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Research on the Construction of an Evaluation System for the Diversion Effect of Urban Tourist Flow

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Abstract

To address the challenge of assessing real-time urban tourist flow diversion effectiveness, this study incorporates knowledge graph technology, leveraging extensive research results as foundational data. Through the steps of information extraction, knowledge fusion and knowledge processing of the keywords of the article, the index system was preliminarily established by combining the quantitative and qualitative methods of expert consultation. In this study, the Delphi method was used to optimize the index system, and an evaluation index system consisting of 1 standard-level index, 6 system-level indicators and 21 index-level indicators was constructed. Then, the analytic hierarchy process was used to calculate the weights of the index system. Through research and interviews, practical experience and literature to determine the index measurement and scoring rules, combined with the national scientific and technological innovation project based on this institute, the pilot evaluation of tourist flow regulation in Suzhou, Tianshui, Wuhu and other places was carried out, and the evaluation system and method were verified. This comprehensive method, which is based on a knowledge graph and combines qualitative and quantitative approaches, offers a novel idea for constructing an index system, especially in the absence of mature theoretical references and practical experiences. This study effectively solves the problem of the evaluation system of the effectiveness of urban tourist flow control, and has strong theoretical innovation and practical significance.

Keywords: tourist flow, diversion effectiveness, Index; Assess, Knowledge Graph

1. Introduction

In the era of mass tourism, the surge of holiday visitors has led to severe urban congestion and safety issues in China's tourist cities, posing a significant challenge to the effectiveness of urban governance frameworks and presenting a theoretical puzzle that requires in-depth scholarly examination in tourism studies. Cities such as Hangzhou, Suzhou, and Lijiang have pioneered the application of Big Data and AI for real-time monitoring and regulation at popular tourist sites and key transportation arteries, resulting in noticeable enhancements. However, as tourists increasingly integrate into shared urban spaces that blend visitor and resident experiences, localized measures have been found wanting in tackling tourism safety issues across the city. Given this evolving scenario, it is imperative for various departments to collaborate extensively across the city to establish comprehensive tourism governance frameworks. According to the relevant requirements of *China's Emergency Response Law*, responding to emergencies necessitates a comprehensive system encompassing prevention, prediction, early warning, emergency response, and post-disaster reconstruction. Building on synthesized operational intelligence, the institutionalization of an urban tourist flow performance evaluation system, coupled with the advancement of a holistic urban tourism governance framework through performance-driven methodology, constitutes a critical pathway for safeguarding metropolitan tourism ecosystem's safety and operational integrity. At the theoretical level, the existing research mainly focuses on the measurement and evaluation of tourist flow regulation and diversion effects in scenic spots and resorts. Feng et al. (2010) constructed an application framework and performance evaluation system for temporal and spatial diversion navigation management, and conducted an empirical study in conjunction with the Jiuzhaigou. Zheng and Wu (2015) designed a decision-making algorithm for tourists' recreational direction in theme parks based on the field environment, and Zhang (2020) constructed a simulation system for scenic spot passenger flow regulation and control based on a hybrid model of metric automaton and multi-agent systems, and improved the metric automaton model and the ripple diffusion algorithm for the regulation and control of tourist flow. Niu et al. (2005), Yang and Mo (2015) and Rao (2015) proposed rational arrangement of space and tour lines for reasonable diversion in scenic spots to improve diversion efficiency. Xu (2013) believes that the core of tourist flow management in scenic spots lies in the establishment of a reasonable mechanism for evacuating tourist flows, and regulating the distribution of passenger flows through changes in tourist routes and management of key nodes. However, the regulation of tourist flows at the city level is region-wide, and the regulating space includes not only scenic spots, but also the city's major business districts, leisure neighborhoods, cultural and museum venues, and other areas with dense tourism attractions. The focus of passenger flow regulation at the city level is in the field of transportation, and Yang et al. (2014) have explored passenger flow diversion in urban rail transportation. The evaluation and management of urban tourist flows, including the assessment of their effectiveness, is an emerging area of research. Only a few scholars have explored the spatial release, network structure, influencing factors and channeling paths of urban tourist flows (Yang et al., 2011; Ou et al., 2018; Lu et al., 2022) In response to the real needs of urban tourism development, the construction of a comprehensive and scientific evaluation index system for the effectiveness of urban tourist flow diversion is an inevitable need for the high-quality development of urban tourism.

2. Research Design

2.1 Research Ideas

Effectiveness evaluation requires a scientific evaluation indicator system and methodology. According to management science theories, indicator selection methods are primarily categorized into two types: qualitative and quantitative; the selected indicators should be representative, reflecting the characteristics of a certain aspect of the object of the study; and the indicator system should be comprehensive, reflecting all the information of the object (Zhong, 2020). In constructing indicators, quantitative research is often predicated on qualitative analysis, and basic concepts are defined before selecting indicators (Wang et al., 2002). The selection of indicators mostly relies on the fact that researchers have the problem of subjective selection for evaluation indicators based on their personal experience, this practice often leads to problems such as high correlation between indicators and potential duplication (Wang et al., 1991). Regarding evaluation methods, there are traditional index method and efficacy coefficient method, as well as Analytic Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Fuzzy Comprehensive Evaluation, Factor Evaluation Method, Grey Relational Evaluation Method and so on. However, the existing comprehensive evaluation theories and methods are weak on the research of intelligent evaluation methods that combine subjectivity and objectivity (Ren et al., 2024; Hu and He, 2000). In recent years, some scholars have applied new technologies such as knowledge graphs and neural networks for indicator extraction and evaluation, expanding the methods of indicator construction and evaluation.

In order to avoid problems such as the high subjectivity of evaluation indicators, this study investigates a method of constructing indicators for the effectiveness of urban tourism passenger flow diversion based on knowledge mapping (Figure 1). It is to introduce knowledge graph technology, draw on the research results of tourist flow diversion and effect evaluation in the field of transportation and urban emergency response to extract information and integrate knowledge from the literature on passenger flow diversion in the fields of scenic spots, transportation, and urban emergency response, and optimize the indexes by combining with the Delphi expert consulting method, so as to construct an evaluation index system of the effectiveness of urban tourist flow diversion, which includes the target layer, the system layer, and the index layer.

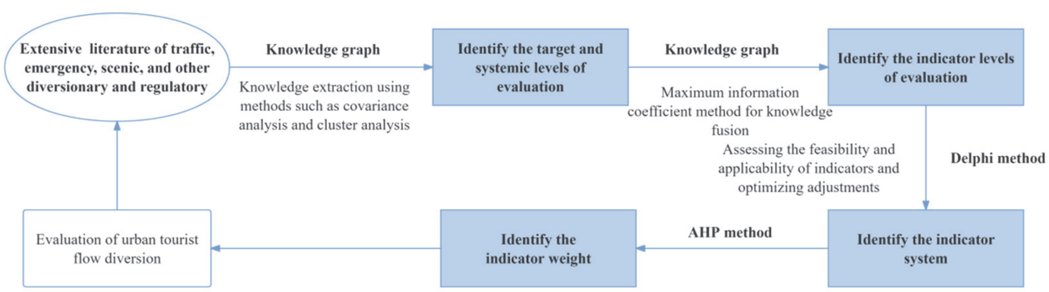

Figure 1. The process of establishing the index and weight of the diversion effectiveness of urban tourist flow

2.2 Methods

2.2.1 Indicator construction based on knowledge graph

As a cross-disciplinary approach originating from the field of artificial intelligence, knowledge graph is actually a specialized semantic network. Constructing a knowledge graph is an iterative updating process, and according to the logic of knowledge acquisition, each round of iteration consists of three stages, information extraction, knowledge fusion and knowledge processing (Hu and Zhang, 2023) Knowledge graphs have highlighted advantages in decision-making evaluation in several industries. Some scholars have also applied knowledge graph to the construction of indicator systems, which is generally based on determining the target layer of evaluation, constructing a specific knowledge semantic network for information extraction through co-occurrence analysis and clustering analysis of keywords in the literature to establish the system layer of evaluation, and then utilizing the Maximum Information Coefficient (MIC) method for knowledge fusion to form the indicator layer (Zeng and Duan, 2023; Li and Zhang, 2024).

2.2.2 Delphi Experts Consulting

Due to the scarcity of literature in this field, expert opinions are particularly important, and this study will revise the indicator system based on knowledge graph through the Delphi method to screen and optimize the indicator system. Two rounds of consultation and communication were conducted through the questionnaire survey on the Questionnaire Star for 30 experts with intermediate or higher titles from the field of tourism and urban management. Among these 30 experts, there are 14 undergraduates and master's degree holders who are responsible for the supervision and regulation of tourist flow including Suzhou, Wuhu, and Tianshui, in China and have rich practical experience; the other 16 are university experts in the field of tourism and transportation with doctoral degrees.

The first round of the survey returned 28 valid questionnaires; the second round returned 29 valid questionnaires (Table 1). In the first round of consultation, the research team provided the experts with detailed background information and a list of questions, encouraged them to propose changes to the content of the questionnaire. In the second round of consultation, the research team conducted an in-depth analysis of the experts' feedback from the first round, as well as the questionnaire data results, to develop an updated questionnaire, which was again submitted to the experts for review. The expert consultation questionnaire utilizes a five-point Likert scale ranging from 1 to 5, representing *Very unimportant*, *Not too important*, *Moderately important*, *More important* and *Very important*, *Fairly important* and *Very important*. If experts had additional explanations or suggestions for improvement of an indicator, they could mark the corresponding position in the questionnaire. Finally, through systematic analysis and statistical processing of the two-round Delphi expert consultation results led to the construction of a comprehensive indicator weighting system for assessing the effectiveness of urban tourist flow regulation.

Table 1. Basic information of Delphi experts consulting

Basic Information		**First round（n=28）**	**Composition ratio（%）**	**Second round（n=29）**	**Composition ratio（%）**
Gender	Man	19	0.68	19	0.66
	Woman	9	0.32	10	0.34
Age	30-39 Years	11	0.39	11	0.38
	40-49 Years	12	0.43	13	0.45
	50-59 Years	5	0.18	5	0.17
Education	Bachelor's degree	5	0.18	5	0.17
	Master's degree	9	0.32	9	0.31
	Doctoral degree	14	0.50	15	0.52
Major	Tourism Management	10	0.36	11	0.38
	Economics	8	0.29	8	0.28
	Transportation	4	0.14	4	0.14
	Business administration	6	0.21	6	0.21
Title	Senior	14	0.5	15	0.48
	Middle	14	0.5	14	0.52

3. Indicator Construction of the Effectiveness of Urban Tourist Flow Diversion

3.1 Defining the Target Level of the Evaluation System

The target level, serving as the evaluation goal, reflects the overall status or level of the indicator. The target layer of this study is *Diversion effect of urban tourist flow*. After determining the target layer, constructing the system and indicator layers based on principles of systematicness, comprehensiveness, and feasibility is crucial for scientifically reflecting the target object.

3.2 Establishing the System Layer of the Evaluation System Based on Information Extraction

Urban systems' tourist flow evacuation is characterized by a distinct pattern where tourists predominantly converge in popular attractions, theme parks, commercial districts, cultural venues, and leisure areas. This differs from pure emergency evacuation by public transportation, and it is a more comprehensive system. Therefore, the subsystem identification should also take into consideration the spatial characteristics and evolutionary patterns of tourist flows in the urban system.

3.2.1 Physical Extraction of Evaluation Indicators

Using the China National Knowledge Infrastructure (CNKI) full-text database as the literature retrieval platform, this study conducted searches in the Tourism and Transportation Economics subject categories within CNKI. The search strategy incorporated keyword combinations such as 'Tourist flow management', 'Tourist flow evacuation', 'Tourist flow distribution', and 'Tourist flow guidance', which were paired with terms like 'effectiveness', 'efficiency', 'evaluation', 'assessment', and 'capability'. 'performance' and so on. Up to January 31, 2024, 246 relevant Chinese literature were retrieved, and 221 literature samples were obtained after excluding conference papers, duplicates, and irrelevant papers. The keywords of the sample literature are analyzed for co-occurrence to construct a specific knowledge semantic network and indicator library.

3.2.2 Relational Extraction of Evaluation Indicators

Evaluation indicator relationship extraction includes associations between siblings and subordinates between levels, where associations between siblings are represented in the form of co-occurrence. The subordinate relationship is fixed relatively, generally embodied in the containing relationship, that is, the effectiveness of urban tourist flow diversion contains subsystems, and subsystems contain each individual indicator, which is embodied in the form of clustering. The study extracts the relationship of evaluation indicators through keyword co-occurrence analysis and cluster analysis.

1) Co-occurrence analysis

Setting the time range from 2000 to 2023, the time slice as one year, and the threshold as the top 30 keywords with the most frequent occurrences, then the keyword co-occurrence knowledge graph (Figure 2) was drawn, showing the keyword co-occurrence knowledge graph containing 182 keyword nodes with 246 connections. The density of the network, as calculated by the Citespace software, is 0.149. Density values typically range from 0 to 1, representing the ratio of the number of connections relative to the number of nodes.

Figure 2. Knowledge graph of keyword co-occurrence analysis

To analyze the evaluation indicator relationships in depth, the top 30 high-frequency keywords were further extracted (Table 2). For nodes having the same or similar number of connections and connection strength, they can be considered to be at the same level of indicators. Combined with the keyword co-linear knowledge graph in Figure 2, the words *Heavy tourist flow*, *Tourist flow evacuation, Tourist flow organization* and *Emergency evacuation* in Table 2 have the highest frequency of occurrence, and with other high-frequency words forming a co-linear relationship, it can be initially considered as a sibling indicator, corresponding to the system-level indicator of this indicator construct. The remaining keywords, such as *Tourist flow prediction*, *Passenger flow control*, *Bottleneck identification*, *Simulation optimization, Passenger flow guidance*, *Passenger flow warning*, *Service level*, etc., can be preliminarily judged as the same level indicators according to the common line relationship, corresponding to the indicator layer indicators for the evaluation of tourist flow diversion in the city.

Table 2. The top 30 high-frequency keywords in the co-occurrence analysis

Number	Keywords	Word Frequency	Number	Keywords	Word Frequency
1	heavy tourist flow	49	16	Passenger Transportation Organization	27
2	Rail station	47	17	Bottleneck Identification	25
3	Tourist flow evacuation	47	18	contingency	25

4	Tourist flow organization	43	19	Simulation Optimization	23
5	Emergency evacuation	42	20	Simulation Modeling	22
6	Simulation	38	21	Simulation studies	20
7	Rapid transit	38	22	Complex network	20
8	Tourist flow forecast	37	23	Safety evacuation	19
9	Tourist flow distribution	35	24	Tourist flow guidance	19
10	Personnel evacuation	34	25	Tourist flow diversion	19
11	Subway	32	26	Tourist flow warning	17
12	Subway station	32	27	Transfer station	16
13	Urban traffic	30	28	Service level	16
14	Tourist flow control	27	29	Fire	16
15	Tourist flow characteristic	27	30	Evacuation	13

2) Cluster analysis

Cluster analysis of keywords with the help of Citespace software streamlines the original complex network relationships of many keywords into a limited number of categories (Figure 3). Modularity Q is an evaluation metric of network modularity, the larger the value, the better the clustering obtained by the network. The Modularity Q value obtained from this clustering analysis is 0.7323 > 0.3, which indicates that the network clustering structure is significant. Mean Silhouette value is used to measure the homogeneity of the network, the larger its value, the higher the homogeneity of the network. In this case the Mean Silhouette value is 0.9352 > 0.5, which indicates that the network clustering is internally homogeneous.

As can be seen in Figure 3, the subsystems that are closely related to the effectiveness of tourist flow diversion include, *#1 Tourist flow organization, #2 Subway, #3 Heavy tourist flow, #4 Tourist flow characteristic, #5 Tourist flow evacuation, #6 Transfer system, #7 Evacuation efficiency,* and *#8 Bottleneck identification.* It provides a base for constructing a systematic layer of indicators for evaluating urban tourist flow diversion.

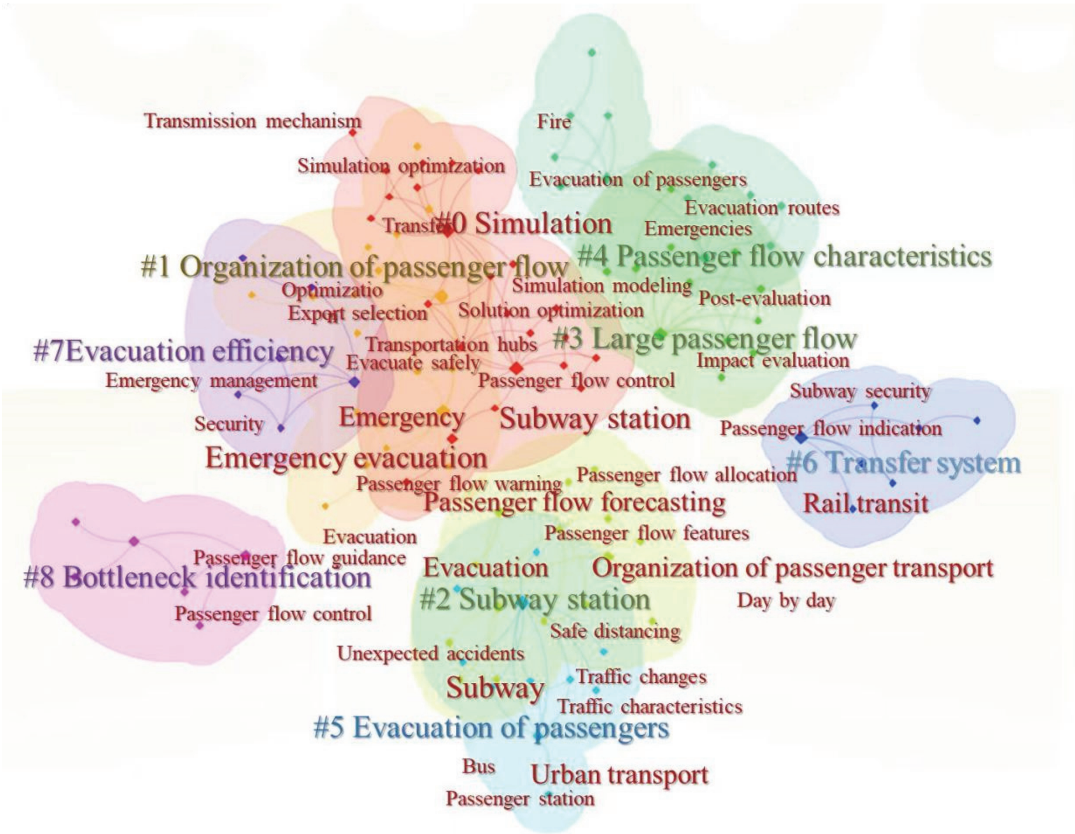

Figure 3. Results of keyword clustering analysis

Taking into account the results of co-occurrence analysis and the connotation of urban tourist flow evacuation, as well as the common procedures of urban emergency and transportation evacuation, the keyword clustering results are further refined. Among them, *#2 subway* and *#6 transfer system* are not the core of urban tourist flow evacuation, so they are deleted here. *#3 Heavy tourist flow* and *#4 Tourist flow characteristics* are synonymous and have been grouped together as *Tourist flow characteristics.* Both *Tourist flow organization* and *Tourist flow evacuation* are the scope of tourist flow control, but *Tourist flow organization* focuses on the process and *Tourist flow evacuation* more focuses on the result. This study is to evaluate the effectiveness of tourist flow evacuation, including the evaluation of the process, so the two are combined into *Tourist flow organization*. Thus, combining the results of co-occurrence analysis, four subsystems are initially obtained for evaluating the effectiveness of urban tourist flow diversion, tourist flow organization, tourist flow characteristics, evacuation efficiency and bottleneck identification.

3.2.3 Evaluation Indicator Attribute Extraction

Attributes were extracted for the evaluation indicator that ranked in the top 20% based on usage frequency ranking. Based on the results of keyword co-occurrence analysis and cluster analysis, combined with the keywords with high frequency in Table 2 and related literature, the general framework of the tourist flow diversion index system was initially determined, including the target layer, system layer and index layer. The target level reflects the overall status or level of the evaluation, that is, *Effectiveness of the urban tourist flow diversion*; The system layer belongs to the sub-item of *Effectiveness of urban tourist flow diversion,* which contains four items, *Tourist flow Characteristics*, *Bottlenecks identification*, *Tourist flow organization,* and *Diversion Efficiency.*

3.3 Establishment of the Indicator Layer of the Evaluation System Based on Knowledge Integration

Knowledge integration mainly includes the treatment of uniform expression of the indicator′s name and clarification or removal of unclear references of the indicator in order to maximize the misrepresentations of the indicator (Li and Zhang, 2024). The specific processing can utilize the evaluation index entity alignment method to fuse the extracted index entities for the evaluation of the effectiveness of tourist flow diversion.

Evaluation metric entity alignment. The entity alignment method in the knowledge graph is utilized to integrate the entities of the evaluation indicators of the effectiveness of urban tourist flow diversion, The entity alignment method in the knowledge graph is utilized to integrate the entities of the evaluation indicators of the effectiveness of urban tourist flow diversion, which mainly includes the unified expression processing of the indicator names and clarification or removal of the unclear references of the indicators. For example, *Optimization scheme* and *Optimization*, *Optimization design* and *Simulation optimization* are merged into *Optimization scheme; Number of people to be evacuated Passenger flow* and *Human flow* are combine into *Size of tourist flow*.

MIC(Maximal Information Coefficient)-based Knowledge Integration of Evaluation Metrics. Following entity alignment of the extracted entity set for water resources carrying capacity evaluation metrics, There are still some indicators that may have information crossover and duplication among them, and the maximum information coefficient (MIC) method was used to analyze the correlation of evaluation indicators in the entity set and to merge knowledge on evaluation indicators. After calculating the maximum information coefficient between different indicators in the entity set of evaluation indicators, the correlation between evaluation indicators with a maximum information coefficient greater than 0.9 is analyzed to minimize the crossover and repetition between indicators and to realize the duplication analysis of evaluation indicators.

3.4 Indicators Optimization Based on Knowledge Processing

Knowledge processing is the process for extracted and fused knowledge to validating, cleaning and standardizing it, this process typically involves experts. This research combines literature and expert opinion to optimize the indicators. From the literature, urban subway emergency diversion mainly considers three main aspects, personnel activities, equipment systems and environmental systems, scenic tourist flow diversion should be diversion of scenic area entrances and exits, parking lots, popular sights, intersection of tour paths and other important nodes that are prone to form a convergence of tourist flow. The evaluation of the emergency response effectiveness of urban comprehensive transportation hubs with heavy tourist flow evacuation often focuses on the Incident Response Timeliness, resources allocation effectiveness, on-site feedback promptness, tactical plan rationality and so on (Lei, 2020; Li, 2023). Evaluation of the effectiveness of tourist flow control in urban rail transit networks focuses on indicators such as the ratio of the maximum decline in the number of people stranded at stations, the average decline ratio (Lu, 2022; Zhao, et al., 2022; Cao et al., 2008) and so on. It can be seen that the evaluation of the effectiveness of tourist flow diversion needs to pay attention to the tourist flow changes, disposition of time, resource scheduling, system feedback and other aspects.

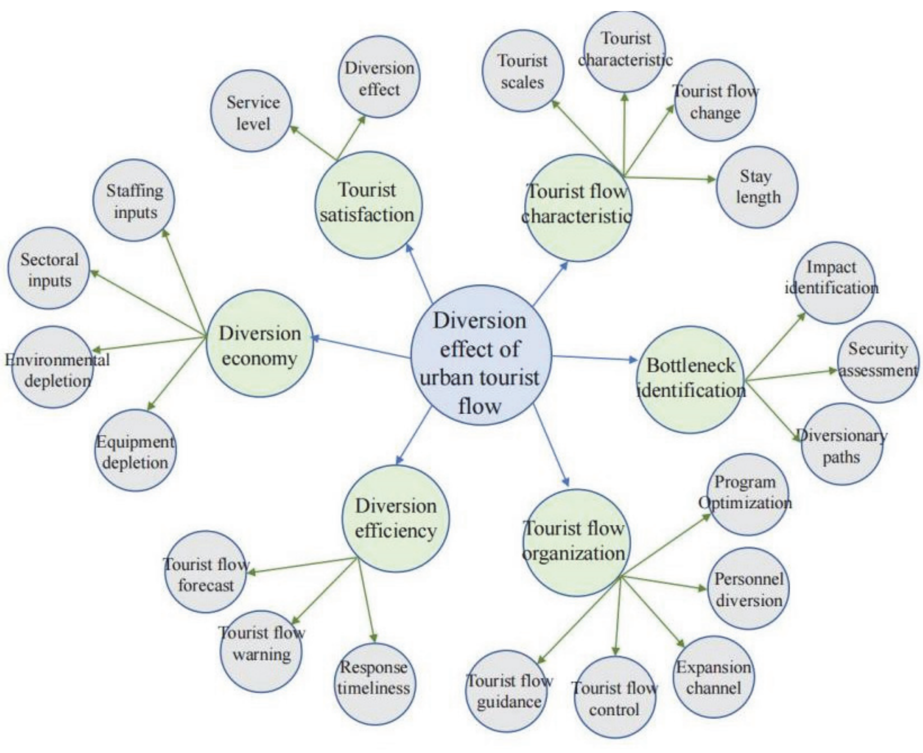

Figure 4. Ontology structure of the evaluation index system of the effectiveness of urban tourist flow diversion

Based on the advice of experts, combined with the results of keyword clustering analysis and the practical application of the index system, two subsystems were added to this study, namely, *Diversion economy and Tourist satisfaction*. *Diversion economy* considering the relationship between the cost and benefit of tourist flow diversion, the smaller the cost for the same diversion effect, the better. Corresponding indicators include environmental loss, facilities and equipment loss, departmental inputs, personnel inputs, and so on. The indicator system of Tourist satisfaction includes indicators of satisfaction with the diversion process and satisfaction with the diversion result. After adding two sub-systems, the evaluation system has six sub-systems (Figure 4), tourist flow characteristics, bottleneck identification, tourist flow organization, diversion efficiency, diversion economy and tourist satisfaction. Translating the above subsystems into indicators is, *Tourist flow characteristic perception capability, Bottleneck identification capability, Tourist flow organization method, Diversion efficiency, Diversion economy,* and *Tourist satisfaction level.* The indicators and their interpretations at the target level, system level and indicator levels are shown in Table 3, including 1 indicator at the target level, 6 indicators at the system level and 21 indicators at the indicator level. The indicator system will be further optimized based on expert opinions during the subsequent Delphi method of determining indicator weights.

Table 3. Indicator system of the diversion effectiveness of urban tourist flow based on knowledge graph

Target level	**System level**	**Indicator level**	**Source and interpretation**
Diversion effect of urban tourist flow	Tourist flow characteristic	Tourist scales	Knowledge graph. Refers to the number of tourists in different scales of tourism and leisure places such as cities, scenic spots, cultural and museum venues, and business districts.
		Tourist characteristic	Knowledge graph. Refers to the characteristics of tourists such as gender, age, and place of travel.
		Tourist flow change	Knowledge graph. Refers to the change of tourist number.
		Stay length	Expert advice. Refers to the length of tourist stays in tourist destination.
	Bottleneck identification	Impact identification	Knowledge graph. Refers to assessment the different types of impacts that may result from the scale of passenger traffic based on the size of the visitors and the space of the premises.
		Security assessment	Knowledge graph. Refers to the hierarchical assessment of different types of security risks for a certain size of tourist flow.
		Diversionary paths	Knowledge graph. Refers to the path of passenger flow diversion based on safety assessment and impact identification, and proposed in accordance with the spatial situation and relevant environmental conditions.
	Tourist flow organization	Tourist flow guidance	Knowledge graph. Refers to the use signage, announcements and so on to provide guidance and risk warnings during tourist flow diversion.
		Tourist flow control	Knowledge graph. Refers to the use cross-section control and flow restriction in tourist flow diversion to manage regional tourist flows.
		Expansion channel	Knowledge graph. Refers to reducing queuing time and speeding up the passage of tourists by setting up additional entry and exit channels in the process of passenger flow diversion.
		Personnel diversion	Knowledge graph. Refers to the use of different route organizations to change the spatial distribution of tourist flow during tourist flow diversion.
		Program Optimization	Knowledge graph. Refers to the continuous optimization the scheme according to the actual situation in the process

		of tourist flow diversion.
Diversion efficiency	Tourist flow forecast	Knowledge graph. Refers to the forecasting of the number of tourists at different scales of tourism and leisure venues, such as cities, scenic spots, cultural and museum venues, and business districts.
	Tourist flow warning	Knowledge graph. Refers to early warning for the identification of impacts and safety ratings of tourism and recreation sites at different scales, such as cities/attractions/cultural and cultural venues/commercial districts.
	Response timeliness	Expert advice. Refers to the length of time it takes from the initiation to completion of tourist diversion.
Diversion economy	Staffing inputs	Cao et al. (2008), Xia (2015), Refers to the number of personnel invested in the deescalation process. Generally speaking, the more personnel there are, the less economical it is.
	Sectoral inputs	Cao et al. (2008), Xia (2015), Refers to the number of sectors involved in the deescalation process. The more sectors involved, the less economical it is.
	Environmental depletion	Cao et al. (2008), Xia (2015), Refers to the negative impacts and damages to the ecological environment of a tourist site caused by tourist flow diversion activities.
	Equipment depletion	Xing (2012) Refers to the performance degradation and shortened life span of facilities and equipment used for tourist flow diversion that occurs during the diversion process.
Tourist satisfaction	Service level	Knowledge graph. Refers to the subjective feelings and evaluations of tourists about the services provided by the relevant departments during the evacuation process.
	Diversion effect	Expert advice. Refers to the subjective feelings and evaluations of tourists about the actual effects produced by diversionary measures and facilities.

4. Determination of Indicator Weights and Scoring Rules

4.1 Optimization Indicators of the Delphi Method

The research used the Delphi method to further optimize the metrics. The study consulted 30 experts from the field of tourism and urban management, the basic information is shown in Table 1. The results demonstrate that all indicators are within acceptable ranges including expert engagement coefficient, expert authority coefficient, concentration degree of expert opinions, coordination degree of expert opinions and so on. Among them, expert engagement coefficient is way, Thirty questionnaires were distributed in the two rounds of consultation, of which 28 valid questionnaires were collected in the first round of survey, with a recovery rate of 93. 33% and an effective rate of 100%, while 29 valid questionnaires were collected in the second round of survey, with a recovery rate of 96. 67% and an effective rate of 100%. It indicates that the experts who participated in the consultation demonstrated a high level of motivation for this study. The degree of expert authority was measured by the expert authority coefficient (Cr), where the closer the value of Cr is to 1, the higher the degree of authority of the expert is implied. When the Cr value exceeds 0.80, it indicates that the expert holds a high degree of confidence in the outcome of his/her judgment. The Cr for the first round of consultation was 0.894 and the Cr for the second round was 0.896, indicating good reliability of the results. The degree of concentration of expert opinion is reflected by calculating the average value of each indicator, and the indicators identified in the study all received an average score of more than 3. 5, which shows a concentration of opinion. The degree of harmonization of expert opinions is assessed by the Kendall's harmonization coefficient W (Kendall's W value), which, when the value is closer to 1, indicates that the experts are more consistent in their views or evaluations of the indicator. The Kendall's W values for the two rounds of expert consultation were 0.779 and 0.783, respectively, and the p-value was 0.000, indicating that the harmonization of expert opinions was good.

During the first round of expert consultation, three experts suggested replacing *Tourist flow characteristic* with *Tourist flow characteristics perception*, *Bottleneck identification* with *Bottleneck identification capability*, *Tourist flow organization* with *Tourist flow organization method,* and *bottleneck identification* with *Risk identification capability*. Two experts suggested replacing *Tourist flow forecast* with *Tourist flow forecast accuracy* and *Tourist flow warning* with *Tourist flow warning accuracy*.

4.2 Hierarchical Analysis to Determine Indicator Weights

According to the two-by-two comparison matrix of the indicators at each level, the hierarchical analysis method was used to invite experts to score and determine the weights of the indicators at each level. The distribution of the weights assigned to the indicators at each level is shown in table 4. Among them, the highest weighted system level indicator is *Risk identification ability* (0.3261), followed by *Tourist satisfaction* (0.1737), and the others are *Tourist flow evacuation efficiency* (0.1701), *Tourist flow organization method* (0.1380), *Tourist flow characteristics perception* (0.1374) and *Tourist flow Diversion economy* (0.0547).

4.3 Determine the Measurement Basis and Scoring Rules for the Indicators

After determining the weights of indicators at all levels, in order to make the scoring table operationally applicable, it is necessary to determine the basis of measurement and assignment rules of the indicators based on the actual needs of urban tourism passenger flow monitoring and channeling, relevant literature and practical experience, and assigning a score out of 100 points, forming the indicator measurement and assignment rules in Table 4.

Table 4. Indicators and weights of the diversion effectiveness of urban tourist flow

Target level	System level	Indicator level	Indicator Measurement and Scoring Rules
Diversion effect of urban tourist flow (1. 000)	Tourist flow characteristics perception(0. 1374)	Tourist scale (0.0294)	Interview research. Ability to accurately sense and predict the scale of tourist flow at major urban tourism and leisure venues every hour/30 minutes/15 minutes. This item worth 3 points, with 15 minutes being 120% of the score, 30 minutes being 100% of the score, and 1 hour being 80% of the score.
		Tourist characteristics(0.0392)	Interview research. Be able to accurately identify the gender and age characteristics of visitors. If this can be done, this item will receive 4 points out of a possible 4, and vice versa will receive 0 points.
		Tourist flow changes (0.0329)	Interview research. Capable of accurately sensing changes in tourist flow at major tourist and leisure venues in the city every hour/30 minutes/15 minutes. This item worth 3 points, with 15 minutes being 120% of this point, 30 minutes being 100% of this point, and 1 hour being 80% of this point.
		Stay length (0.0359)	Interview research. Ability to accurately perceive the stay length of tourists at major tourist and leisure sites in the city. This item worth 4 points, if data granularity is achieved every 15 minutes it is 120% of this point, every 30 minutes it is 100% and every 1 hour it is 80%.
	Risk identification capability(0. 3261)	Impact identification(0.1007)	Interview research. The ability to accurately identify the impacts caused by all aspects of major tourism and leisure venues in terms of people, property and goods based on real-time tourist flows. This item worth 10 points, with a base score of 6 points for being able to identify the impacts on visitors, and an additional 1 point for each of the remaining impacts, up to a maximum score of 10 points.
		Security assessment(0. 1623)	Interview research. Capable of grading emergency risk, congestion risk, stampede risk, stranding risk, etc. based on real-time tourist flow at major tourism and leisure venues. This item worth 16 points, can be subdivided into more than 4 kinds of security evaluation, this full marks; each decrease of 1 safety evaluation identifies a sequential decrease of 1 point.

	Diversionary paths(0.0631)	Interview research. Be able to propose diversion routes based on the real-time tourist flow of major tourism, leisure venues and the surrounding environment of the venues. This item worth 6 points, can be done to put forward more than six kinds of evacuation paths this item full marks, each reduced by 1 kind of path in turn decreases by 1 point.
Tourist flow organization method(0.1380)	Tourist flow guidance(0.0298)	Interview research. Ability to implement passenger flow guidance based on risk level. If this can be done, score 3 out of 3, otherwise score 0.
	Tourist flow control (0.0377)	Interview research. Ability to implement passenger flow control based on risk level. If this can be done, score this item out of 4, otherwise score 0.
	Expansion channel (0.0246)	Interview research. Ability to expand evacuation routes according to risk level. If this can be done, score 2 out of 2, otherwise score 0.
	Personnel diversion (0.0286)	Interview research. Ability to triage personnel according to risk level. If this can be done, 3 points out of 3, otherwise 0 points.
	Program optimization(0.0173)	Interview research. Be able to optimize the diversion plan according to the effect of tourist flow organization. If this can be done, 2 points out of 2, otherwise 0 points.
Tourist flow evacuation efficiency(0.1701)	Tourist flow forecast accuracy(0.0826)	Interview research. The accuracy of forecasting passenger flow at major tourism and leisure venues exceeds 70%, 80% and 90%. This item is worth 8 points, 90% accuracy is 120% of the score, 80% accuracy is 100% of the score, 70% accuracy is 80% of the score, and no points are awarded for accuracy below 70%.
	Tourist flow warming accuracy(0.0508)	Interview research. The accuracy of forecasting the tourist flow at major tourism and leisure venues based on risk levels exceeds 70%, 80% and 90%. This item is worth 5 points, 90% accuracy is 120% of the score, 80% accuracy is 100% of the score, 70% accuracy is 80% of the score, and no points are awarded for accuracy below 70%.
	Response timeliness (0.0367)	Referring to the requirement of graded response of *Procedural Regulations for Expressway Traffic Emergency Management,* it is able to organize diversion according to the risk warning in real time/30 minutes/1 hour. This item is worth 4 points, *Real-time* response is 120% of this point, *Within 30 minutes* Response is 100% of this point, *Within 1 hour* response is 80% of this point, more than 1 hour response is not scored.
Tourist flow diversion economy(0.0547)	Staffing inputs(0.0113)	Interview research. Does not exceed the number of regular personnel of the emergency mechanism in the region. If it is not exceeded, this item will receive a full score of 1 points, otherwise 0 points.
	Sectoral inputs(0.0182)	Interview research. Not exceeding the number of coordinated departments of the emergency mechanism in the region. If this is not exceeded, this item will receive a full score of 2 points, otherwise 0 points.
	Environmental depletion (0.0142)	Interview research. Tourist evacuation has not resulted in environmental damage to major tourist and recreational sites. If there is no damage, this item will receive a full score of 1 points, otherwise 0 points.
	Equipment depletion (0.011)	Interview research. Tourist evacuation did not result in damage to facilities and equipment at major tourist and recreational sites. If this is not the case, this item will receive a full score of 1 points.

	Tourist satisfaction(0.1737)	Service level (0.0787)	Referring to the grading standard of tourist satisfaction in the *National Tourist Satisfaction Survey*, 60 points or less is *Very dissatisfied*, 60-70 points is *Dissatisfied*, 70-80 points is *General*, 80-90 points is Satisfied, and 90 points or more is *Very satisfied*. 60-70 is *Dissatisfied*, 70-80 is *Average*, 80-90 is Satisfied, and 90 or more is *Very satisfied*. This item worth 8 points, *Unsatisfactory* and below, 0 points; grade *General* is 60% of the score, grade *Satisfactory* is 80% of the score, grade *Very satisfactory* is 100%.
		Evacuation effect (0.095)	Same as *Service level*

4.4 Applications

This study relies on the application demonstration requirements of the *Science and Technology Innovation 2030 - Artificial Intelligence Major Special Project of the Ministry of Science and Technology of the People s Republic of China*, to test the application of the demonstration cities Tianshui, Suzhou, Wuhu and other municipal cultural and tourism departments and demonstration undertaking units. After two self-evaluations of the effectiveness of the local tourism passenger flow monitoring and channeling systems in the demonstration cities of Tianshui, Suzhou and Wuhu, the results of the second evaluation were 91. 0, 82. 4 and 78. 0, respectively, which were more in line with the actual effects of the project demonstration, indicating that the evaluation indexes and the weighting of the assigned points were good. The indicator system better meets the passenger flow diversion needs of the three demonstration cities.

5. Conclusion and Discussion

5.1 Main Findings

1) A comprehensive qualitative-quantitative approach to constructing indicators based on knowledge mapping is rigorous and feasible. The study follows a rigorous and standardized process, based on the selection of literature, knowledge extraction through knowledge graph co-occurrence analysis and cluster analysis to obtain the target layer and system layer of the indicator system. Then, the knowledge fusion is carried out by the method of maximum information coefficient of knowledge map to get the indicator layer of the evaluation system, on the basis of which the indicators are improved by the Delphi expert consulting method, and the weights of the indicators are determined by using the AHP hierarchical analysis method, so that a set of indicator system for evaluating the effectiveness of tourist flow diversion is constructed. This approach, which combines artificial intelligence techniques, expert opinion and testing applications, ensures the scientific rigor of the entire indicator system.

2) Risk identification ability, tourist satisfaction, and evacuation efficiency, these three subsystems embody the core of the evaluation of the effectiveness of urban tourist flow diversion. Among them, the risk identification ability has the highest weight (0.3261), reflecting the effectiveness of the city s tourist flow monitoring and diversion system, followed by tourist satisfaction, with a weight of 0.1737, which directly reflects the quality level of tourist flow monitoring and diversion. Tourists, as the object to be diverted, are closely involved in tourist flow diversion and regulation, and the process of tourist flow diversion can be carried out without affecting the experience of tourists, which is the key to ensure the success of urban tourism tourist flow diversion. Evacuation efficiency, on the other hand, was ranked third with a weight of 0.1701, which covers the accuracy of passenger flow prediction, the precision of warning, and the timeliness of disposal and so on. In addition, the tourist flow characteristics perception (weight, 0.1374), the tourist flow organization method(weight, 0.1380), and the tourist flow diversion economy (weight, 0.0547) are also indispensable indicators for the evaluation of the effectiveness of tourist flow diversion. Tourist flow characteristics perception is reflected as being the ability to perceive the regularity and variability in the flow of tourists or customers over a specific time and spatial scale. The tourist flow organization mode, measures the effectiveness of the way in which tourist flow control measures are organized and implemented to ease the flow. Tourist flow diversion economy refers to the comprehensive consideration of cost-effectiveness in the process of tourist diversion to ensure that the best diversion effect is achieved with minimum economic input.

3) Urban tourism tourist flow monitoring and diversion should cover the whole process of tourists before, during and after the tour, and its monitoring and diversion optimization system needs to form a closed loop of data. The indicator level of the evaluation system includes indicators such as tourist flow forecast, Tourist flow warming,

response timeliness, program optimization, etc., thus, it can realize the functions of advance perception of passenger flow, real-time monitoring, advance warning, risk research and judgment, and carry out tourist flow organization planning. As a result, it is possible to realize a new type of governance of human-machine cooperation.

4) A rigorous and feasible evaluation system for the effectiveness of urban tourism tourist flow monitoring and diversion will help optimize the new technology-supported urban tourism-related governance system and promote the urban tourism passenger flow monitoring and diversion system to give full play to its role.

5.2 Discussion

The first is that the role of the evaluation index system in accomplishing the monitoring and channeling system of urban tourism tourist flow needs to be tested for effectiveness through practical application. Future research can further improve the indicator system, especially for the completeness of the content of individual indicators and the rationality of the assignment criteria. Secondly, the study adopted the knowledge graph method to carry out the evaluation of the effectiveness of tourism tourist flow diversion. Although this method has its unique advantages, there is still room for future research to further optimize the indicator system construction method and continuously improve the practicality of the evaluation method.

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