Ekoloji 28(107): 259-265 (2019)

Assessment of the Sustainable of Water-based Tourism on the Basis of Interval-valued Intuitionistic Fuzzy Sets

Zhangmiao Li [1], Huimin Li [2*], Xiaowei An [1]

[1] Business School, Hohai University, Nanjing 210098, CHINA

[2] Department of Construction Engineering and Management, North China University of Water Resources and Electric Power, Zhengzhou 450045, CHINA

[*] Corresponding author: lihuimin3646@163.com

Abstract
Water-based tourism has consistently been popular. However, the water environment is fragile and easily affected by human activities. Thus, the sustainability of water-based tourism is at a serious condition. Quantitative evaluation is needed to formulate sustainable development strategies and guarantee the sustainable development of water-based tourism. From the goal of the sustainable development of tourism and characteristics of water-based tourism, this paper have built an evaluation index system for the sustainable development of water-based tourism, this study used to select 18 index factors from 5 aspects, namely, economic, social, environmental, management, and development conditions. Index weight coefficients are measured through the analytic hierarchy process. And a sustainable development evaluation model for water-based tourism is built based on interval-valued intuitionistic fuzzy sets. Empirical analysis is performed with an actual case to verify the validity of the proposed method. Case analysis shows that the evaluation method for the sustainable development of water-based tourism presented in this study is valid and provides a reference for the management of sustainable development and formulation of strategies for water-based tourism.
Keywords: water-based tourism, sustainable development, evaluation, IVIFS

Li Z, Li H, An X (2019) Assessment of the Sustainable of Water-based Tourism on the Basis of Interval-valued Intuitionistic Fuzzy Sets. Ekoloji 28(107): 259-265.

INTRODUCTION

The beautiful water landscape is definitely attractive for people with lofty ideals. At present, water-based tourism is gradually becoming an important platform for entertainment and regional tourism development. Water-based tourism resource refers to the natural and cultural landscapes of a water area (body of water) and the correlative banks, islands, forests and grass, and buildings that are attractive to people (Ding et al. 2013). The continuous development of the economy and society has resulted in an increasing demand of people for water-based tourism, thereby leading to the increasing number of water-based tourist projects. However, the water environment is fragile and easily affected by human activities, thereby resulting in the unfavorable sustainability of water-based tourism. Moreover, people are concerned with the methods of maintaining the sustainability of water-based tourism. Kapp et al. (1995) discussed the development and implementation of water resource management strategies in key tourism regions. Li et al. (2012) employed the regional economic development angle and proposed six basic strategies for the waterfront tourism development of Jianghan Canal. Yu (2012) analyzed the value, contents, development processes, and operating situations of a water conservancy scenic area and proposed recommendations on management. Liu et al. (2011) analyzed the tourism spatial structure of a national water conservancy area in China. Liao (2010) discussed environmental issues and control countermeasures in the development of water conservancy tourism.

With the accelerated development of water tourism development, the problem of sustainable development of water-based tourism has gradually been paid attention to. Dong et al. (2015) analyzed the construction progress and proposed the sustainable development of a water conservancy area. Da (2013) used the Three Gorges Reservoir Region as an example and introduced principles, models, and countermeasures for the sustainable development of water conservancy tourism through the analysis of the development advantages. Feng (2010) expounded the relationship among ecological environment maintenance, water conservancy function, and tourism function of a water conservancy area from a systematic

 Received: 1 Sep 2017 / Accepted: 4 May 2018

Table 1. Evaluation index system for the sustainable development of water-based tourism

<table>
<tr><th>Target layer</th><th>Criterion layer</th><th>Index factor layer</th><th>Remarks</th></tr>
<tr><td rowspan="18">Evaluation of the sustainable development of water-based tourism</td><td rowspan="3">Economically sustainable development B1</td><td>Tourist income growth rate C1</td><td>Shows economic development of tourist destination.</td></tr>
<tr><td>Tourist growth rate C2</td><td>Basic guarantee for water-based tourist destination to realize sustainable development.</td></tr>
<tr><td>Contribution to the local economy C3</td><td>Contribution made by the tourism industry to the local economy.</td></tr>
<tr><td rowspan="4">Socially sustainable development B2</td><td>Attitude of residents toward water-based tourism developmentC4</td><td>Attitudes of nearby residents to water-based tourism development that can be determined through actual investigation.</td></tr>
<tr><td>Local labor force absorbed C5</td><td>Shows the important role of tourism as a labor intensive industry in driving the employment of local residents.</td></tr>
<tr><td>Improved local popularity C6</td><td>Survey whether water-based tourism development can improve the popularity of a place.</td></tr>
<tr><td>Tourist satisfaction C7</td><td>Evaluation of tourists on the place of sightseeing that can be determined through actual investigation.</td></tr>
<tr><td rowspan="3">Environmentally sustainable development B3</td><td>Water environment quality C8</td><td>Quality of the water environment situations of water-based tourist destinations.</td></tr>
<tr><td>Ecological environment quality C9</td><td>Quality of the ecological environment of water-based tourist destination.</td></tr>
<tr><td>Environment capacity C10</td><td>Refers to the most capable tourists without generating permanent damage to the ecological environment.</td></tr>
<tr><td rowspan="5">Management of sustainable development B4</td><td>Management organization C11</td><td>Whether the institution of management is complete or management system is ideal; Whether responsibility of management personnel is clarified.</td></tr>
<tr><td>Planning management C12</td><td>Whether development planning is scientific and reasonable.</td></tr>
<tr><td>Environmental management C13</td><td>Catering and accommodation conditions; public restroom setting and health conditions; public place sanitary; waste treatment situation</td></tr>
<tr><td>Service management C14</td><td>Whether service project is matching; whether service level is favorable; whether complaint institution handles issues in time</td></tr>
<tr><td>Safety management C15</td><td>Engineering and equipment safety; recreation facility safety; safety sign setting; public security and fire control management; emergency plan</td></tr>
<tr><td rowspan="3">Development condition of sustainable development B5</td><td>Development value C16</td><td>Value of water-based tourism development</td></tr>
<tr><td>Traffic conditions C17</td><td>Traffic situations near water-based tourist destinations</td></tr>
<tr><td>Location conditions C18</td><td>Refers to the geological condition of water-based tourist destinations, such as whether the area is near world and national scenic spots</td></tr>
</table>

Note: A few indexes in this system depend on the analysis of statistical data, such as the growth rates of tourists and tourist income. The corresponding data for these indexes will be collected prior to the evaluation and sent to experts for evaluation. Other indexes, such as tourist satisfaction, need on-site investigation. The corresponding basic data of these indexes will be acquired via questionnaire before evaluation.

angle and proposed an approach to promote the sustainable development of tourism in this area. Ding et al. (2013) divided water-based tourism resources by main, sub-, and basic classes; established an evaluation index system; and conducted an empirical study with Nanjing as example.

The quantitative evaluation of sustainable development is the foundation to formulate sustainable development strategies and the popular and difficult problem of the current study on sustainable development. The current study establishes an evaluation index system for sustainable development of water-based tourism based on document analysis and actual investigation. In addition, this research builds a water-based tourism sustainable development evaluation model based on the interval-valued intuitionistic fuzzy sets (IVIFS) to perform a quantitative evaluation on the sustainable development of water-based tourism and provide a reference for the formulation of sustainable development strategies.

CONSTRUCTION OF AN EVALUATION INDEX SYSTEM

The objectives of the sustainable development of tourism are (1) to enhance the capability of economic and social development and improve the standard of living of local residents; (2) to maintain a favorable circulation of the ecological environment and provide high-quality tourist environment to tourists; (3) to value resource management and guarantee the sustainability of tourism resources, (4) and to acknowledge the resource development and available potential of tourism as basic powers of regional tourism development. The current study refers to the results of existing research (Ding et al. 2015) and combines the objectives of the sustainable development of tourism to build an evaluation index system for the sustainable development of water-based tourism in the aspects of economy, society, environment, management, and development conditions. Specific evaluation indexes are listed for every aspect to establish a targeted, adaptive, and operable evaluation index system for the sustainable development of water-based tourism. A total of 18 indexes are selected based on 5 subsystems (i.e., economic, social, environment, management of sustainable development, and development conditions and potential) to develop the evaluation index system for the sustainable development of water-based tourism. **Table 1** presents the specific indexes.

RESEARCH METHODS

The aforementioned index system indicates that the evaluation indicators are considerably ambiguous and uncertain. To evaluate the sustainability of water-based tourism in a scientific and effective manner, this study intends to establish a corresponding evaluation model via IVIFS. Intuitionistic fuzzy sets can simultaneously consider the membership, non-membership, and hesitation of the evaluation index and effectively describe the fuzzy concept of “neither this nor that” to exquisitely depict the fuzzy nature of the objective world (Li 2005, Xu and Yager 2006, Xu and Chen 2008). Intuitionistic fuzzy sets have been applied extensively (Farhadinia 2014, Huang et al. 2015, Kharal 2009, Papakostas et al. 2013). IVIFS is its further expansion and the evaluation effect is excellent. Moreover, indication evaluation involves the confirmation of the index weight. Large amount of practices prove that the analytic hierarchy process (AHP) can favorably confirm the weight of index. The current study adopts AHP to confirm the weight of index. IVIFS and the relevant algorithm will be introduced in a simple manner in the following section.

IVIFS

Suppose X is a non-empty set and $A = \{\langle x, \mu_A(x), \upsilon_A(x)\rangle | x \in X\}$ is a intuitionistic fuzzy set (Atanassov 1986), where $\mu_A(x)$ and $\upsilon_A(x)$ are membership and non-membership, respectively. x belongs to the judgment set in the non-empty set, $\mu_A(x) \in [0,1]$, $\upsilon_A(x) \in [0,1]$, and $0 \le \mu_A(x) + \upsilon_A(x) \le 1$. $\pi_A(x) = 1 - \mu_A(x) - \upsilon_A(x)$ is the hesitation degree $\pi_A(x) \in [0,1]$. In particular, if $\pi_A(x) = 1 - \mu_A(x) - \upsilon_A(x) = 0$ for $\pi_A(x) = 1 - \mu_A(x) - \upsilon_A(x) = 0$ (i.e., $\upsilon_A(x) = 1 - \mu_A(x)$), then the intuitionistic fuzzy set degrades to a common fuzzy set. In reality, the values of membership and non-membership are difficult to confirm. Thus, Atanassov and Gargov (1989) further expanded the intuitionistic fuzzy set and expressed membership and non-membership in terms of uncertain language (e.g., $\mu_A(x) = [\mu_A^L(x), \mu_A^U(x)]$ and $\upsilon_A(x) = [\upsilon_A^L(x), \upsilon_A^U(x)]$). Thus, intuitionistic fuzzy set is involved with IVIFS.

$$\tilde{A} = \{\langle x, [\mu_A^L(x), \mu_A^U(x)], [\upsilon_A^L(x), \upsilon_A^U(x)]\rangle | x \in X\} \quad (1)$$

where $\mu_A^L(x)$ and $\upsilon_A^L(x)$ are the lower limit of membership and non-membership, respectively, while $\mu_A^U(x)$ and $\upsilon_A^U(x)$ are the upper limit of membership and non-membership, respectively. Moreover, $0 \le \mu_A^L(x) \le \mu_A^U(x) \le 1$, $0 \le \upsilon_A^L(x) \le \upsilon_A^U(x) \le 1$, $\mu_A^U(x) + \upsilon_A^U(x) \le 1$ and $x \in X$. Meanwhile, hesitation $\pi_A(x) = [\pi_A^L(x), \pi_A^U(x)] = [1 - u_A^U(x) - \upsilon_A^U(x), 1 - u_A^L(x) - \upsilon_A^L(x)]$. $\pi_A^L(x)$ and $\pi_A^U(x)$ are the lower and upper limits of hesitation degree, respectively. Specifically, if $\mu_A^L(x) = \mu_A^U(x)$ and $\upsilon_A^L(x) = \upsilon_A^U(x)$ for $\forall x \in X$, then IVIFS will degrade to a common intuitionistic fuzzy set.

Weighted Average Operator

Weighted average operator is the most frequently used aggregation algorithm for intuitionistic fuzzy set. Suppose $A = (\tilde{A}_1, \tilde{A}_2, \cdots, \tilde{A}_n)$ is a series of IVIFS vectors $\tilde{A}_i = \{\langle x_i, [\mu_A^L(x_i), \mu_A^U(x_i)], [\upsilon_A^L(x_i), \upsilon_A^U(x_i)]\rangle | x_i \in X\}$, and X is a nonempty set ($i = 1,2,\cdots,n$). The weighted aggregation vector can be shown as follows (Das et al. 2016):

$$\tilde{A}_0 = \left\langle \left[1 - \prod_{i=1}^{n}\left(1 - \mu_A^L(x_i)\right)^{w_i}, 1 - \prod_{i=1}^{n}\left(1 - \mu_A^L(x)\right)^{w_i}\right], \left[\prod_{i=1}^{n} \upsilon_A^L(x)^{w_i}, \prod_{i=1}^{n} \upsilon_A^U(x)^{w_i}\right]\right\rangle \quad (2)$$

Formula (2) shows that $W = (w_1, w_2, \cdots, w_n)$ is the weight of each vector $w_i \in [0,1]$ and $\sum_{i=1}^{n} w_j = 1$.

Distance Measurement Formula

Suppose that two IVIFS sets $\tilde{A}_1 = \{\langle x_1, [\mu_A^L(x_1), \mu_A^U(x_1)], [\upsilon_A^L(x_1), \upsilon_A^U(x_1)]\rangle | x_1 \in X\}$, $\tilde{A}_2 = \{\langle x_2, [\mu_A^L(x_2), \mu_A^U(x_2)], [\upsilon_A^L(x_2), \upsilon_A^U(x_2)]\rangle | x_2 \in X\}$. Thus, the distance between the two sets can be defined as follows (Xu and Yager 2009):

$$d(\tilde{A}_1, \tilde{A}_2) = \frac{1}{4}(|\mu_A^L(x_1) - \mu_A^L(x_2)| + |\mu_A^U(x_1) - \mu_A^U(x_2)| + |\upsilon_A^L(x_1) - \upsilon_A^L(x_2)| + |\upsilon_A^U(x_1) - \upsilon_A^U(x_2)| + |\pi_A^L(x_1) - \pi_A^L(x_2)| + |\pi_A^U(x_1) - \pi_A^U(x_2)|) \quad (3)$$

where $\pi_A^L(x_1) = 1 - \mu_A^U(x_2) - \upsilon_A^U(x_2)$ and $\pi_A^U(x_2) = 1 - \mu_A^L(x_1) - \upsilon_A^L(x_1)$.

Information Concentration

For expert evaluation, the validities of the evaluation information offered are different due to the varied fields of expertise. Different weights will be provided when aggregating information that combines the characteristics of experts. Suppose expert D_i (i =1, 2, …, n) offered the evaluation value $r_{ij} = \left\langle \left[\mu_{ij}^L, \mu_{ij}^U\right], \left[\upsilon_{ij}^L, \upsilon_{ij}^U\right]\right\rangle$ for index C_j. The mean value of the defined evaluation value will be $m_{ij} = \langle [\mu_{ij}^{L\prime}, \mu_{ij}^{U\prime}], [\upsilon_{ij}^{L\prime}, \upsilon_{ij}^{U\prime}]\rangle$ (Chen and Yang 2011), in which:

$$\mu_{ij}^{L\prime} = \frac{1}{n}\sum_{i=1}^{n} \mu_{ij}^L$$
$$\mu_{ij}^{U\prime} = \frac{1}{n}\sum_{i=1}^{n} \mu_{ij}^U \quad (4)$$
$$\upsilon_{ij}^{L\prime} = \frac{1}{n}\sum_{i=1}^{n} \upsilon_{ij}^L$$

Table 2. Evaluation of the index weight value

Criterion layer	Weight	Index factor layer	Weight
Economically sustainable development B1	0.212	Tourist income growth rate C1	0.297
		Tourists growth rate C2	0.328
		Contribution of tourism output to the local economy C3	0.375
Socially sustainable development B2	0.245	Attitude of residents to water-based tourism development C4	0.308
		Local labor force absorbed C5	0.227
		Improved local popularity C6	0.204
		Tourist satisfaction C7	0.261
Environmentally sustainable development B3	0.235	Quality of water environment quality C8	0.279
		Quality of ecological environment quality C9	0.279
		Environmental capacity C10	0.442
Management of sustainable development B4	0.134	Management organization C11	0.235
		Planning management C12	0.258
		Environmental management C13	0.173
		Service management C14	0.179
		Safety management C15	0.154
Development of conditions and potential B5	0.183	Development value C16	0.406
		Traffic conditions C17	0.311
		Location conditions C18	0.283

$$v_{ij}^{U'} = \frac{1}{n}\sum_{i=1}^{n} v_{ij}^{U}$$

The similarity of the evaluation value r_{ij} and mean value m_{ij} can be presented by $s(r_{ij}, m_{ij})$. Thereafter,

$$s(r_{ij}, m_{ij}) = 1 - \frac{d(r_{ij}, m_{ij})}{\sum_{i=1}^{n} d(r_{ij}, m_{ij})} \quad (5)$$

The weight of the evaluation information r_{ij} offered by expert D_i about index C_j can be defined as follows:

$$w_{ij} = \frac{s(r_{ij}, m_{ij})}{\sum_{i=1}^{n} s(r_{ij}, m_{ij})} \quad (6)$$

After the weight is acquired, all the evaluation values offered by experts can be aggregated as follows:

$$r_j = \sum_{i=1}^{n} w_{ij} r_{ij} \quad (7)$$

Thus, the comprehensive evaluation matrix $R_0 = (r_j)_{18\times1}$ can be acquired by aggregating all the expert judgment information.

Score Function

Score function is a valid measurement of IVIFS and valid reference to confirm the evaluation results. The score function of IVIFS $\tilde{A} = \{\langle x, [\mu_A^L(x), \mu_A^U(x)], [v_A^L(x), v_A^U(x)]\rangle | x \in X\}$ is presented as follows (Xu 2007):

$$S(x) = \frac{\mu_A^U(x) + \mu_A^L(x) - v_A^U(x) - v_A^L(x)}{2} \quad (8)$$

The corresponding evaluation result can be acquired based on the score function value and corresponding evaluation standard. This study sets five levels of evaluation standards, namely, excellent, good, medium, bad, and worse, which correspond to the following score function values: 0.75, 0.65, 0.55, 0.45, and 0.35, respectively.

CASE STUDY

The sustainable development of water-based tourism in a certain national water conservancy area in city A was evaluated based on the evaluation index system and the calculation method established in the previous section. The statistical data and investigation results indicate that four experts in the relevant fields of expertise were invited to conduct the evaluation. The evaluation expert set is $D = (D_1, D_2, D_3, D_4)$ and the evaluation language adopts IVIFS. The specific evaluation steps are as follows.

Step 1. Confirming the indexes weights. The weight of each level will be calculated through AHP. **Table 2** shows the weight calculation results.

Step 2. Experts' evaluation. After the statistical analysis of the basic data, experts were invited to offer the evaluation results for every index of evaluation object pursuant to the established evaluation index system. The evaluation results are offered in the form of IVIFS.

Step 3. Calculating and analysis. The mean value of each evaluation index m_{ij} and similarity $s(r_{ij}, m_{ij})$ between evaluation value r_{ij} and mean average value m_{ij} are calculated. **Table 3** shows the calculation values of the similarity.

Table 3. Calculation values of the similarity

	D1	D2	D3	D4
C1	0.824	0.765	0.588	0.824
C2	0.684	0.711	0.842	0.763
C3	0.773	0.705	0.659	0.864
C4	0.885	0.654	0.577	0.885
C5	0.735	0.735	0.647	0.882
C6	0.579	0.921	0.579	0.921
C7	0.750	0.833	0.750	0.667
C8	0.853	0.676	0.676	0.794
C9	0.759	0.655	0.759	0.828
C10	0.750	0.750	0.694	0.806
C11	0.545	0.970	0.727	0.758
C12	0.833	0.500	0.833	0.833
C13	0.644	0.889	0.778	0.689
C14	0.677	0.806	0.903	0.613
C15	0.750	0.750	0.750	0.750
C16	0.621	0.862	0.828	0.690
C17	0.500	0.900	0.700	0.900
C18	0.600	0.900	0.600	0.900

Table 4. Weight of the evaluation values by the experts

	D1	D2	D3	D4
C1	0.275	0.255	0.196	0.275
C2	0.228	0.237	0.281	0.254
C3	0.258	0.235	0.220	0.288
C4	0.295	0.218	0.192	0.295
C5	0.245	0.245	0.216	0.294
C6	0.193	0.307	0.193	0.307
C7	0.250	0.278	0.250	0.222
C8	0.284	0.225	0.225	0.265
C9	0.253	0.218	0.253	0.276
C10	0.250	0.250	0.231	0.269
C11	0.182	0.323	0.242	0.253
C12	0.278	0.167	0.278	0.278
C13	0.215	0.296	0.259	0.230
C14	0.226	0.269	0.301	0.204
C15	0.250	0.250	0.250	0.250
C16	0.207	0.287	0.276	0.230
C17	0.167	0.300	0.233	0.300
C18	0.200	0.300	0.200	0.300

Table 5. Comprehensive evaluation matrix

Index	Comprehensive evaluation value	Index	Comprehensive evaluation value
C1	[0.777, 0.806], [0.000, 0.074]	C10	[0.627, 0.688], [0.000, 0.094]
C2	[0.676, 0.780], [0.000, 0.088]	C11	[0.660, 0.751], [0.000, 0.150]
C3	[0.747, 0.833], [0.000, 0.079]	C12	[0.696, 0.785], [0.000, 0.125]
C4	[0.816, 0.904], [0.000, 0.058]	C13	[0.652, 0.772], [0.000, 0.110]
C5	[0.567, 0.675], [0.000, 0.098]	C14	[0.566, 0.667], [0.000, 0.096]
C6	[0.656, 0.758], [0.062, 0.113]	C15	[0.615, 0.715], [0.050, 0.150]
C7	[0.752, 0.823], [0.000, 0.078]	C16	[0.819, 0.889], [0.000, 0.058]
C8	[0.680, 0.791], [0.000, 0.077]	C17	[0.837, 0.909], [0.000, 0.050]
C9	[0.553, 0.668], [0.000, 0.130]	C18	[0.650, 0.752], [0.050, 0.138]

The weight of the evaluation value offered by experts can be acquired by the similarity $s(r_{ij}, m_{ij})$ between evaluation value r_{ij} and mean average value m_{ij} pursuant to Formula (6). **Table 4** shows the weight of the evaluation values from the experts.

Formula (2) indicates that the evaluation values and corresponding weights offered by the experts will aggregate the evaluation value (**Table 5**).

The final evaluation value can be acquired by aggregating each index weight and comprehensive evaluation value:

$$\tilde{A}_1 = \langle [0.735, 0.809], [0.000, 0.080] \rangle$$

$$\tilde{A}_2 = \langle [0.634, 0.821], [0.000, 0.086] \rangle$$

$$\tilde{A}_3 = \langle [0.624, 0.716], [0.000, 0.097] \rangle$$

$$\tilde{A}_4 = \langle [0.629, 0.746], [0.000, 0.125] \rangle$$

$$\tilde{A}_5 = \langle [0.789, 0.869], [0.000, 0.071] \rangle$$

$$\tilde{A}_0 = \langle [0.691, 0.803], [0.000, 0.087] \rangle$$

The score function value of each layer can be calculated using Formula (8):

$S(B_1)$=0.732 $S(B_2)$=0.684 $S(B_3)$=0.621

$S(B_4)$=0.625 $S(B_5)$=0.794 S=0.704

Step 4. Results analysis. This study sets five levels of evaluation standards, namely, excellent, good, medium, bad, and worse. The corresponding score function values are 0.75, 0.65, 0.55, 0.45, and 0.35, respectively. The comprehensive evaluation value for the sustainability of water-based tourism project calculated by the score function is 0.704. The evaluation result is good, which means a favorable development of the sustainability of water-based tourism scenic spot.

The sub-item indexes provide the following evaluation values: economically sustainable development is 0.732 (result is good); environmentally sustainable development is 0.621 (medium); management of sustainable development is 0.625 (medium); and development condition sustainability is 0.794 (excellent). Hence, the performance of this water-based tourist spot is favorable in the economically and socially sustainable development and development condition suitability. However, the performance in the environmentally sustainable development and management of sustainable development is the same. The local government and management personnel of a water-based tourist spot should further their endeavor in environmental protection and scenic spot management to improve the environment and management efficiency and ensure the realization of a comprehensive sustainable development.

CONCLUSION

Water-based tourism is an important component of numerous tourism projects and a hot spot of tourism development as well. But the water-based tourism is fragile and easily affected by human activities, the sustainability of the area is considered inferior. From the sustainable development angle, the tourism development management department needs to regularly conduct evaluations on sustainable development of water-based tourism to find and solve problems in time, and to make sure water-based tourism projects developing favorably in the long term.

This study selects 18 indicators from the economy, society, environment, management, and development conditions to build the evaluation index system for the sustainable development of water-based tourism. The sustainable development evaluation model for water-based tourism based on IVIFS is constructed to overcome the fuzziness and the uncertainty of the index evaluation. The empirical study on a typical water-based tourist spot shows that a sustainable development evaluation index system for water-based tourism is applicable and operable. In addition, the results of the assignment, standard, and evaluation value calculation of the index weight coefficients are feasible. These results can provide a reference for the development of decision-making and management strategies for water-based tourism areas.

REFERENCES

Atanassov KT (1986) Intuitionistic Fuzzy Sets. Fuzzy Sets System, 20(1): 87-96.

Atanassov KT, Gargov G (1989) Interval valued intuitionistic fuzzy sets. Fuzzy Sets System, 31(3): 343-9.

Chen Z, Yang W (2011) A new multiple attribute group decision making method in intuitionistic fuzzy setting. Applied Mathematical Modelling, 35(9): 4424-37.

Da L (2013) Sustainable development model and countermeasure of water conservancy tourism in reservoir area-taking three gorges reservoir area as an example. Water Resources Development Research, 13(4): 76-9.

Das S, Dutta B, Guha D (2016) Weight computation of criteria in a decision-making problem by knowledge measure with intuitionistic fuzzy set and interval-valued intuitionistic fuzzy set. Soft Computing, 20(9): 3421-42.

Ding L, Wu XG (2013) Construction and application of water tourism resources evaluation index system. Economic Geography, 33(8): 183-87.

Ding L, Wu XG, Wang LC, Zhang JHA (2015) on the sustainable development evaluation of water tourism. Geographical Research, 34(3): 578-86.

Dong Q, Zhang L, Yu XD (2015) Construction Progress and Sustainable Development Countermeasure of Water Conservancy Scenic Spot. Water Resources Development Research, 15(11): 1-6.

Farhadinia B (2014) An efficient similarity measure for intuitionistic fuzzy sets. Soft Computing, 18(1): 85-94.

Feng WH (2010) Discussion on Sustainable Development of Water Conservancy Scenic Spot Based on Systematic View. Journal of Economics of Water Resources, 28(6): 57-60.

Huang CW, Lin KP, Wu MC, et al. (2015) Intuitionistic fuzzy c-means clustering algorithm with neighborhood attraction in segmenting medical image. Soft Computing, 19(2): 459-70

Kapp JF, Fijen APM, Zyl FV (1995) Towards a water management strategy for an environmentally sensitive and popular tourist region. Water Science and Technology, 32(5-6): 245-54.

Kharal A (2009) Homeopathic drug selection using intuitionistic fuzzy sets. Homeopathy, 98(1): 35-9.

Li DF (2005) Multiattribute decision making models and methods using intuitionistic fuzzy sets. Journal of Computer and System Sciences, 70(1): 73-85.

Li SX, Tian ZM (2012) Basic strategies of tourism development of Jianghan Canal waterfront. Journal of Capital Normal University: Natural Science Edition, 33(5): 50-5.

Li ZH, Ke XK, Zhou LF, et al. (2000) The appraisal system of beach tourism resources. Journal of Natural Resources, 15(3): 229-35.

Liao JH (2010) A Study on China's Water Conservation: Tourism and Environmental Protection. Ecological economy, (2): 301-7.

Liu GM, Yang XZ, Zhang LW (2011) An Analysis of the Tourism Spatial Structure of China's National Water Conservancy Scenic Spots. Journal of Hohai University (Philosophy and Social Sciences), 13(1): 49-53.

Papakostas GA, Hatzimichailidis AG, Kaburlasos VG (2013) Distance and similarity measures between intuitionistic fuzzy sets: a comparative analysis from a pattern recognition point of view. Pattern Recognition Letters, 34(14): 1609-22.

Xu ZS (2007) Methods for aggregating interval-valued intuitionistic fuzzy information and their application to decision making. Control & Decision, 22(2): 215-9.

Xu ZS, Chen J (2008) An overview of distance and similarity measures of intuitionistic fuzzy sets. International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 16(04).

Xu ZS, Yager RR (2006) Some geometric aggregation operators based on intuitionistic fuzzy sets. International Journal of General Systems, 35(4): 417-433.

Xu ZS, Yager RR (2009) Intuitionistic and interval-valued intuitionistic fuzzy preference relations and their measures of similarity for the evaluation of agreement within a group. Fuzzy Optimization & Decision Making, 8(2): 123-39.

Yu FL, Huang ZF, Shang ZY (2012) Value Connotation and Development Course and Running Status of Water Park. Economic Geography, 32(12): 169-75.