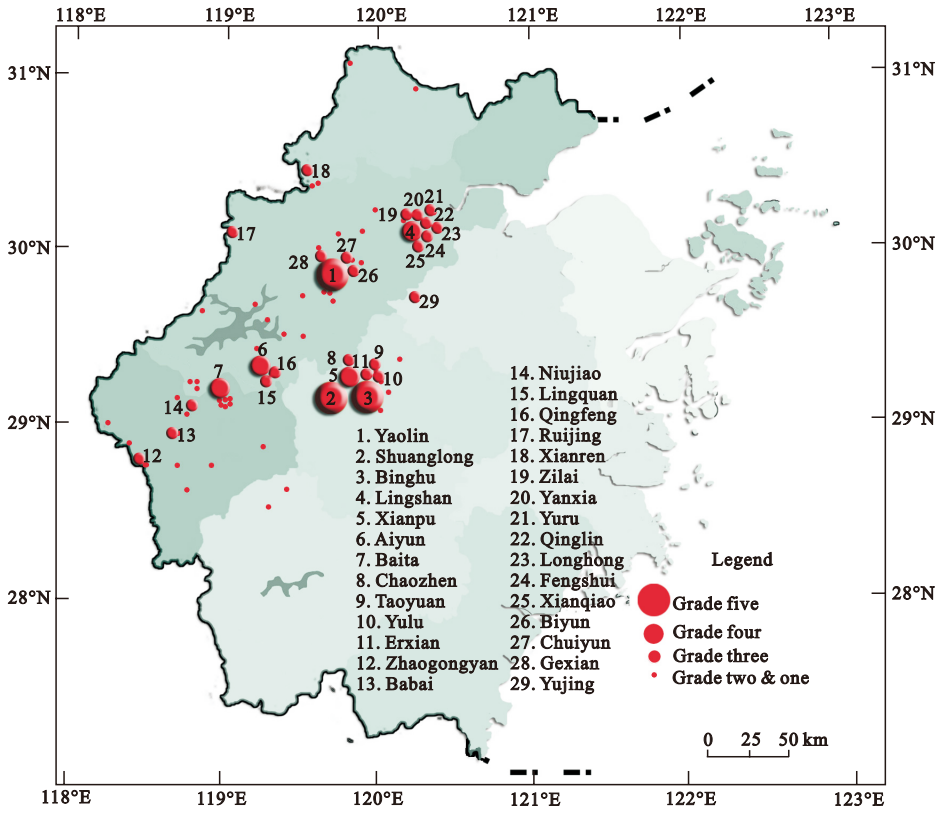

Fig. 1 Distribution of karst cave tourism resources in Zhejiang Province

Table 1 Proportion of karst carve tourism resources in other resources

City	Quantity of karst cave resources	In rock cavern and cave type		In physiographic resources		In all regional resources	
		Number	Proportion (%)	Number	Proportion (%)	Number	Proportion (%)
Hangzhou	38	54	70.37	482	7.88	2707	1.40
Quzhou	20	73	27.40	490	4.08	1570	1.27
Jinhua	14	54	25.93	551	2.54	1950	0.72
Huzhou	5	14	35.71	290	1.72	1528	0.33
Lishui	2	66	3.03	875	0.22	2365	0.08
Shaoxing	1	18	5.56	377	0.27	1863	0.05
In total	80	279	28.67	3065	2.61	11983	0.67
Zhejiang	80	522	15.33	6026	1.33	21126	0.38

Abundance in resource quantity and landscape variety, and high-grade (grades five, four, and three) karst cave tourism resources in Zhejiang Province have produced great achievements in the economy and society under the administration of the city or county government. In contrast, resources of inferior quality are generally exploited in a lower level and simultaneously lack resource conservation awareness, making the benefits barely satisfying.

To measure the strength effect of karst cave tourism resources in Zhejiang Province, this study applied the results from Classification, Investigation and Evaluation of Tourism Resources (GB/T 18972–2003), with the exception of grade one tourism resources.

As a whole, karst cave tourism resources of Zhejiang Province are of high quality, 36.25% are high-grade resources (Table 2).

According to the General Survey of Zhejiang Tourism (Tourism Administration of Zhejiang Province, 2008; 2009), karst caves have been exploited in various scenic spots and have already greatly influenced their surrounding areas. From Fig. 3, it can also be concluded

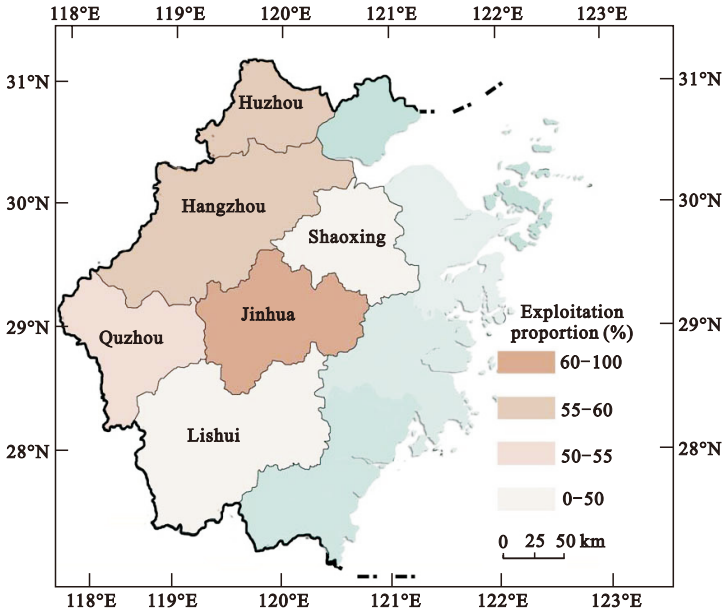

Fig. 2 Exploitation proportion of karst cave resources in different regions of Zhejiang Province

Table 2 Grade of karst cave tourism resources in each city

City	Number	High-grade resource ratio (%)			General grade resource ratio (%)	
		Grade five	Grade four	Grade three	Grade two	Grade one
Hangzhou	38	2.63	5.26	34.21	13.16	44.74
Quzhou	20	0.00	5.00	15.00	35.00	45.00
Jinhua	14	14.29	7.14	28.57	28.57	21.43
Huzhou	5	0.00	0.00	20.00	80.00	0.00
Lishui	2	0.00	0.00	0.00	100.00	0.00
Shaoxing	1	0.00	0.00	100.00	0.00	0.00
In total	80	3.75	5.00	27.50	27.50	36.25

that high-grade karst caves are mainly exploited in scenic spots above 3A. The scenic spots of karst cave themes mainly include Shuanglong, Yaolinxianjing, Lingshan, Chuiyuntongtianhe, Tongtianfeipu, and Liudongshan. On the contrary, other karst caves did not get reasonable exploitation without the support from scenic spots, which also led to an imbalance of karst cave exploitation in Zhejiang Province.

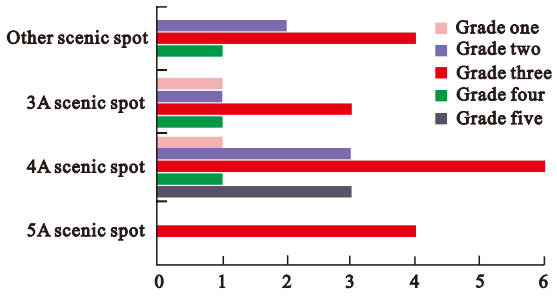

Fig. 3 Karst cave tourism resources in scenic spots

3.1.3 Combined effect

The combined effect is a main indicator describing the regional relationship between resources and tourism markets (main cities). NNI is applied based on the analysis of NND to continue further research on the regional property of karst cave tourism resources. Table 3 lists the area, amount of high-grade karst cave tourism resources, NND, and NNI of different regions according to Equations (1), (2) and (3).

Table 3 Analysis result of combined effect

Region	Number of high-grade karst cave tourism resources	Area (km^2)	NND	NNI
Hangzhou	16	16596	30.902	1.919
Jinhua	7	10919	1.935	0.098
Quzhou	4	8837	24.512	1.043
Zhejiang	29	101800	9.606	0.324

From a market perspective, karst cave tourism resources are generally intensively distributed, which is beneficial to resource integration and cost reduction. However, when the NNI is relatively low, there will be an overcrowding effect restraining the exploitation of lower-grade resources. Zhejiang Province has an NNI of 0.324. At the same time, Jinhua evidently gets the lowest value in the NNI, which indicates that the higher-grade resources in Jinhua will get an obvious superiority in exploitation.

This paper extends quantitative methods for karst cave tourism resource research. According to sufficient related data, this study introduces the scale effect, strength effect, and combined effect to explain the fundamental conditions of karst cave tourism resources. Moreover, the NNI and NND indexes are applied to make a quantitative measurement, which is more comprehensive and systematic than before.

3.2 Regional analysis

Based on the regional structure, there are 29 resource points and 68 lines in the karst cave tourism resource network in Zhejiang Province.

Therefore, it can be calculated from Equation (4) that the index β of karst cave tourism resources in Zhejiang Province is 2.43. The result reveals that the karst cave tourism resources are of high connectivity, relying on the convenient transportation system, which has provided the reliable basis for karst cave resource exploitation.

According to Equation (5), the index α of karst cave tourism resources in Zhejiang Province is 0.67, which means the property of circuit is generally reasonable. The circuits consisting of karst caves are also favorable for the diversified development.

According to an official survey, the tourist market of Zhejiang Province is relatively concentrated. Moreover, domestic tourists are mainly from the eastern China. In view of the market characteristics and the comparative geographic locations of karst cave tourism resources, it is reasonable to take the following cities as primary analysis targets: the 11 cities in Zhejiang Province and Shanghai, Nanjing, Suzhou, Wuxi, and Changzhou.

Based on Equation (6), the accessibility index of each karst cave resource is listed in Table 4.

Accordingly, the analysis indicates that the high-grade karst cave tourism resources are superior in accessibility to the main markets with a comprehensive average accessibility index below 4.00. Furthermore, the average interior accessibility index of markets in Zhejiang Province is 2.78. With prominent tourism market advantage, the tourism resources display great potential in tourism exploitation (Table 4).

Table 4 shows the average external accessibility index of markets of karst cave tourism resources in Zhejiang Province to be 4.36. Different karst caves demonstrate

Table 4 Accessibility index of each karst cave tourism resource

Number	Resource name	Accessibility index			Number	Resource name	Accessibility index		
		Interior	External	Comprehensive			Interior	External	Comprehensive
1	Lingshan	2.15	2.99	2.41	16	Shuanglong	2.56	5.60	3.51
2	Fengshui	2.15	2.99	2.41	17	Xianpu	2.56	5.60	3.51
3	Xianqiao	2.15	2.99	2.41	18	Chaozhen	2.56	5.60	3.51
4	Longhong	2.17	3.00	2.43	19	Erxian	2.56	5.60	3.51
5	Yuru	2.17	3.00	2.43	20	Taoyuan	2.56	5.60	3.51
6	Qinglin	2.17	3.00	2.43	21	Ruijing	3.49	3.91	3.62
7	Zilai	2.18	3.00	2.44	22	Qingfeng	3.48	4.41	3.77
8	Yanxia	2.18	3.00	2.44	23	Aiyun	3.48	4.41	3.77
9	Biyun	2.42	3.33	2.70	24	Lingquan	3.48	4.41	3.77
10	Yujing	2.30	3.97	2.82	25	Yulu	2.79	5.98	3.79
11	Gexian	2.53	3.57	2.86	26	Niujiao	3.31	5.94	4.13
12	Yaolin	2.64	3.71	2.97	27	Babai	3.73	6.10	4.47
13	Chuiyun	2.64	3.71	2.97	28	Zhaogongyan	3.71	6.27	4.51
14	Xianren	3.78	2.59	3.41	29	Baita	4.16	6.38	4.85
15	Binghu	2.56	5.60	3.51		Average	2.78	4.36	3.27

diversity in accessibility to tourist markets. Therefore, the Lingshan Cave has the highest accessibility with an external accessibility index of less than 3.00, and the Zhaogongyan and Baita caves have the lowest external accessibility index.

During the process of regional analysis, this study combines the background conditions with karst cave tourism resources and emphasizes regional relationship. Especially in methodology, this study supplements previous studies with a perspective of regional analysis. For example, Xu (1989) only made a list of caves from a geographical perspective, which was confined to the characterization of geological conditions. However, the present study applies the indexes of α, β, and accessibility to get a specific result about each karst cave and compares karst cave tourism resources.

3.3 Karst cave tourism system

The Growth Pole Theory points out the imbalance of regional development, claims preferential development of superior resources, and provides a theoretical basis for the exploitation of tourism resources. There are various imbalances in the exploitation of karst cave tourism resources in Zhejiang Province. Therefore, following the guidance of this theory, the study aims to search the development with a hierarchical and sequential concept.

Resources grade and traffic location are the primary impact factors for the karst cave tourism growth poles. Based on characteristics and regional analysis, this study settles on the following karst caves as growth poles of exploitation: Yaolin Cave, Binghu and Shuanglong Cave, Lingshan Cave, Xianren Cave, Baita Cave, Aiyun Cave, Zhaogongyan Cave, and Wanren Cave.

The prospective development of karst cave tourism should persist in exploiting the existing karst cave tourism resources as a system and take the following developing stages continuously.

3.3.1 Fostering multigrade growth poles

The measures include overall planning of different grade karst cave resources with consideration of requirement distribution; heightening the polarization degree of Ruijing Cave, Huanglong Cave, Babai Cave, Niujiao Cave, Yulu Cave, and Yujing Cave progressively; and paying close attention to the exploitation of scattered karst cave resources.

3.3.2 Creating inter-regional tourism routes

The measures include strengthening the cooperation among different karst cave scenic spots; creating excellent tourism routes such as ′Jiangnan Karst Cave tourism route′; utilizing the potentialities of karst cave tourism resources in the ′Two Rivers and a Lake′ scenic spot (Fuchunjiang River, Xin′anjiang River, and Qiandao Lake); integrating the resources in Fuyang, Tonglu, Jiande, and Chun′an; exploiting the karst cave tourism resources along the Hangjinqu Highway (Hangzhou–Quzhou), Hangxinjing Highway (Hangzhou–Jingdezhen), and National Highways 320 and 330; and exploiting the karst caves near the province boundaries between Zhejiang and Jiangsu, Shanghai, Anhui, and Jiangxi.

The inter-regional tourism routes not only promote connections between the caves, but also connect tourism development between different provinces. For example, the caves in the north of Zhejiang Province can cooperate with other resources in Jiangsu Province and Shanghai.

3.3.3 Optimized exploitation network

By relying upon the growth poles of different grades, it is necessary to optimize the overall structure of karst cave tourism in Zhejiang Province. Consequently, it is feasible to plan six karst cave tourism theme cluster (Fig. 4).

(1) Hangzhou West Lake karst cave tourism cluster. The main karst caves in this cluster are Lingshan Cave, Zilai Cave, and so on (Fig. 4). Among the karst caves, Lingshan Cave is the growth pole of karst tourism.

With the support of a favorable tourism environment in Hangzhou, the karst cave in Lingshan and West Lake scenic spots should be exploited further and short, high-quality tourism routes in Hangzhou should be created. Those karst caves can cooperate with West Lake, and they will be an important part of Hangzhou tourism.

(2) TongluYaolin karst cave tourism cluster. The main karst caves in this cluster are Yaolin Cave and other caves as shown in Fig. 4. Yaolin Cave is the growth pole of karst tourism in this cluster.

It is feasible to integrate the karst caves in the scenic spots of Yaolinxianjing, Chuiyuntongtianhe, Fuchuntaoyuan, and Tongtianfeipu so that lower-grade karst caves can be stimulated and the tourism cluster with great landscape features will be established. Among the karst caves, Yaolin Cave should be upgraded and it will be the most important cave in the cluster.

(3) Jinhua Shuanglong karst cave tourism cluster. The main karst caves in this cluster are Shuanglong Cave, Binghu Cave, and other caves, as shown in Fig. 4, with Binghu and Shuanglong Cave as the growth poles.

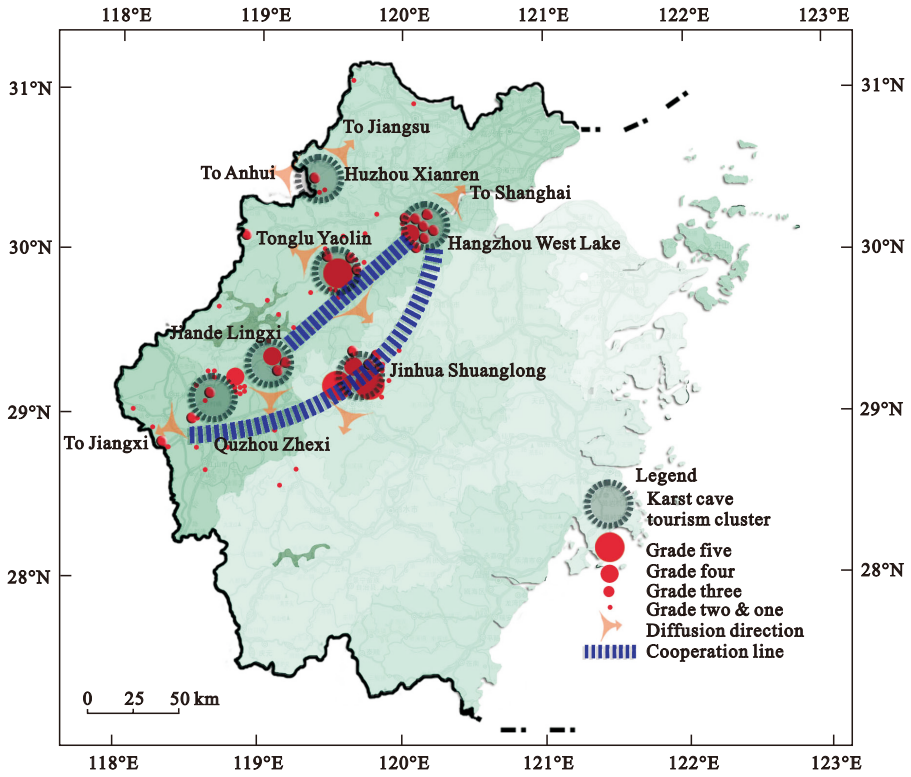

Fig. 4 Karst cave tourism system in Zhejiang Province

To advance the significant physiographic tourism cluster in central Zhejiang, the karst cave tourism resources in Shuanglong and Dixiachanghe scenic spots should be integrated, at the same time influencing the karst caves around Shaoxing, such as Yujing Cave.

(4) Jiande Lingxi karst cave tourism cluster. The main karst caves in this cluster are Aiyun Cave, Lingquan Cave, Qingfeng Cave, and so on, as shown in Fig. 4. Aiyun Cave is the growth pole.

The first step is to improve the main karst caves in Lingxidongtian scenic spot to make a positive impact on the karst caves surrounding Qiandao Lake, and then create a tourism cluster with a natural landscape background.

(5) Quzhou Zhexi karst cave tourism cluster. The main karst caves in this cluster include Baita Cave and other karst caves, as shown in Fig. 4. Baita Cave, Zhaogongyan Cave and Wanren Cave are the growth poles.

External transportation should be provided, and Baita Cave, Niujiao Cave, Babai Cave and the karst caves in Sanqu Mountain and Taizhen scenic spot should be exploited to promote the karst caves in Chun′an, Kaihua, Jiangshan, and Longyou. These should be done to enhance the cooperation between Jiangxi and Anhui provinces, and consequently, for a karst cave tourism cluster of considerable scale to be constructed.

(6) Huzhou Xianren karst cave tourism cluster. The main karst caves in this cluster include Xianren Cave and other caves, as shown in Fig. 4. Xianren Cave is the growth pole of karst cave tourism.

Xianren Cave and Huanglong Cave will be exploited as two wings of karst cave tourism to make full use of the scarcity of karst cave resources in the area, to reinforce the cooperation with the south of Jiangsu, Shanghai, and Taihu tourist holiday resorts, and to construct a distinctive karst cave tourism cluster in the northern Zhejiang Province.

4 Conclusions

Through quantitative methods, this study addresses the karst cave tourism system in Zhejiang Province. It makes a comprehensive overview of characteristics of karst cave tourism resources and a regional analysis based on the development background. Moreover, it emphasizes the significance of regional analysis in the research on karst cave tourism resources.

The results of this study provide a feasible strategy

for karst cave tourism development in Zhejiang Province. Based on the Growth Pole Theory, a Pole-Route-Network process for karst cave tourism resource exploitation should be advanced. This concept is superior in explaining the development process of karst cave tourism resources compared to previous concepts. Moreover, in the form of a planning chart, this study displays the general pattern of karst cave tourism system in Zhejiang Province.

First, this study focuses on six cave groups taking into consideration their resource superiority and external conditions. Compared with previous studies, this study prioritizes a number of karst caves and encourages an efficient allocation of investment and market opportunity.

Furthermore, this study promotes inter-regional tourism routes to enhance the cooperation between karst caves in different regions. In comparison with other studies, this study emphasizes the accessibility and development status of karst cave tourism resources.

Taking internal and external factors into consideration, this study promotes a system of karst cave tourism in Zhejiang Province, instead of isolated cave development. The six karst cave tourism clusters will achieve dominant positions in the regions. With the effects of polarization and diffusion, these clusters can exert influence on the surrounding karst cave tourism resources.

This study preliminarily puts forward a hierarchical and sequential exploitation of karst cave tourism resources, and achieves a karst cave tourism system in Zhejiang Province. It is practically significant in the present karst cave tourism development in Zhejiang Province. However, the structure and mechanism of karst cave tourism cluster still require further studies.

References

Arrigo A C, Ezio B, 2000. Development, management and economy of show caves. *International Journal of Speleology*, 29B (1/4): 1–27.

Bao Jigang, 1995. Tourism development of karst caves. *Acta Geographica Sinica*, 50(4): 353–358. (in Chinese)

Bao Jigang, Hou Lingmei, 2007. Competition of karst cave tourism under the non-competitive market conditions. *Tourism Science*, 21(3): 52–58. (in Chinese)

Ding Jian, Bao Jigang, 2000. A study on the life cycle of special karst cave with a case of Jianshui Swallow Cave in Yunnan Province. *Carsologica Sinica*, 19(3): 284–289. (in Chinese)

Li Rui, Ying Juying, Zhang Zhue, 2004. Quantitative researches on the life cycle of karst cave tourist areas, case of study of Yaolin Cave. *Economic Geography*, 24(5): 683–687. (in Chinese)

Li Rui, Zhang Zhue, 2003. The pilot study of the lifecycle of karst cave scenic spots. *Bulletin of Science and Technology*, 19(6): 497–501 (in Chinese)

Li Ya, Ren Jing, Zhao Fuxiagn, 2003. Control mechanism study on lifecycle of karst cave in Yunnan. *Yunnan Geographic Environment Research*, 15(4): 26–31. (in Chinese)

Long Xin, Ma Yaofeng, Liu Hongying *et al*., 2007. Study on the internalization of externalities of karst tourism. *Acta Agriculturae Jiangxi*, 19(7): 154–156. (in Chinese)

Miller H J, 1999. Measuring space-time accessibility benefits within transportation networks: basic theory and computational methods. *Geographical Analysis*, 31(1999): 187–212. doi: 10.1111/j.1538-4632.1999.tb00976.x

Ming Qingzhong, 1997. The development research on karst cave tourism resources in Yunnan Province. *Geography and Territorial Research*, 13(1): 32–35 (in Chinese)

Perroux F, 1950. Economic space: Theory and applications. *Quarterly Journal of Economics*, 64(1): 89–104. doi: 10.2307/1881960

Philip J C, Francis C E, 1954. Distance to Nearest Neighbor as a measure of spatial relationships in populations. *Ecology*, 35: 445–453. doi: 10.2307/1931034

Samuel S K, Miju K, Jungwoong P *et al*., 2008. Cave tourism: Tourists′ characteristics, motivations to visit, and the segmentation of their behavior. *Asia Pacific Journal of Tourism Research*, 13(3): 299–318. doi: 10.1080/10941660802280448

Tourism Administration of Zhejiang Province, 2008. *General Survey Zhejiang Tourism*. Hangzhou: Tourism Administration of Zhejiang Province. (in Chinese)

Tourism administration of Zhejiang Province, 2009. *General Survey Zhejiang Tourism*. Hangzhou: Tourism Administration of Zhejiang Province. (in Chinese)

Wang Linxia, 2010. Study on strategy of Guilin karst cave tourism. *Market Forum*, 5: 58–60. (in Chinses)

Wang Ying, Wang Zheng, 2000. Analysis of tourism location, case of Yunnan Province. *Acta Geographica Sinica*, 55(3): 346–353. (in Chinese)

Wu Wenzhi, Zhuang Zhimin, 2007. The sustainable development of mature tourism cave: The case study of Anhui Jiushan cave. *Journal of Guilin Institute of Tourism*, 18(3): 378–382 (in Chinese)

Xu Feixiong, 1989. Study on karst cave resources and the development in Hunan Province. *Economic Geography*, 9(4): 283–287. (in Chinese)

Xu Shenglan, Chen Hongde, 2009. Research on upgrading karst cave tour products. *Journal of Anhui Agricultureal Science*, 37(13): 6258–6259, 6262. (in Chinese)

Xu Xiudeng, 1990. The distribution and development vision of karst caves in North Mountain of Jinhua. *Carsologica Sinica*, 9

(3): 265–276. (in Chinese)

Yang Mingde, 1998. The resource characteristics and protection of karst cave tourism resources. *Carsologica Sinica*, 17(3): 233–238. (in Chinese)

Ye Hongyan, Gan Lu, 1999. The development of karst cave tourism resources in Guizhou Province. *Journal of Guizhou Normal University* (*Natural science*), 17(1): 29–32. (in Chinese)

Yin Hongmei, 1999. Flow distribution and behavior characteristics of tourists in Zhijin Cave in Guizhou Province. *Geography and Territorial Research*, 15(2): 71–79. (in Chinese)

Zhejiang Tourism Resources Investigation Office, 2004. *The Report of Investigation of Tourism Resources in Zhejiang*. Hangzhou: Zhejiang Tourism Resources Investigation Office. (in Chinese)

Zhu Guoqiang, Dong Chuanwan, 2007. The fundamental characteristic of karst caves of Zhejiang Province and several issues of tourism development. *Scientific and Technological Management of Land and Resources*, 24(2): 109–113. (in Chinese)