Research on Safety Risk Assessment of Ninghai 4A Scenic Spots

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Abstract. With the rapid development of tourism, the tourist population is expanding. The security of tourist attractions is sensitive and fragile, and the accident risk is high and the social impact is great. Therefore, it is necessary to carry out risk assessment research. This paper takes Ninghai 4A scenic spot in Zhejiang Province as the research object, objectively identifies and analyses six kinds of accident risks such as firefighting, falling casualties and so on, establishes three-dimensional risk matrix model, and combines Borda ordinal value method to identify the main risk of scenic spot. Based on the risk identification and assessment, some reasonable risk management and control measures are proposed. Relevant research can provide reference for the safety risk assessment and control of similar scenic spots in China.

1. Introduction

The tourism industry has certain sensitivity and is vulnerable to the impact of various factors, which increases the risk of accidents. The necessary safety risk assessment of scenic spots can effectively and intuitively show the security status of scenic spots and expose the relationship between security system and various subsystems. The basic conceptual system of safety management in domestic tourist attractions has been established: on the basis of two-dimensional risk matrix, Lin Baiquan¹ and others used Delphi method and analytic hierarchy process to calculate the weight of each risk factor of scenic spot security; Zhang Yongling² and others proposed using three-dimensional risk matrix to analyse and evaluate scenic spots; Yin Shiqiang³ proposed applying contingency theory to scenic spot security index system and using relative differences. There are many shortcomings in traditional research methods for safety risk assessment, which still need to be further explored.

Ninghai County is a county under the jurisdiction of Ningbo City, China. The area is warm in winter and cool in summer and suitable for tourists to travel and vacation. There are currently four national 4A tourist attractions in the county, including Ninghai Forest Hot Springs, East Zhejiang Grand Canyon, Qiantong Zheng and Wushan Grottoes. Ninghai's tourism advantage has become increasingly obvious, and tourism has increasingly become an important support for the county's economic source.⁴ This paper takes Ninghai 4A-level scenic spot in Zhejiang as the research object, combines theory with practice, identifies and controls the potential safety hazards of scenic spot from the perspective of scenic spot itself and society, and finally establishes a three-dimensional risk
assessment system based on Borda ordinal value method, evaluates scenic spot and puts forward suggestions.

2. Safety risk identification

2.1. Falling Casualty Risk
Mountainous area has always been an important choice for people to travel. It is also a tourist safety accident-prone area. The Grand Canyon in eastern Zhejiang Province, which has been named the first batch of national water resources tourist attractions, and even the name of "the Valley of Death". First, the roads in mountainous scenic areas are generally facing water and cliffs, with steep and narrow roads, and unpredictable climate change; Second, there are insufficient protective measures, such as lack of warning signs or inconspicuous display, insufficient professional protective personnel [6,7].

2.2. Facility accident risk
Scenic area equipment refers to all kinds of material facilities that constitute the fixed assets of the scenic area. A 7-year-old boy was killed by a suddenly disconnected landscape lamp in a scenic spot in Ninghai. Resulting in many reasons, such as the lack of professional careful inspection during construction, lack of necessary hidden danger investigation in the operation process, and even did not take into account the carrying capacity of the equipment. It is difficult to predict the consequences of equipment and facilities accidents, which requires operators to spend their energy on maintenance.

2.3. Fire accident risk
Fires in scenic spots mostly occur in buildings rather than forests, especially in ancient wooden buildings. The main causes of fire are the man-made factors, including inappropriate use of fire, smoking, fire prevention and so on [8]. Human factors account for the vast majority, which provides a reference for the builders of such ancient buildings as Tonggu Town in Ninghai. Hostels, hotels and vendors are also common places where fires occur. A local fire broke out in the outdoor shop of a resort in Ninghai, causing burns to varying degrees to six people.

2.4. Drowning accident risk
Drowning accidents are directly related to water resources scenic spots. There are many causes of drowning deaths during tourism. The main reasons are: first, excessive number of tourists and tourists fear; poor health or poor swimming skills lead to drowning. Second, do not give early warning to tourists, such as safety education or the establishment of relevant signs. Third, the emergency rescue of scenic operators is inappropriate, such as inadequate safety equipment, the departure of on-site supervisors, the absence of emergency rescue programs and timely rescue measures [9].

2.5. Scenic Area Safety Capacity Risk
The security capacity of scenic spots refers to the maximum number of tourists that scenic spots can bear under the premise of ensuring the safety and resources of tourists in scenic spots [10]. Most scenic spots often face the situation of overload, frequent trampling events which greatly reduces the experience of tourists. Many scenic spots take measures, such as through ticket checking system and monitoring to control the flow of tourists. However, it is impossible to evacuate people in time because of the sparse terrain, facilities and evacuation personnel [11].

2.6. Natural Disaster Accident Risk
Natural disasters have become an important factor restricting the normal development of tourism. When severe weather and emergencies affect the tourists during the operation of scenic spots, the administrators of scenic spots shall immediately close the scenic spots temporarily, promptly guide tourists to leave, and report to relevant departments in a timely manner [12]. Ninghai County is located in the eastern part of Zhejiang Province. It is mainly affected by typhoons, which directly destroy
people’s houses, drumming and farms. Natural disasters include disaster-causing factors, exposure and vulnerability. Through analysis and judgment of these three factors, people can combine their own experience and disaster characteristics to manage the weak links and carry out effective measures \cite{13,14}.

3. Safety risk assessment

In this paper, three-dimensional risk matrix model is the main method to evaluate the risk level. One is based on the two-dimensional risk matrix model, which integrates the third attribute \cite{15}. For the tourism industry, the social impact of the accident is actually more serious than the physical loss, so we must integrate the social impact of the accident. Basis of comprehensive evaluation of the object's accident tolerance, coping ability, the possibility of risk occurrence, the severity of consequences and the social impact are quantified, and a three-dimensional risk matrix model is constructed.

According to the three-dimensional risk matrix model and evaluation criteria, combined with the basic conditions of the overall safety production of Ninghai tourism industry and control capabilities, the major accidents were evaluated. According to the frequency of accidents, the possibility of accidents can be roughly divided into five levels, that is the level of accident possibility, as shown in Table 1. According to the casualties and damage to equipment and property caused by the accident, the accident severity is divided into five grades, namely the consequence severity grade, as shown in Table 2. According to the impact of the accident on the society, this paper comprehensively analyses and predicts the social impact of the accident from two aspects: the impact of the accident and the degree of the accident being concerned by the society, as shown in Table 3.

According to the possibility, severity and social impact of the accident, a three-dimensional risk matrix is established as shown in Figure 1. According to the requirements of "Ningbo Provisional Measures for the Control and Control of Safety Production Risk", the risk level is divided into four levels, namely low risk I, general risk II, larger risk III and major risk IV.

| Grade | Statement of Grade | describe |
|-------|--------------------|----------|
| 1     | Very likely | Most of the time, every week or even every day. |
| 2     | Stand a good chance | In most cases, it's possible, once a month. |
| 3     | Probably | In some cases, it happens at most once a quarter. |
| 4     | Less likely | Sometimes it happens, at most once a year. |
| 5     | Fundamentally impossible | Sometimes it can happen, at most once every two years or not. |

Table 1 Qualitative Measuring Table of Accident Possibility

| Grade | Statement of Grade | describe |
|-------|--------------------|----------|
| A     | Particularly significant | Major casualties and serious damage to tourism resources |
| B     | major | Major property losses, destruction of tourist resources or death of individual persons |
| C     | more | Serious casualties or property losses |
| D     | commonly | Individual minor injuries or minor property losses |
| E     | Very small | No injury or loss of property occurred. |

Table 2 Qualitative Measurement Table of Accident Seriousness

| Grade | Statement of Grade | describe |
|-------|--------------------|----------|
| a     | Extreme disadvantage | Great impact, causing devastating impact on Tourism |
| b     | Very disadvantageous | Continuous public concern, bad influence and serious damage to tourism image |
| c     | Moderate disadvantage | To a certain extent, it will bring about greater negative social impacts. |
| d     | Mild disadvantage | The scope of influence is small and has slight negative effects. |
| e     | Weak disadvantage | The scope of impact is minimal, with little negative impact. |

Table 3 Qualitative Measuring Table of Social Impact of Accidents
It is found that if three-dimensional risk matrix is used for safety risk assessment, there will be risk knots, that is, different accident risks will evaluate the same risk level. Therefore, the United States Air Force Electronic Systems Centre proposed the Borda ordinal value method to eliminate the risk knot. The algorithm is as follows: set the number of accident safety risk factors as I, the evaluation criteria as K, and this paper takes K as 3, that is, the possibility of accidents, the severity of accidents and the social impact caused by accidents. Assuming that the number of accident risks corresponding to the same level under the same standard is $I_j$, and the ordinal value of accident risks under K is $P_j$:

$$P_j = B_j + \frac{1 + I_j}{2}, \quad B_j = \sum_{p=1}^{j-1} I_p \quad (j > 1, \text{if } B_j = 0, j = 1)$$

Taking the possibility of accident risk calculation as an example, it is extended to the calculation of other standards. Let $C_j$ represent the possibility ordinal value of class $J$ ($j \leq 5$), for example, $C_1$ represents class 1, and so on; $I_j$ represents the corresponding number of risks under the possibility of class $C_j$. The corresponding ordinal value of the likelihood of an event in the hierarchy:

$$P_j = B_j + \frac{1 + I_j}{2}, \quad B_j = \sum_{p=1}^{j-1} I_p \quad (j > 1, \text{if } B_j = 0, j = 1)$$

The sequence values under other criteria of accidents are calculated by the same method. After calculating the ordinal values of the three criteria, $B_i$ ordinal value corresponding to risk factor $i$:

$$B_i = (I - P_{i1}) + (I - P_{i2}) + (I - P_{i3})$$

$P$ refers to the ordinal value of a risk under the corresponding criteria. $i1$ refers to the ordinal value of the probability of occurrence corresponding to risk factor $i$, $i2$ refers to the seriousness of the corresponding occurrence, and $i3$ refers to the ordinal value of the social impact after the corresponding occurrence. Calculated the Borda ordinal value of risk under the corresponding three criteria, and calculated according to 0, 1...I-1, and the concrete results are shown in Table 4.
Table 4 Scenic Area Accident Risk Assessment Result Table

| Accident risk factors          | Possibility | Physical loss | Social influence | Risk Level | Possibility ordinal value | Ordinal value of physical loss | Ordinal value of Social Impact | Order Value of Social Impact | Borda ordinal value | Borda ordinal value |
|-------------------------------|-------------|---------------|------------------|------------|---------------------------|-------------------------------|--------------------------------|-------------------------------|---------------------|---------------------|
| Falling Casualty Risk         | 4           | B             | b                | II         | 5                         | 2.5                           | 1.5                            | 1.5                           | 9                   | 2                   |
| Facility accident risk        | 3           | B             | c                | II         | 2.5                       | 2.5                           | 3.5                            | 3.5                           | 9.5                 | 1                   |
| Fire accident risk            | 4           | A             | b                | II         | 5                         | 1                             | 1.5                            | 1.5                           | 10.5                | 0                   |
| Drowning accident risk        | 3           | C             | e                | II         | 2.5                       | 4.5                           | 3.5                            | 3.5                           | 7.5                 | 3                   |
| Scenic Area Safety Capacity  | 2           | D             | d                | III        | 1                         | 6                             | 5.5                            | 5.5                           | 5.5                 | 4                   |
| Natural Disaster Accident Risk| 4           | C             | d                | III        | 5                         | 4.5                           | 5.5                            | 5.5                           | 3                   | 5                   |

4. Results and discussion

According to the corresponding Borda sequence value, the risk ranking of six main types of accidents in Ninghai 4A scenic spot can be obtained: fire accident risk > facility accident risk > falling casualty accident risk > drowning casualty accident risk > scenic area capacity accident risk > natural disaster accident risk. We should take pertinent measures to improve the efficiency of treatment. For ancient towns, it is necessary to strengthen investment in firefighting in scenic spots and service areas and timely correct the situation of cables and wires in buildings. For mountain scenic spots and water resources scenic spots, advanced and reliable warning system should be established and relevant service personnel should be organized regularly to conduct rescue exercises. For scenic spots with overloaded tourist capacity, we should calculate the demand capacity in peak and off-season respectively, carry out targeted tourist dredging control. In view of natural disasters, scenic spots should establish and improve the detection and warning system of natural disasters.

5. Conclusion

Taking Ninghai 4A scenic spot as the research object, this paper firstly identifies and analyses six kinds of potential accident risks. Then, the three-dimensional risk matrix model under the three evaluation indexes of occurrence possibility, accident severity and social impact caused by accidents is established, and the identified accident risks are sorted by Borda ordinal value method. The fire accident risk, facility accident risk, falling casualty risk and drowning accident risk are obtained. Finally, put forward some countermeasures and suggestions, such as strengthening fire control in scenic spots, and investigating electrical appliances and related facilities. The research results can provide reference for the safety risk management and control of similar scenic spots in China.

Acknowledgments

This article is supported by Ningbo Natural Science Foundation (2017A610066, 2018A610122), Student Technology Innovation Fund of Ningbo University of Technology (2018044), Higher Education Research of Ningbo University of Technology (NG2017021), and School-level Research Project of Ningbo University of Technology (D2017012).

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