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EVALUATING THE COMPREHENSIVE IMPACTS OF TOURISM IN HAINAN BY INTERGRATING INPUT-OUTPUT MODEL WITH MCDM METHODS

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Abstract. To evaluate the comprehensive impacts of tourism in Hainan, this paper proposes an approach integrating input-output (IO) model with multi-criteria decision making (MCDM) methods. Four steps are taken: (1) constructing an extended IO model that can separate out domestic and imported effects from the traditional IO system; (2) constituting a 3-level evaluation criteria hierarchy based on various tourism multipliers obtained from the extended IO model; (3) calculating the weights of criteria using the entropy theory; (4) giving an evaluation of comprehensive impacts of tourism based on four MCDM methods – WSM, TOPSIS, ELECTRE, and PROMETHEE. Using Hainan 2002, 2007, and 2012 IO tables as database, the proposed approach is implemented in the empirical study of Hainan. The results show economic dimension is the most important consideration and the overall performance of tourism in Hainan shows a trend of first increasing and then decreasing from 2002 to 2012. Two types sensitivity analysis of weights show single criterion weight change has little influence on the results. But it is different when four dimensions weights change. Especially, when the environmental dimension is valued, the overall performance gets worse annually. These findings can offer insightful policies for the development of Hainan's tourism.

Keywords: comprehensive evaluation, tourism, input-output model, multi-criteria decision making, Hainan.

JEL Classification: D57, D81, L83, O11.

Introduction

Hainan, situated in the southern of China, is an unique province with tropical islands in China. Due to its pleasant climate resources, rich marine and coastal landscape, unique tropical virgin forest and good location conditions, Hainan has become the most popular

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tourism destination in China. In order to further promote the development of Hainan's tourism, Chinese governments have provided many favorable policies. In 2009, China State Council decided to build Hainan as the first international tourist island in China. In 2018, China's State Council continued to strengthen its policy support for the construction of Hainan international tourism island and built Hainan as the China Pilot Free Trade Zone to simplify administrative procedures for customs clearance, yacht management and enhanced trade in tourism services. Furthermore, China's national leaders have further decided to build Hainan into an international tourist consumption center in 2018. Clearly, these policies worked in attracting tourists arrivals. Statistics showed that the total tourist arrivals in 2019 in Hainan were 83.14 million, tourism income were 105 billion yuan, which accounted for 19.78% of the GDP of Hainan, indicating that tourism sector has become a pillar industry in Hainan (Hainan Provincial Bureau of Statistics & National Bureau of Statistics Hainan Investigation Team, 2019d). Tourism has played an indispensable role in the economic development of Hainan.

However, many scholars doubt the achievements of tourism development in Hainan. Wang and Liu (2013) used the high-resolution remote sensing and detailed socioeconomic data to show that tourism-led development has greatly changed land-use patterns, resulting in landscape fragmentation, vegetation degeneration, and coastal erosion in Hainan. Zhang et al.(2001) indicated the booming of tourism harmed the local landscape and environment in Hainan. Furthermore, on September 2014, the National Development and Reform Commission (NDRC) of China gave a low evaluation to Hainan as the international tourism island, mainly because the proportion of the international tourists is low, and the tourism environment and management have a big gap. Beyond that, someone claimed Hainan consumed substantial amounts of energy and emitted lots of greenhouse gas to support the economic benefits of tourism, but they could not provide favorable evidence to support their opinion. Therefore, what is the actual situation of the development of tourism in Hainan? It is urgent to give a comprehensive evaluation about the impacts of tourism industry on Hainan's economy, environment, society and culture. However, researches on the tourism industry in China are insufficient, especially research on Hainan's tourism industry. Thus, this paper first attempts to give an evaluation of comprehensive impacts of tourism industry in Hainan, including economic and non-economic impacts simultaneously.

As for that investigating the economic and non-economic impacts from tourism in various regions, there are several effective analysis methods have been generally employed. These main methods can be generally classified into top-down and bottom-up approaches (Luo et al., 2018). The top-bottom approaches for tourism include input-output (IO) model and computable general equilibrium (CGE) model. The bottom-top approaches for tourism include a life cycle assessment and carbon footprint. In general, the bottom-top approach is more suited for small regions, but the top-bottom approach is suited to analyze tourism as a sector within a comprehensive national economic system. Compare the top-bottom approaches of IO and CGE, creating a social accounting matrix (SAM), the basis of CGE, needs a great deal of cost and time. And the indirect impacts cannot be calculated separately in CGE model. But the IO model is compiled based on the physical-monetary IO tables that are published by the National Statistics Bureau, and it can be relatively easily to compute the cumulative economic benefit and energy consumption (Li et al., 2019). Accordingly, there are numerous studies have calculated economic and environmental impacts from tourism expenditures based on IO model (Archer, 1995; Henry & Deane, 1997; Zhou et al., 1997; Pratt, 2011, 2015a, 2015b; Hanly, 2012; Sun & Pratt, 2014; Croes & Semrad, 2015; Frechtling & Horváth, 1999; Ferrari et al., 2018; Khoshkhoo et al., 2017; Liu et al., 2017; Lenzen et al., 2018).

On calculating the economic impacts of tourism, Fletcher (1989) claimed the usefulness of IO approach to calculate the economic impacts of tourism. It was indicated that compared with cost-benefit analysis, *hoc* multiplier, IO model is a general equilibrium approach which focus attention upon the sectoral interdependencies based on physical-monetary IO tables. The very nature of IO structure enables the researchers can calculate direct, indirect, and induced economic impacts of tourism, and makes policy makers with a neutral and comprehensive view of the tourism economy. Further evidences can be found in several studies. Archer (1995) measured the relative contribution of tourism to exports, incomes, employment, and public sector revenue in Bermuda based on 1985, 1987, and 1992 IO tables. Compared with other export sectors, tourism made a major contribution to economy in Bermuda. Henry and Deane (1997) calculated the contribution of tourism to GNP of Irich in 1990 and 1995 based on the IO model. They estimated international tourism showed a higher GNP impact than other aggregate exports of goods and services in Irich. Frechtling and Horváth (1999) employed the IO model to estimate multiplier effects of visitor expenditures in Washington, D. C. in 1994. It showed that businesses were generated by tourism spending for over 38,000 job in Washington, D. C. West and Gamage (2001) measured the relative contribution of four categories (day-tripper, intrastate, interstate, and international visitor) on the Victorian economy through relaxing the linearity assumption of IO model. The results indicated that in gross terms, day-trippers contributed the greatest amount to GDP, followed by interstate, intrastate, and international visitors in Victoria from 1993 to 1994. Kim et al. (2003) used IO model to assess the multiplier impacts of the convention industry in Korea. These authors founded that the convention industry is a high value-added export. Osterhaven and Fan (2006) manipulated the IO model and SAM model to calculate the contribution of international tourism on the economy of China in 1997. The results showed 1.6% of GDP is dependent on international tourism. Polo and Valle (2008) presented a comparison of the effect of a 10% reduction in tourists' expenditures on the Balearic economy using IO and CGE. They indicated that the results provided by IO model were close to CGE, and that the Dwyer, Foesyth, and Spurr's (2004) a prior dismissal of fixed-price models (i.e. IO model) seemed a bit hasty. Pratt (2011) used IO and CGE models to evaluate the economic importance of tourism to Hawaii at different stages of the Tourism Area Life Cycle (TALC) process. It was founded that the direct and indirect contributions to the destination increased and then plateaued as the value of the multipliers increased and then stabilized. Hanly (2012) employed the IO model to demonstrate there are strong output multiplier, income multiplier, value added multiplier, imported multiplier and product tax multiplier effects from the international association conference market to Ireland in 2007. Pratt (2015a) utilized the IO and CGE model to estimate multipliers effects for the tourism-oriented sectors in seven small islands and founded that transportation is the sector with strongest forward and backward linkage multiplier with other sectors. Pratt (2015b) provided a cross province comparative analysis of impact multipliers to examine China's relative potential for benefiting from tourism. Ferrari et al. (2018) identified the exogenous and endogenous linkage coefficients and impact multipliers of tourists' demand on the economic system of Tuscany in 2011 through the IO model. Artal-Tur et al. (2019) presented a newly regional IO model to compute the indirect and induced effects of cruise tourism in the Port of Cartagena, Spain, which obtained the direct effects from survey data.

When the positive impacts of tourism on economy is gradually confirmed by above previous studies, many authors almost at the same time started a lot of researches to measure the GHG emission impacts of tourism on regional environmental climate change. Leontief (1974) developed an environmental extended IO (EEIO) accounting framework. Tabatchnaia-Tamirisa et al. (1997) estimated the direct and indirect energy consumption by tourists of Hawaii based on the EEIO model and the flow data of Hawaii IO table in 1987. Konan and Chan (2010) developed dataset methodologies to integrate emission coefficients for three greenhouse gases (CO_2, CH_4, NO_2), and estimated domestic greenhouse gas (GHG) emission associated with the visitor expenditure in Hawaii based on EEIO accounting framework. But the limitation of the methodologies for obtaining GHG emission coefficients made it only applicable to Hawaii not to other regions. In order to solve it, Intergovernmental Panel on Climate Change [IPCC] provided a standard international emission coefficient accounting framework (IPCC, 1997). Hence, Liu et al. (2011) calculated the domestic direct and indirect carbon dioxide emissions of tourism industry in Chengdu of China based on IPCC report 2007. More than that, these authors provided a decomposition analysis to identify five key factors causing the change of carbon dioxide emission in tourism: energy intensity, visitor expenditure size, industry size, energy mix, and consumption structure. But another limitation of these analysis had inability to measure GHG emission from the tourism's imported goods and service. Aware of this, Sun (2014) made an assumption that imported goods were produced under the same technology procedures as domestic goods and measured the carbon footprint of domestic tourism sectors, international aviation, and imports in Taiwan based on EEIO and TSA model. Learning from the research of Sun (2014), Cadarso et al. (2015) developed an IO model to quantify the carbon footprint linked to residents' and visitors' tourist consumption in the Spanish economy between 1995 and 2007. In order to measure the GHG emission from tourism more precisely, Cadarso et al. (2016) proposed a newly measure method, called the whole carbon footprint, to broade the concept of tourism's carbon footprint to include not only emissions embodied in tourism consumption but also emissions linked to the investments of the tourism sector. Since tourism is not tradition sector in the system of national accounts in China, Meng et al. (2016) established a national tourism satellite account by integrating the tourism satellite account (TSA), and quantified direct and indirect carbon dioxide emissions of the Chinese tourism industry based on the IO model. Except for focusing on the single relationship between visit and environmental, Sun (2016) proposed an analytical framework to decompose national tourism carbon footprint and carbon efficiency over time from both economic and environmental perspectives in Taiwan based on TSA and EEIO model. In order to improve the accuracy of carbon emission measurement, Liu et al. (2017) established a detailed consumption list based on household survey data and calculated the carbon emissions of accommodation and services of the rural tourism industry of Mount Qingcheng using the IO model and life cycle methods. Li et al. (2019) estimated the economic benefit and CO_2 emission of tourism in Beijing based on the EEIO and TSA models, and indicated the balance between economic benefit and environmental pollution leans towards the side of high-income and low-emission. Since previous studies have provided many evidences of carbon effects range from national analysis to regional analysis, but global carbon emission associated with tourism has not been well estimated. So Lenzen et al. (2018) quantified tourism-related global carbon flows between 160 countries.

Previous studies have made contributions to quantify the economic benefit and GHG emission generated by the tourism sectors at macro-level. But there still are some weaknesses. First, these authors indicated that it is necessary to compute direct and overall effects of tourism expenditures at a national and regional level by using multiplier analysis. But most studies usually analyzed the tourism sectors as a package, while few studies focused on the estimation of import and export from international tourism on economy. Second, previous studies on the economic and environmental impacts of tourism were isolated from each other. Few studies analyzed overall impacts of tourism development simultaneously considering economic and non-economic impacts (especially like the environmental, social and cultural impacts). Third, previous papers have not given clear calculation steps in quantifying these economic benefits and GHG emissions. Thus, it is very difficult for other scholars to refer in the future. Last, although there are numerous studies that have explored the economic or environment impacts of tourists, to the best of our knowledge, studies regarding the comprehensive evaluation about economic and non-economic impacts simultaneously from tourism in Hainan are still lacking. Therefore, in order to fill in these literature gaps, this paper intends to evaluate comprehensive impacts of tourism from four perspectives of economic, environmental, social, and cultural impacts in Hainan.

In this regard of comprehensive evaluation, multi-criteria decision making (MCDM) method, whose aim is to rank or select alternatives based on their evaluation information associated with multiple criteria (Liu et al., 2019), is an effective approach. It has been widely used in many areas of tourism, such as tourism destination competitiveness evaluation (Zhang et al., 2011; Alptekin & Buyukozkan, 2011), hotel selection (Li et al., 2013; Yu et al., 2017; Aksoy & Ozbuk, 2017), tourism industry evaluation (Huang & Peng, 2012), tourism leisure site location (Pourahmad et al., 2015), travel intermediary evaluation (Lin et al., 2009), heritage tourism performance evaluation (Peng & Tzeng, 2019), visitor satisfaction evaluation for theme park (Cheng et al., 2016), and service position of package tour services (Lin & Kuo, 2019) and so on. Common used MCDM approaches include: AHP (Analytic Hierarchy Process) (Saaty, 1981, 2013), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) (Yoon & Hwang, 1981), PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) (Behzadian et al., 2010; Brans & Vincke, 1985), ELECTRE (Elimination and Choice Translating Reality) (Rogers & Bruen, 1998), VIKOR (Visekriterijumsko Kompromisno Rangiranje) (Opricovic & Tzeng, 2004), WSM (Weighted Sum Method) (Marler & Arora, 2010), and so on. Several comprehensive comparative of these MCDM have been conducted in literature (Karni et al., 1990; Wallenius et al., 2008; Kabak & Ervural, 2017). These literature indicated that each MCDM method had its advantages and disadvantages as well as application fields; none of these methods dominate other methods. More than one method can be used to solve the same multi-criteria decision problem and provide more robust decision information (Lee & Chang, 2018). But with the respect of the comprehensive evaluation integrating MCDM with IO models, there are very few studies. Ahmadi et al. (2014) used IO model to calculate emissions of five emission pollution and then employed the TOPSIS technique to determine the pollution levels of the Kyoto Protocol. Khalid and Ali (2019) employed the IO model and PROMETHEE to estimate the economic impacts caused by the flood disaster in Pakistan. Sanaú et al. (2020) assessed the suitability of public investment projects based on the IO model and AHP approach. And there is a lack of comprehensive evaluation on the impacts of tourism integrating IO model with more than one MCDM methods.

Therefore, in order to fill in these literature gaps, this paper originally proposes an approach integrating IO model with four MCDM methods (WSM, TOPSIS, ELECTRE, PROMETHEE) to evaluate the comprehensive impacts of tourism considering four dimensions, including economic contribution, environment pollution, social welfare, and cultural impacts from tourist activities in Hainan. This study firstly tries to calculate the domestic, imported, direct, and indirect impacts of tourism sector on economy, environment, society, and culture of Hainan using extended IO model. Then with four MCDM technique, WSM, TOPSIS, ELECTRE, and PROMETHEE, the comprehensive evaluation of tourism sector in Hainan will be determined. The remainder of this paper is organized as follows. Section 1 describes the formulation process of the proposed methodology. The empirical data and results are reported and discussed in Section 2. Section 3 is devoted to analyze sensitivity analysis caused by the changes of weights. Last section makes some conclusion and political recommendations for the development of Hainan tourism.

1. Methodology

In this section, an approach integrating IO model with MCDM methods is formulate to evaluate the comprehensive impacts of tourism consider four dimension impacts of economy, environment, society, and culture in Hainan. According, as illustrated in Figure 1, the analytical framework includes four components: constructing an extended IO mathematics framework, constituting a 3-level evaluation criteria hierarchy, calculating the weights of criteria based on the entropy theory, aggregating the comprehensive impacts of tourism based on four MCDM methods.

1.1. Constructing an extended IO mathematics framework

Currently, there is no special imported accounting framework for tourism sector in traditional IO model proposed by Leontief (1936). The domestic and imported effects of tourism sector can not be separated out precisely. Although Sun (2014) has made a contribution in calculating the domestic and imported CO_2 emission of tourism, but the issue of the leakage of the tourism foreign exchange through the international trade is less discussed. Therefore, it is a critical step to construct an extended IO model mathematics framework that can estimate domestic, imported, direct, and indirect impacts of tourism sector on economy, environment,

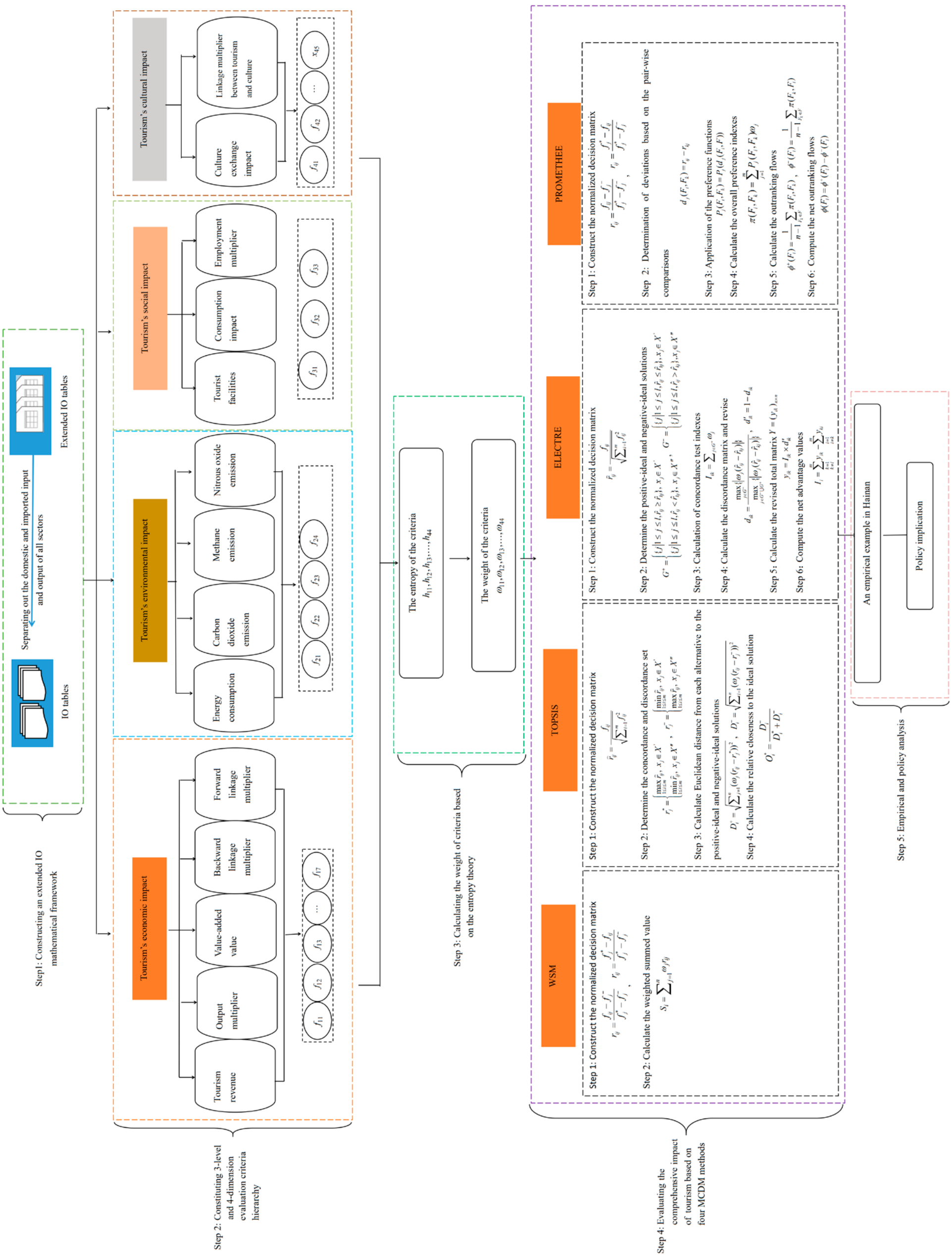

Figure 1. Analytical framework for the comprehensive impacts of tourism sectors

society, and culture. As depicted as in Table 1, the linear equation balance of traditional IO model can be expressed as Eqs (1)–(2):

$$x_i = \sum\nolimits_{j=1}^{n} x_{ij} + y_i; \quad (1)$$

$$x_j = \sum\nolimits_{i=1}^{n} x_{ij} + v_j. \quad (2)$$

In the matrix notation, Eqs (1) and (2) can be rewritten as follows:

$$\boldsymbol{X} = \boldsymbol{AX} + \boldsymbol{Y}, \quad \boldsymbol{X}^T = \boldsymbol{A}_c \boldsymbol{X}^T + \boldsymbol{V}, \quad (3)$$

where $\boldsymbol{X} = (x_i)_{n\times1}$ is the column vector of the total output of n $(n \in N, n > 1)$ number of sectors. $\boldsymbol{A} = (a_{ij})_{n\times n}$ is the technology coefficient matrix which shows the proportion of input that each sector must purchase in order to produce one unit of output, where $a_{ij} = {x_{ij}}/{x_j}$. $\boldsymbol{Y} = (y_i)_{n\times1}$ refers to the column vector of the final demand, which equals to the sum of final consumption $\boldsymbol{C} = (c_i)_{n\times1}$, the capital formation $\boldsymbol{IN} = (in_i)_{n\times1}$, net exports $\boldsymbol{EX} - \boldsymbol{M} = (ex_i - m_i)_{n\times1}$, and net inter-regional transfer $\boldsymbol{OP} - \boldsymbol{INP} = (op_i - inp_i)$, i.e. $\boldsymbol{Y} = \boldsymbol{C} + \boldsymbol{IN} + (\boldsymbol{EX} - \boldsymbol{M}) + (\boldsymbol{OP} - \boldsymbol{INP})$, where ex_i, m_i, op_i and inp_i are the export, import, inter-regional transfer out and in of the ith sector, respectively. $\boldsymbol{X}^T = (x_j)_{1\times n}$ is the row vector of the total input. $\boldsymbol{V} = (v_j)_{1\times n}$ is the row vector of the value-add, which is composed of the depreciation of the fixed assets $\boldsymbol{D} = (d_j)_{1\times n}$, wages $\boldsymbol{W} = (w_j)_{1\times n}$, net taxes $\boldsymbol{T} = (t_j)_{1\times n}$ and profits $\boldsymbol{P} = (p_j)_{1\times n}$, i.e. $\boldsymbol{V} = \boldsymbol{D} + \boldsymbol{W} + \boldsymbol{T} + \boldsymbol{P}$. $\boldsymbol{A}_c(t)$ can be expressed as follows:

$$\boldsymbol{A}_c = \begin{pmatrix} \sum\nolimits_{i=1}^{n} a_{i1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sum\nolimits_{i=1}^{n} a_{in} \end{pmatrix}.$$

Due to that total output of a sector equals to its total input, so $x_i = x_j$, if and only if $i = j$. Using the matrix transform method, Eq. (3) can be rewritten as

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1} \boldsymbol{Y}, \quad (4)$$

where I is an identity matrix, $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is the well-known Leontief-inverse matrix.

In order to separate out the domestic and imported input and output of tourism sector, we extend traditional IO Table 1 into Table 2. The domestic products are marked by d, the imported products are marked m.

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A}^d)^{-1} \boldsymbol{Y}^d; \quad (5)$$

$$\boldsymbol{M} = (\boldsymbol{I} - \boldsymbol{A}^m)^{-1} \boldsymbol{Y}^m, \quad (6)$$

where $\boldsymbol{A}^d = (a_{ij}^d)_{n\times n}$ and $\boldsymbol{A}^m = (a_{ij}^m)_{n\times n}$ are domestic and imported consumption coefficients matrix, respectively. $\boldsymbol{Y}^d = (y_i^d)_{n\times1}$ is the domestic final demand which equals to the sum of the domestic consumption $\boldsymbol{C}^d = (c_i^d)_{n\times1}$, the domestic capital formation $\boldsymbol{IN}^d = (in_i^d)_{n\times1}$, net export $\boldsymbol{EX}^d = (ex_i^d)_{n\times1}$, and net inter-regional transfer $\boldsymbol{OP} - \boldsymbol{INP} = (op_i - inp_i)$, i.e. $\boldsymbol{Y}^d = \mathbf{C}^d + \boldsymbol{IN}^d + \boldsymbol{EX}^d + (\boldsymbol{OP} - \boldsymbol{INP})$. Correspondingly, the final demand satisfied by imported product $\boldsymbol{Y}^m = (y_i^m)_{n\times1}$ equals to the sum of final consumption $\boldsymbol{C}^m = (c_i^m)_{n\times1}$, capital formation $\boldsymbol{IN}^m = (in_i^m)_{n\times1}$, and entrepot export $\boldsymbol{EX}^m = (ex_i^m)_{n\times1}$. That is $\boldsymbol{Y}^m = \boldsymbol{C}^m + \boldsymbol{IN}^m + \boldsymbol{EX}^m$, where $ex_i(t) = ex_i^d(t) + ex_i^m(t)$, $x_j = \sum\nolimits_{i=1}^{n} a_{ij}^d x_i + \sum\nolimits_{i=1}^{n} a_{ij}^m x_j + v_j$. Since the input-output relationship of imports among sectors is not reflected in China's input-output accounting system, referring to Lin et al. (2019), so we assume imported product are homogeneous with domestic products. The input-output relationship of imports can be obtained approximately as follows.

$$\frac{y_i^m}{m_i}=\frac{y_i}{x_i},\quad \frac{x_{ij}^m}{\sum_{j=1}^{n}x_{ij}^m}=\frac{x_{ij}}{\sum_{j=1}^{n}x_{ij}},\quad \frac{c_i^m}{y_i^m}=\frac{c_i}{y_i},\quad \frac{in_i^m}{y_i^m}=\frac{in_i}{y_i},\quad \frac{ex_i^m}{y_i^m}=\frac{ex_i}{y_i}.$$

Table 1. Simplified regional input-output table

		Intermediate demand	Final demand					Imports	Inter-regional transfer in	Total output
		$1,2,\cdots,n$	Consumption	Capital formation	Exports	Inter-regional transfer out	Total			
Intermediate input	$1,2,\cdots,n$	x_{ij}	c_i	in_i	ex_i	op_i	y_i	m_i	inp_i	x_i
Depreciation of fixed assets		d_j								
Wages & salaries		w_j								
Net taxes on production		t_j								
Profits & dividends		p_j								
Value added		v_j								
Total input		x_j								

Table 2. Extended regional input-output table

		Intermediate demand	Final demand					Imports	Inter-regional transfer in	Total output
		$1,2,\cdots,n$	Consumption	Capital formation	Exports	Inter-regional transfer out	Total			
Domestic intermediate input	$1,2,\cdots,n$	x_{ij}^d	c_i^d	in_i^d	ex_i^d	op_i	y_i^d		inp_i	x_i
Imported intermediate input	$1,2,\cdots,n$	x_{ij}^m	c_i^m	in_i^m	ex_i^m		y_i^m	m_i		
Depreciation of fixed assets		d_j								
Wages & salaries		w_j								
Net taxes on product		t_j								
Profits & dividends		p_j								
Value added		v_j								
Total input		x_j								

1.2. Constituting a 3-level evaluation criteria hierarchy

Based on the extended IO mathematics framework constructed in step 1, various domestic, imported, direct, and indirect multipliers of tourism sectors can be calculated. Using these multipliers, a 3-level evaluation criteria hierarchy can be constituted in this paper as shown in Table 3 in detail. It includes three hierarchy, four dimensions, and 63 criteria. The four dimensions are economic criteria (ς_1), environmental criteria (ς_2), social criteria (ς_3) and cultural criteria (ς_4).

1.2.1. Economic criteria

Tourism revenue: Tourist consumption in tourism destination, such as accommodation, transportation, catering, entertainment, purchasing and so on, will generate revenue for tourism destination. When one industry's output value exceeds five percentage of regional gross domestic product, it can be regarded as a pillar industry in China. In order to reflect the real situation of tourism income in destination's economy, we use domestic, inbound and total tourism revenue at same consumer price index to reflect the changes of tourism revenue.

Direct output multiplier: This criterion describes the impact of the final output of the tourism sector on the production and service of all sectors of the social and economic system. Let's denote the domestic Leontief inverse matrix $(\boldsymbol{I}-\boldsymbol{A}^d)^{-1}$ as the matrix $\boldsymbol{u}=(u_{ij})_{n\times n}$, direct output multiplier of tourism sector can be calculated by Eq. (7), which equals to the column sum of domestic Leontief inverse matrix (Fletcher, 1989):

$$u_j = \sum_{i=1}^{n} u_{ij}, \tag{7}$$

where u_j is the direct output multiplier of the jth tourism sector, it shows the impact of final output of the tourism on other sectors.

Indirect output multiplier: As the direct output multiplier only reflects the correlation among sectors, ignoring the pulling effect of household and government consumption on the economy. In order to calculate the effect of household and government consumption on the output of sectors, the $n\times n$ domestic consumption coefficients matrix $\boldsymbol{A}^d$ should be extended to corresponding $(n+1)\times(n+1)$ domestic consumption coefficients matrix by adding the consumption coefficient vector in column and adding a zero vector in row as follows:

$$\hat{\mathbf{A}}^d = \begin{pmatrix} a_{11}^d & a_{12}^d & \cdots & a_{1n}^d & c_1^d/x_1 \\ a_{21}^d & a_{22}^d & \cdots & a_{2n}^d & c_2^d/x_2 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ a_{n1}^d & a_{n2}^d & \cdots & a_{nn}^d & c_n^d/x_n \\ 0 & 0 & \cdots & 0 & 0 \end{pmatrix}.$$

The indirect output multiplier of tourism sector equals to the column sum of extended Leontief-inverse matrix $(\hat{\boldsymbol{I}}-\hat{\boldsymbol{A}}^d)^{-1}$, denoted by the matrix $\boldsymbol{u}^* = (u^*)_{(n+1)\times(n+1)}$, which can be expressed as Eq. (8):

$$u_j^* = \sum_{i=1}^{n} u_{ij}^*, \tag{8}$$

where $\hat{\boldsymbol{I}}$ is $(n+1)\times(n+1)$ identity matrix.

Direct value-added multiplier of tourism: This criterion shows the contribution in employment, tax revenue and capital formation brought about by each unit input of tourism sector. Direct value-added multiplier of tourism equals to the tourism sectoral value-added coefficients (Kim et al. 2003). Let $\boldsymbol{A_V}$ be the value-added coefficients diagonal matrix, the diagonal elements of $\boldsymbol{A_V}$ equal to the proportions of the value-added in the total output:

$$\boldsymbol{A_V} = diag(a_{v_1}, a_{v_2}, \ldots, a_{v_n}) = \begin{pmatrix} a_{v_1} & 0 & \cdots & 0 \\ 0 & a_{v_2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & a_{v_n} \end{pmatrix} = \begin{pmatrix} {}^{v_1}\!/_{x_1} & 0 & \cdots & 0 \\ 0 & {}^{v_2}\!/_{x_2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & {}^{v_n}\!/_{x_n} \end{pmatrix},$$

when the *j*th sector is tourism sector, a_{v_j} is the direct value-added multiplier of tourism sector.

Indirect value-added multiplier of tourism: The value-added of sectors equals to the product of the value-added coefficients and total output of sectors, which can be expressed as follows:

$$\boldsymbol{V} = \boldsymbol{A_V X}. \tag{9}$$

Based on Eq. (5), Eq. (9) can be rewritten as follows:

$$\boldsymbol{V} = \boldsymbol{A_V}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}\boldsymbol{Y}^d. \tag{10}$$

The indirect value added of tourism sector equals to the diagonal elements the product of the value-added coefficient diagonal matrix and the domestic Leontief inverse matrix, which can reflect the correlation between the value-added of sectors.

Value-added of tourism export trade: According to $\boldsymbol{Y}^d = \boldsymbol{C}^d + \boldsymbol{IN}^d + \boldsymbol{EX}^d + (\boldsymbol{OP} - \boldsymbol{INP})$, Eq. (10) is equivalent to Eq. (11):

$$\boldsymbol{V} = \boldsymbol{A_V}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}(\boldsymbol{C}^d + \boldsymbol{IN}^d + \boldsymbol{EX}^d + (\boldsymbol{OP} - \boldsymbol{INP})). \tag{11}$$

The valued-added brought by export of sectors can be obtained by Eq. (12):

$$\boldsymbol{V}^{EX} = \boldsymbol{A_V}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}\boldsymbol{EX}^d, \tag{12}$$

where $\mathbf{V}^{EX} = (v_i^{ex})_{n\times 1}$ is the value-added matrix of export. In order to analyze the relationship between export structure of each sector and value-added. Eq. (12) can be rewritten according to the meaning of each matrix. Let $\boldsymbol{EX}^D$ be the diagonal matrix of export wiped off the entrepot trade:

$$\boldsymbol{EX}^D = \begin{pmatrix} ex_1^d & 0 & \cdots & 0 \\ 0 & ex_2^d & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & ex_n^d \end{pmatrix}.$$

Eq. (12) can be rewritten in another matrix form in Eq. (13):

$$\widehat{\boldsymbol{V}}^{EX} = \boldsymbol{A_V}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}\boldsymbol{EX}^D. \tag{13}$$

The elements of matrix $\widehat{\boldsymbol{V}}^{EX} = (\widehat{v}_{ij}^{ex})_{n\times n}$ represent the value-added of the *i*th sector brought by the export of the *j*th sector. According to the relationship between matrix elements, it is known that the row sum of matrix $\widehat{\boldsymbol{V}}^{EX}$ equals to the element of the matrix $\boldsymbol{V}^{EX}$. The value-added of export trade of the jth tourism sector equals to the jth column sum of the matrix $\widehat{\boldsymbol{V}}^{EX}$.

The contribution rate of value-added of tourism output and trade: Based on Eqs (9)–(13), the contribution rate of the value-added of tourism sector to the local economy can be calculated as follows as Eqs (14)–(15):

$$\eta_j = \frac{v_j}{\sum_{j=1}^{n} v_j}; \tag{14}$$

$$\eta_j^{ex} = \frac{\sum_{i=1}^{n} \widehat{v}_{ij}^{ex}}{\sum_{j=1}^{n}\sum_{i=1}^{n} \widehat{v}_{ij}^{ex}}, \tag{15}$$

where η_j represents the contribution rate of the value-added brought by total output of the jth tourism sector to local economy, η_j^{ex} is the contribution rate of the value-added brought by export of the jth tourism sector to local economy.

Domestic and imported direct backward linkage multiplier: These criteria measure the relative importance of tourism sector as a purchaser to all other sectors in the economy (Fletcher, 1989). The higher the backward linkage multiplier, the stronger the driving effect of tourism sector to other sectors. Backward linkage multiplier includes direct and indirect backward linkage multiplier. Direct backward linkage multiplier of tourism sector equals to the column sum of the consumption coefficients matrix $\boldsymbol{A}$, which can be expressed as Eq. (16) (Pratt, 2011):

$$a_j = \sum_{i=1}^{n} a_{ij}, \tag{16}$$

where a_j is the total backward linkage multiplier of the jth tourism sector. Considering the international trade in tourism, direct backward linkage multiplier can be divided into domestic and imported backward linkage multiplier. Domestic and imported direct backward multiplier of tourism sector can be obtained from the the column sum of the domestic and imported consumption coefficients matrix respectively, which can be expressed as Eq. (17):

$$a_j^d = \sum_{i=1}^{n} a_{ij}^d, \quad a_j^m = \sum_{i=1}^{n} a_{ij}^m, \tag{17}$$

where a_j^d and a_j^m are domestic and imported backward linkage multipliers of the jth tourism sector, respectively.

Domestic and imported indirect backward linkage multiplier: Considering the comprehensive pulling effect of tourism sector to other all corresponding sectors, indirect backward linkage multiplier of tourism sector equals to the column sum of the completed consumption coefficient matrix, which can be expressed as Eq. (18):

$$b_j = \sum_{i=1}^{n} b_{ij}, \tag{18}$$

where b_{ij} is the elements of the completed consumption coefficient matrix $\boldsymbol{B} = (b_{ij})_{n\times n}$:

$$\boldsymbol{B} = (\boldsymbol{I} - \boldsymbol{A})^{-1} - \boldsymbol{I}.$$

Similarly, domestic and imported indirect backward linkage multipliers of tourism sector equal to column sum of the domestic and imported completed consumption coefficient matrix respectively, which can be expressed as Eq. (19).

$$b_j^d = \sum_{i=1}^{n} b_{ij}^d, \;\; b_j^m = \sum_{i=1}^{n} b_{ij}^m, \tag{19}$$

where b_{ij}^d and b_{ij}^m represent domestic and imported completed consumption coefficients, respectively:

$$\boldsymbol{B}^d = (\boldsymbol{I} - \boldsymbol{A}^d)^{-1} - \boldsymbol{I}, \;\; \boldsymbol{B}^m = (\boldsymbol{I} - \boldsymbol{A}^m)^{-1} - \boldsymbol{I}.$$

Domestic and imported direct forward linkage multiplier: These criteria measure the relative importance of each sector as a supplier to other sectors in the economy. It includes direct and indirect forward linkage multipliers. Direct forward linkage multiplier equals to the row sum of direct distribution coefficient matrix, which refers to the supporting effects of the tourism sector to other all corresponding sectors, which can be expressed as Eq. (20) (Pratt 2015b).

$$h_i = \sum_{j=1}^{n} h_{ij}, \tag{20}$$

where h_i is total direct forward linkage multiplier of the ith tourism sector, h_{ij} is total direct distribution coefficient, the element of direct distribution coefficient matrix $\boldsymbol{H} = (h_{ij})_{n \times n}$.

$$h_{ij} = \frac{x_{ij}}{x_i + inp_i + m_i}.$$

Considering the international tourism trade, domestic and imported direct forward linkage multiplier of tourism sector can be calculated by the row sum of domestic and imported direct distribution coefficient matrix by Eq. (21):

$$h_i^d = \sum_{j=1}^{n} h_{ij}^d, \;\; h_i^m = \sum_{j=1}^{n} h_{ij}^m, \tag{21}$$

where h_i^d and h_i^m are domestic and imported direct forward linkage multipliers of the ith tourism sector, respectively. h_{ij}^d and h_{ij}^m are domestic and imported direct distribution coefficients, which are the elements of domestic and imported direct distribution coefficient matrix $\boldsymbol{H}^d = (h_{ij}^d)_{n \times n}$ and $\boldsymbol{H}^m = (h_{ij}^m)_{n \times n}$, respectively.

$$h_{ij}^d = \frac{x_{ij}^d}{x_i + inp_i}, \;\; h_{ij}^m = \frac{x_{ij}^m}{m_i}.$$

Domestic and imported indirect forward linkage multiplier: To reflect the comprehensive supporting effects of the tourism sector to other all corresponding sectors, indirect forward backward linkage multiplier equals to the row sum of indirect distribution coefficient matrix, which can be expressed by Eq. (22):

$$w_i = \sum_{j=1}^{n} w_{ij}, \tag{22}$$

where $\boldsymbol{W} = (w_{ij})_{n \times n}$ is the indirect distribution coefficient matrix $\boldsymbol{W}$.

$$\boldsymbol{W} = (\boldsymbol{I} - \boldsymbol{H})^{-1} - \boldsymbol{I}.$$

Alike that, domestic and imported indirect forward linkage multipliers of tourism sector can be derived from the row sum of indirect distribution coefficient matrix, which can be expressed by Eq. (23):

$$w_i^d = \sum_{j=1}^{n} w_{ij}^d, \quad w_i^m = \sum_{j=1}^{n} w_{ij}^m, \tag{23}$$

where w_i^d and w_i^m are domestic and imported indirect forward linkage multipliers of the ith tourism sector, respectively. w_{ij}^d and w_{ij}^m are domestic and imported indirect distribution coefficients, which are the elements of domestic and imported indirect distribution coefficient matrix $\boldsymbol{W}^d = (w_{ij}^d)_{n\times n}$ and $\boldsymbol{W}^m = (w_{ij}^m)_{n\times n}$, respectively.

$$\boldsymbol{W}^d = (\boldsymbol{I} - \boldsymbol{H}^d)^{-1} - \boldsymbol{I}, \ \boldsymbol{W}^m = (\boldsymbol{I} - \boldsymbol{H}^m)^{-1} - \boldsymbol{I}.$$

1.2.2. Environmental criteria

Domestic and imported energy consumption: These criteria refer to the amount of the energy consumption during tourism activities. Following the EEIO model (Leontief, 1974), energy consumption of a sector equals to the product of the energy consumption intensity per unit output and total output of a sector, which can be expressed by Eq. (24):

$$\boldsymbol{E} = \boldsymbol{\varepsilon}\boldsymbol{X}, \tag{24}$$

where $\boldsymbol{\varepsilon}$ is a $n\times n$ diagonal matrix of energy consumption coefficients, the diagonal elements of $\boldsymbol{\varepsilon}$ which express the energy consumption per unit output of sectors. In same framework, the energy consumption produced by producing domestic products can be obtained by equivalent transformation of $\boldsymbol{X}$ in Eq. (25) with Eq. (5):

$$\boldsymbol{E}^d = \boldsymbol{\varepsilon}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}\boldsymbol{Y}^d, \tag{25}$$

where $\boldsymbol{E}^d = (e_i^d)_{n\times 1}$ is the $n\times 1$ vector of all sectors' energy consumed by domestic product, the elements of $\boldsymbol{E}^d$ is the domestic energy consumption of the ith sector. Obviously, energy consumption implied in imports can be calculated by Eq. (26):

$$\boldsymbol{E}^m = \boldsymbol{\varepsilon}(\boldsymbol{I} - \boldsymbol{A}^m)^{-1}\boldsymbol{Y}^m, \tag{26}$$

where $\boldsymbol{E}^m = (e_i^m)_{n\times 1}$ is similar to the domestic energy consumption. So total energy consumption can be calculated as follows as Eq. (27) :

$$\boldsymbol{E} = \boldsymbol{E}^d + \boldsymbol{E}^m, \tag{27}$$

when the ith sector is tourism sector, e_i, e_i^d, and e_i^m are the total, domestic and imported energy consumption of tourism sector.

Domestic and imported carbon dioxide emission: These criteria refer to the amount of the CO_2 emissions during tourism activities. Total amount of carbon dioxide implied in the final demand equals to the sum of carbon dioxide emitted by domestic tourism products consumption and tourism inter-national and -regional exchange (Sun, 2014, 2016). In the same framework of the Leontief EEIO model, carbon dioxide emission equals to the product of the carbon dioxide emission coefficient per unit output and total output of a sector. Let $\boldsymbol{\alpha}$ be the CO_2 emission intensity coefficient diagonal matrix. The domestic CO_2 emission matrix

$G_{co}^{d} = (g_{co_i}^{d})_{n\times 1}$ can be calculated by Eq. (28):

$$G_{co}^{d} = \alpha (I - A^{d})^{-1} Y^{d}, \tag{28}$$

where $g_{co_i}^{d}$ is domestic CO_2 emission produced by the *i*th sector. Assuming that CO_2 emission intensity coefficients of domestic and imported products of a sector are identical. The imported CO_2 emission matrix $G_{co}^{m} = (g_{co_i}^{m})_{n\times 1}$ can be expressed as Eq. (29):

$$G_{co}^{m} = \alpha (I - A^{m})^{-1} Y^{m}, \tag{29}$$

where the diagonal elements of **α** equal to a ratio of total emissions to total output of a sector based on the report of IPCC (Liu et al. 2011, 2017; Wang & Liu, 2013).

$$\alpha = \begin{pmatrix} CO_1^d / x_1 & 0 & \cdots & 0 \\ 0 & CO_2^d / x_1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & CO_n^d / x_n \end{pmatrix},$$

where CO_i^d refers to the direct carbon dioxide emissions from economic activities of the *i*th sector, which equals to the product of the recommended emission factors and the economic activities intensity of a sector, which can be expressed by Eq. (30). Economic activities intensity refers to the energy consumption used by these economic activities, and the recommended emission factors is the product of the IPCC (Liu et al., 2011) original emission factor, national calorific value and carbon oxidation factor.

$$CO_i^d = \sum_{k=1}^{K} E_i^k \times P_i^k \times coe_i^k \times O_i^k \times 10^{-6} \times \frac{44}{12}, \tag{30}$$

where E_i^k, P_i^k, and O_i^k are the energy consumption, calorific value, and carbon oxidation factor of the *k*th energy used by the *i*th sector. coe_i^k is the IPCC initial carbon dioxide emission coefficient of the *k*th energy used by the *i*th sector. So the total carbon dioxide implied in final demand $G_{co} = (g_{co_i})_{n\times 1}$ can be expressed by Eq. (31):

$$G_{co} = G_{co}^{d} + G_{co}^{m}, \tag{31}$$

when the *i*th sector is tourism sector, g_{co_i}, $g_{co_i}^{d}$ and $g_{co_i}^{m}$ are the total, domestic and imported CO_2 emission of the tourism sectors.

Domestic and imported methane emission: These criteria refer to the methane emission, the other green house gas emission whose greenhouse effect is more 30 times than carbon dioxide. Similarly to the carbon dioxide emission. Let **β** be the methane emission coefficient diagonal matrix of sectors, CH_i^d, the direct methane from economic activities of the *i*th sector, can be obtained by Eq. (32):

$$\beta = \begin{pmatrix} CH_1^d / x_1 & 0 & \cdots & 0 \\ 0 & CH_2^d / x_1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & CH_n^d / x_n \end{pmatrix};$$

$$CH_i^d = \sum_{k=1}^{K} E_i^k \times P_i^k \times che_i^k \times 4186.8 \times 10^{-9} \times 10^{-6}, \quad (32)$$

where E_i^k and P_i^k are the same as the above, che_i^k is the IPCC initial methane emission coefficient of the kth energy used by the ith sector. Therefore, the total, domestic, imported methane emission matrix $\boldsymbol{G}_{ch} = (g_{ch_i})_{n\times1}$, $\boldsymbol{G}_{ch}^d = (g_{ch_i}^d)_{n\times1}$ and $\boldsymbol{G}_{ch}^m = (g_{ch_i}^m)_{n\times1}$ can be calculated as follows:

$$\boldsymbol{G}_{ch}^d = \boldsymbol{\beta}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}\boldsymbol{Y}^d, \ \boldsymbol{G}_{ch}^m = \boldsymbol{\beta}(\boldsymbol{I} - \boldsymbol{A}^m)^{-1}\boldsymbol{Y}^d, \ \boldsymbol{G}_{ch} = \boldsymbol{G}_{ch}^d + \boldsymbol{G}_{ch}^m,$$

when the ith sector is tourism sector, g_{ch_i}, $g_{ch_i}^d$, and $g_{ch_i}^m$ are the total, domestic and imported CH_4 emission of the tourism sector.

Domestic and imported nitrous oxide emission. Nitrous oxide is the substance that destroys the ozone layer which can be transported to the stratosphere. Similarly to the carbon dioxide and methane emission. Let $\boldsymbol{\theta}$ be the nitrous oxide emission coefficient diagonal matrix of sectors, NO_i^d be the direct nitrous oxide emission from economic activities of the ith sector, that is the diagonal elements of $\boldsymbol{\theta}$ can be calculated by NO_i^d / x_i, where $NO_i^d = \sum_{k=1}^{K} E_i^k \times P_i^k \times no_i^k \times 4186.8 \times 10^{-9} \times 10^{-6}$, no_i^k is the IPCC initial nitrous oxide emission coefficient of the kth energy used by the ith sector. Therefore, the total nitrous oxide emission matrix $\boldsymbol{G}_{no} = (g_{no_i})_{n\times1}$, domestic nitrous oxide emission matrix $\boldsymbol{G}_{no}^d = (g_{no_i}^d)_{n\times1}$, imported nitrous oxide emission matrix $\boldsymbol{G}_{no}^m = (g_{no_i}^m)_{n\times1}$ can be calculated by Eq. (33):

$$\boldsymbol{G}_{no}^d = \boldsymbol{\theta}(\boldsymbol{I} - \boldsymbol{A}^d)^{-1}\boldsymbol{Y}^d, \ \boldsymbol{G}_{no}^m = \boldsymbol{\theta}(\boldsymbol{I} - \boldsymbol{A}^m)^{-1}\boldsymbol{Y}^m, \ \boldsymbol{G}_{no} = \boldsymbol{G}_{no}^d + \boldsymbol{G}_{no}^m, \quad (33)$$

when the ith sector is tourism sector, g_{no_i}, $g_{no_i}^d$ and $g_{no_i}^m$ are the total, domestic and imported N_2O emission of the tourism sector, respectively.

1.2.3. Social criteria

Tourist facilities: This criterion refers to the social acceptance of the tourism, which is recognized as an important symbol of the tourism maturity. To some extent, the maturity of tourist facilities represents the local social acceptance. In this study, the maturity of tourist facilities can be measured by the total number of tourist hotels, hotel rooms, beds, room, travel agencies and occupancy rate. These data can be collected by statistics yearbook.

Direct employment remuneration coefficient: These criteria show the effects of one additional unit of tourism final demand upon the employment. Clearly, it is important for policymaker to be aware of the employment effects of anticipated changes in final demand, making the employment effects an important indicator (Fletcher, 1989). In this paper, specific criteria for measuring employment effect include direct and indirect employment remuneration coefficient. Among them, the direct employment remuneration coefficient of the jth sector can be calculated by Eq. (34):

$$v_j^w = w_j / x_j, \quad (34)$$

where w_j is the employment remuneration of the jth sector, x_j is the total input of the jth sector. When the jth sector is the tourism sector, v_j^w is the direct employment remuneration multiplier of tourism sector.

Indirect employment remuneration coefficient: Considering the correlation between sectors, the indirect employment remuneration coefficient of sectors can be derived from the indirect employment remuneration coefficient matrix $\boldsymbol{B}^w = (b_{ij}^w)_{n\times n}$ as follows:

$$\boldsymbol{B}^w = \boldsymbol{V}^w (\boldsymbol{I} - \boldsymbol{A}^d)^{-1},$$

where $\boldsymbol{V}^w$ is the employment remuneration coefficient diagonal matrix of sectors.

$$\boldsymbol{V}^w = \begin{pmatrix} {}^{w_1}\!/_{x_1} & 0 & \dots & 0 \\ 0 & {}^{w_2}\!/_{x_2} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & {}^{w_n}\!/_{x_n} \end{pmatrix}.$$

The indirect employment remuneration of the *j*th sector equals to the column sum of the indirect employment remuneration coefficient matrix, which can be expressed by Eq. (35):

$$b_j^w = \sum_{i=1}^{n} b_{ij}^w, \tag{35}$$

when the *j*th sector is tourism sector, b_j^w is the indirect employment remuneration multiplier of tourism sector.

Domestic and imported direct consumption coefficient: Tourism consumption is a high level consumption demand. It includes the direct and indirect consumption coefficients that show the stimulating effect brought by household consumption on the tourism production. Direct consumption coefficient can be obtained by Eq. (36):

$$\delta_i = c_i / x_i, \tag{36}$$

where δ_i is the direct consumption coefficient of the *i*th sector, c_i is the consumption satisfied by the *i*th sector, x_i is the output of the *i*th sector. Considering the international trade, direct consumption coefficient can be divided domestic and imported direct consumption coefficients, which can be expressed by Eq.(37):

$$\delta_i^d = c_i^d / x_i, \;\; \delta_i^m = c_i^m / x_i. \tag{37}$$

Domestic and imported indirect consumption coefficient: Indirect consumption effects of sectors can be derived from the indirect consumption coefficient matrix $\boldsymbol{B}^c = (b_{ij}^c)_{n\times n}$ as follows:

$$\boldsymbol{B}^c = \boldsymbol{\delta}(\boldsymbol{I} - \boldsymbol{A})^{-1},$$

where $\boldsymbol{\delta}$ is the direct consumption coefficient diagonal matrix of sectors. Similarly, domestic and imported indirect consumption coefficient matrix $\boldsymbol{B}^{cd} = (b_{ij}^{cd})_{n\times n}$, $\boldsymbol{B}^{cm} = (b_{ij}^{cm})_{n\times n}$ can be expressed as follow:

$$\boldsymbol{B}^{cm} = \boldsymbol{\delta}^m (\boldsymbol{I} - \boldsymbol{A}^m)^{-1}, \;\; \boldsymbol{B}^{cd} = \boldsymbol{\delta}^d (\boldsymbol{I} - \boldsymbol{A}^d)^{-1}.$$

The indirect consumption multiplier of a sector equals to the column sum of the indirect employment remuneration coefficient matrix, which can be expressed as Eq. (38):

$$b_j^c = \sum_{i=1}^{n} b_{ij}^c, \tag{38}$$

when the jth sector is tourism sector, b_j^c is the indirect consumption multiplier of tourism sector. b_j^{cd} and b_j^{cm} are the domestic and imported indirect multiplier of tourism sector, respectively.

$$b_j^{cd} = \sum_{i=1}^{n} b_{ij}^{cd}, \quad b_j^{cm} = \sum_{i=1}^{n} b_{ij}^{cm}. \tag{39}$$

1.2.4. Cultural criteria

The culture exchange impact: Inbound and outbound tourism can make different culture communicate with each other. It makes the regional culture to be understood, excavated, developed and protected. In this paper, we use the tourist reception number and nationality amount to reflect the culture exchange impact.

The linkage multiplier between tourism and culture: Tourism and culture both play an important role in image creation processes, providing a major rationale for the aesthetics of landscapes, as well as in shaping the environment to meet the needs of consumers. As culture is increasingly utilized as a means of social and economic development, the cultural tourism market is being flooded with new attractions, cultural routes and heritage (Richards & Wilson, 2006). The forward and backward linkage multiplier between tourism and culture can be calculated to reflect the support effect the cultural sector on the tourism-related sectors and the driving effect the tourism-related sectors on the culture sectors. They represent integration between the tourism sectors and culture sectors. As same as the linkage multipliers between tourism sectors and other sectors, the linkage multipliers between tourism and culture includes the domestic and imported direct and indirect forward linkage multipliers and the domestic and imported direct and indirect backward linkage multiplier. According to Eqs (16)–(23), when the ith sector is the culture sector and the jth sector is tourism sector, a_{ij}, a_{ij}^d, and a_{ij}^m are the total, domestic, and imported direct backward linkage multiplier between tourism and culture sector, respectively. b_{ij}, b_{ij}^d, and b_{ij}^m are the total, domestic, and imported indirect backward linkage multiplier between tourism and culture sector, respectively. h_{ij}, h_{ij}^d, and h_{ij}^m are the total, domestic, and imported direct forward linkage multiplier between tourism and culture sector, respectively. And w_{ij}, w_{ij}^d, and w_{ij}^m are the total, domestic, and imported indirect forward linkage multiplier between tourism and culture sector, respectively. The selected criteria can be shown in Table 3.

1.3. Calculating weight of criteria based on the entropy theory

After determine 63 criteria, it is a crucial step to measure the weights of criteria to perform the following MCDM analysis in Step 4. As for obtaining the criteria weights, there are several approaches. These approaches are usually divided into three categories: the subjective weight, objective weight, and integrated weight approaches (Dong et al. 2018). The subjective weight approach mainly depends on the knowledge and experience of experts to obtain the weights of criteria, for example, AHP and Delphi (Lee & Chang, 2018). The objective approach depends on statistical methods and measurement data. It mainly includes the entropy method. And the integrated approach mainly combines both decision makers' subjective information and objective decision matrix information. Entropy weight method is constructed based on the information entropy and the practical background of raw data, the advantage of which reduces the subjective impacts of decision makers and increases objectivity. Originally defined by Rudopy Clausius in 1865, entropy is a measure in thermodynamics of the unavailability of a system's energy to do work. Shannon (1948) first used the entropy to measure the uncertainty associated with a random variable in information theory. According to the entropy theory, the less the entropy value, the more information. Therefore, the criterion can be assigned a bigger weight (Lee & Chang, 2018). The concept of entropy weight has been employed in several fields. For example, Zhang et al. (2011) used the entropy weight to calculate indices' weights and employed TOPSIS to obtain the ranking order of tourism destination competitiveness of 16 cities in Yangtze River Delta of China. Lee and Chang (2018) also used the entropy weight combined the WSM, TOPSIS, VIKOR, ELECTRE, four MCDM methods to rank renewable energy source in Taiwan. Lots of evidences have illustrated the usefulness of the entropy theory in calculating the weights of criteria. Thus, we choose the entropy weight method over the other methods to obtain the weights of criteria. Let's set the above criteria set $\varsigma = \{\varsigma_1, \varsigma_2, \ldots, \varsigma_n\}$, alternative set $A = \{a_1, a_2, \ldots, a_m\}$, the value matrix of criteria $\boldsymbol{F} = (f_{ij})_{m \times n}$ can be expressed as follows.

$$\boldsymbol{F} = \begin{pmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{pmatrix} = (f_{ij})_{m \times n},$$

where f_{ij} denotes the value of the ith alternative on the jth criterion. we can calculate the weights of criteria in this paper as follows.

Step 1: Normalize the value matrix by Eqs (40)–(41).

Since criteria have different physical dimensions, the value f_{ij} needs to be normalized to common measurable units to allow for comparisons of different criteria.

For benefit criteria $\varsigma_j \in \varsigma'$, f_{ij} can be normalized as follows:

$$r_{ij} = \frac{f_{ij} - f_j^-}{f_j^* - f_j^-}. \tag{40}$$

For cost criteria $\varsigma_j \in \varsigma''$, f_{ij} can be normalized as follows:

$$r_{ij} = \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}. \tag{41}$$

where $f_j^* = \max\{f_{ij} \mid i = 1,2,\ldots,m\}$ and $f_j^- = \min\{f_{ij} \mid i = 1,2,\ldots,m\}$ are the biggest value and smallest value of the jth criteria in all alternatives, ς' is the benefit criteria set and ς'' is the cost criteria set (Li, 2005). r_{ij} is the normalized value of f_{ij}. In order to compute the entropy, we stipulated:

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}. \tag{42}$$

Step 2: Compute entropy by Eq. (43):

$$h_j = -h_0 \sum_{i=1}^{m} p_{ij} \ln p_{ij}, \tag{43}$$

where $h_0 = 1/\ln m$ is the entropy constant, and $p_{ij} \ln p_{ij}$ is defined as 0 if $p_{ij} = 0$.

Step 3: Calculate the weights of criteria by Eq. (44):

$$\omega_j = \frac{1-h_j}{\sum_{j=1}^{n}(1-h_j)}, \tag{44}$$

where ω_j is the degree of importance of the jth criterion, the criteria weight set denotes $\omega = \{\omega_1, \omega_2, \ldots, \omega_n\}$.

1.4. Aggregating information using MCDM methods

After determining the values and weights of evaluation criteria based on Eqs (1)–(44), MCDM methods, are applied to aggregate information to obtain the comprehensive evaluation and the order ranking of alternatives. Due to more than one MCDM methods can provide a more robust evaluation, in this paper, we use four MCDM methods–WSM, TOPSIS, ELECTRE, and PROMETHEE to give a comprehensive evaluation of impacts of tourism in Hainan considering four dimensions of economy, environment, society, and culture.

1.4.1. WSM

The WSM, which is also called the weighted sum method, is the simplest and widely used MCDM methods. After the weights and normalized values of criteria are determined through Eqs (40)–(44), the total score of each alternative can be obtained by simple addition of the weighted utility of each criterion $S_i = \sum_{j=1}^{n} \omega_j r_{ij}$. The higher the total score, the better the alternative.

1.4.2. TOPSIS

TOPSIS, proposed by Hwang and Yoon, is one of the MCDM methods to determine the out-ranking of alternatives. The core idea of TOPSIS is that alternative closest to the positive-ideal solution and furthest from the negative-ideal solution is the best alternative. The calculation procedure of the TOPSIS method is shown as follows.

Step 1: Construct the normalized decision matrix $\widehat{\boldsymbol{R}} = (\widehat{r}_{ij})_{m\times n}$ by Eq. (45):

$$\widehat{r}_{ij} = \frac{f_{ij}}{\sqrt{\sum_{i=1}^{m} f_{ij}^2}}. \tag{45}$$

Step 2: Determine the positive-ideal and negative-ideal solutions by Eq. (46):

$$\boldsymbol{r}_j^* = \begin{cases} \max\limits_{1\le i\le m} \widehat{r}_{ij}, & \varsigma_j \in \varsigma' \\ \min\limits_{1\le i\le m} \widehat{r}_{ij}, & \varsigma_j \in \varsigma'' \end{cases}, \quad \boldsymbol{r}_j^- = \begin{cases} \min\limits_{1\le i\le m} \widehat{r}_{ij}, & \varsigma_j \in \varsigma' \\ \max\limits_{1\le i\le m} \widehat{r}_{ij}, & \varsigma_j \in \varsigma'' \end{cases}, \tag{46}$$

where $\boldsymbol{r}^* = (r_1^*, r_2^*, \ldots, r_n^*)$ is the vector of the positive-ideal solution, $\boldsymbol{r}^- = (r_1^-, r_2^-, \ldots, r_n^-)$ is the negative-ideal solution vector, ς' is the benefit criteria set , ς'' is the cost criteria set.

Step 3: Calculate Euclidean distance from each alternative to the positive-ideal and negative-ideal solutions by Eq. (47):

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(\omega_j(r_{ij} - r_j^*))^2}, \quad D_i^- = \sqrt{\sum_{i=1}^{n}(\omega_j(r_{ij} - r_j^-))^2}, \tag{47}$$

where D_i^+ and D_i^- are the Euclidean distance from the *i*th alternative to the positive-ideal and negative-ideal solutions, respectively.

Step 4: Calculate the relative closeness to the ideal solution. Based on Eqs (45)–(47), the relative closeness of the alternative F_i with respect to F^* can be calculated by Eq. (48):

$$O_i^* = \frac{D_i^-}{D_i^* + D_i^-}, \tag{48}$$

where $O_i^* \in [0,1]$. The bigger O_i^*, the better the alternative F_i.

1.4.3. ELECTRE

ELECTRE was developed by Bernard Roy as a MCDM method and has been widely adopted to solve various decision problems in many different fields. The main rule of ELECTRE is to establish pair-wise comparisons among alternatives for each criterion separately to establish outranking relationship between the alternatives. The algorithm of the ELECTRE method is presented as follows.

Step 1: Construct the normalized decision matrix by Eq. (45).

Step 2: Determine the concordance and discordance set by Eqs (49)–(50). Assuming the preference relationship is $F_i \succ F_k$, under the *j*th criterion, if the *j*th criterion is benefit criteria $\varsigma_j \in \varsigma'$, when $\hat{r}_{ij} \geq \hat{r}_{kj}$, this criterion will be classified in the concordance set G^+; when $\hat{r}_{ij} < \hat{r}_{kj}$, it will be classified in the discordance set G^-.

$$G^+ = \begin{cases} \{j \mid 1 \leq j \leq l, \hat{r}_{ij} \geq \hat{r}_{kj}\}, \ \varsigma_j \in \varsigma' \\ \{j \mid 1 \leq j \leq l, \hat{r}_{ij} < \hat{r}_{kj}\}, \ \varsigma_j \in \varsigma'' \end{cases}. \tag{49}$$

Otherwise, if the *j*th criterion is cost criteria $\varsigma_j \in \varsigma''$, when $\hat{r}_{ij} \leq \hat{r}_{kj}$, this criterion will be classified in the concordance set G^+; when $\hat{r}_{ij} > \hat{r}_{kj}$, it will be classified in the discordance set G^-.

$$G^- = \begin{cases} \{j \mid 1 \leq j \leq l, \hat{r}_{ij} \leq \hat{r}_{kj}\}, \varsigma_j \in \varsigma' \\ \{j \mid 1 \leq j \leq l, \hat{r}_{ij} > \hat{r}_{kj}\}, \varsigma_j \in \varsigma'' \end{cases}. \tag{50}$$

Step3: Calculate of concordance test indexes by Eq. (51):

$$I_{ik} = \sum\nolimits_{j \in G^+} \omega_j. \tag{51}$$

Step 4: Calculate the discordance matrix and revise by Eq. (52):

$$d_{ik} = \frac{\max\limits_{j \in G^-} \{ |\omega_j (\hat{r}_{ij} - \hat{r}_{kj})| \}}{\max\limits_{j \in G^- \cup G^+} \{ |\omega_j (\hat{r}_{ij} - \hat{r}_{kj})| \}}, \ \ d'_{ik} = 1 - d_{ik}. \tag{52}$$

Step 5: Calculate the revised total matrix $Y = (y_{ik})_{n \times n}$ by Eq. (53):

$$y_{ik} = I_{ik} \times d'_{ik}. \tag{53}$$

Step 6: Compute the net advantage values by Eq. (54):

$$I_i = \sum_{\substack{k=1 \\ k \neq i}}^{m} y_{ik} - \sum_{\substack{i=1 \\ i \neq k}}^{m} y_{ki}. \tag{54}$$

1.4.4. PROMETHEE

The PROMETHEE method is one of MCDM methods that was proposed by Brans (Lotfi & Fallahnejad, 2010) to solve the alternative rankings with conflict criteria. The basic rule of PROMETHEE is based on a pair-wise comparison of alternatives along each criterion. The algorithm of the PROMETHEE is presented as follow (Behzadian et al. 2010).

Step 1: Construct the normalized decision matrix by Eqs (40)–(42).

Step 2: Determine deviations based on the pair-wise comparisons by Eq. (55):

$$d_j(F_i, F_k) = r_{ij} - r_{kj}, \tag{55}$$

where d_j denotes the difference between the evaluations of alternatives F_i and F_k on the jth criterion.

Step 3: Apply preference functions

$$P_j(F_i, F_k) = P_j(d_j(F_i, F)),$$

where $P_j(F_i, F_k)$ is the preference of the alternative F_i to alternative F_k on the jth criterion, Vincke and Brans proposed six basic types preference function, detail can be seen in literature (Brans & Vincke, 1985).

Step 4: Calculate the overall preference indexes by Eq. (56):

$$\pi(F_i, F_k) = \sum_{j=1}^{m} P_j(F_i, F_k)\omega_j. \tag{56}$$

Step 5: Calculate the outranking flows by Eq. (57):

$$\phi^+(F_i) = \frac{1}{n-1}\sum_{F_k \in F} \pi(F_i, F_k), \quad \phi^-(F_i) = \frac{1}{n-1}\sum_{F_k \in F} \pi(F_k, F_i), \tag{57}$$

where $\phi^+(F_i)$ and $\phi^-(F_i)$ are the positive and negative outranking flows for the alternative F_i, respectively.

Step 6: Compute the net outranking flows by Eq. (58):

$$\phi(F_i) = \phi^+(F_i) - \phi^-(F_i). \tag{58}$$

1.5. Procedure of the proposed methodology

In this subsection, we summarize the procedure of the comprehensive evaluation of impacts of tourism sector integrating IO model with MCDM method.

Step 1: Construct the extended IO mathematics framework which can estimate domestic, imported, direct, and indirect impacts of tourism sector on economy, environment, society, and culture based on Eqs (1)–(6).

Step 2: Calculate various domestic, imported, direct, and indirect multipliers of tourism sectors based on Eqs (7)–(39), and using these multipliers to constitute a 3-level evaluation criteria hierarchy. Denote criteria set $\varsigma = \{\varsigma_1, \varsigma_2, \ldots, \varsigma_n\}$.

Step 3: Calculate criteria weight set $\omega = \{\omega_1, \omega_2, \ldots, \omega_n\}$ based on the entropy theory based on Eqs (40)–(44).

Step 4: Aggregate information to give a comprehensive evaluation based on four MCDM methods based on Eqs (45)–(58).

2. Data and results

This paper aims to evaluate comprehensive impacts of tourism from four dimensions of economic, environmental, social, and cultural impacts in Hainan integrating IO model with MCDM methods, which needs to use tourism consumption and IO tables as the database. For the IO data, Hainan has only published input-output tables for 1997, 2002, 2007 and 2012 as China's input-output tables are usually compiled every five years. And 2009 is a turning point for Hainan. In this year, Hainan has been built as the first international tourism island of China, which promotes the rapid development of tourism in Hainan. Dynamic time series from 2002 to 2012 can track the changes of tourism development in Hainan. Therefore, in this paper, we use Hainan IO tables for 2002, 2007, and 2012 published by National Bureau of Statistics of China (2008a, 2011, and 2016) to measure the dynamic and comprehensive impacts of tourism development on Hainan's economy, environment, society, and culture from 2002–2012. However, the structure and amounts of sectors in these three IO tables are different in detail. Especially, The 2002 IO table consists of 122 sectors, the 2007 IO table consists of 135 different sectors, and the 2012 IO table consists of 139 sectors. And these three IO tables all have no special "tourism sector". Since such differences exits among three IO tables, therefore, aggregating sectors into relatively broad categories can overcome the problem of definition inconsistencies of sectors. In this study, these IO tables with different numbers of sectors are unified as IO tables composed of 42 sectors listed in Table 5, and tourism sector in Hainan are separated into six sectors: "Accommodation", "Food serving", "Wholesale & retail trade", "Transportation", "Tours" and "Entertainment".

As for the tourism consumption data, tourism energy consumption data are from China Energy Statistics Yearbook published by National Bureau of Statistics of China (2004, 2008b, and 2012) . Tourism revenue and tourist facilities are from Hainan statistical yearbook published Hainan Provincial Bureau of Statistics &and National Bureau of Statistics Hainan Investigation Team (2019a, 2019b, 2019c). For consistency, domestic, inbound and total tourism revenue are all converted into 1989 constant prices (in RMB Billion Yuan) by using the price indices. Based on these data and Eqs (1)–(39), the values of selected 63 criteria are also shown in Table 3.

Table 3. The initial value of 63 evaluation criteria of tourism impacts in Hainan for 2002, 2007, and 2012

1-level criteria	2-level criteria	3-level criteria	Type	Unit	2002	2007	2012
Economic (ς_1, 0.3907)	Tourism Revenue (ς_{11}, 0.0543)	Total tourism revenue (ς_{111}, 0.0178)	Benefit	Billion Yuan	0.6135	1.1702	2.4704
		Domestic tourism revenue (ς_{112}, 0.0221)	Benefit	Billion Yuan	0.5521	0.8437	2.3250
		Inbound tourism revenue (ς_{113}, 0.0144)	Benefit	Billion Yuan	0.0740	0.1564	0.2268
	Output Multiplier (ς_{12}, 0.0460)	Direct output multiplier (ς_{121}, 0.0239)	Benefit	–	2.4202	2.2858	3.3642
		Completed output multiplier (ς_{122}, 0.0221)	Benefit	–	2.5706	2.3832	3.5288
	Value-added multiplier (ς_{13}, 0.0888)	Direct value-added multiplier (ς_{131}, 0.0133)	Benefit	–	0.3752	0.4216	0.4090
		Indirect value-added multiplier (ς_{132}, 0.0158)	Benefit	–	0.9673	0.7585	0.8451
		Value-added of the tourism output (ς_{133}, 0.0181)	Benefit	Billion Yuan	0.8072	1.5983	3.5632
		Value-added of the tourism export trade (ς_{134}, 0.0137)	Benefit	Billion Yuan	0.2271	0.2487	0.1866
		The contribution rate of value-added of tourism output (ς_{135}, 0.0132)	Benefit	%	0.1916	0.1946	0.1939
		The contribution rate of value-added of tourism trade (ς_{136}, 0.0147)	Benefit	%	0.2201	0.2931	0.1471
	Direct backward linkage multiplier (ς_{14}, 0.0533)	Total direct backward linkage multiplier (ς_{141}, 0.0185)	Benefit	–	0.6248	0.5784	0.5910
		Domestic direct backward linkage multiplier (ς_{142}, 0.0153)	Benefit	–	0.6172	0.5449	0.5773
		Imported direct backward linkage multiplier (ς_{143}, 0.0195)	Benefit	–	0.0077	0.0334	0.0137
	Indirect backward linkage multiplier (ς_{15}, 0.0635)	Total indirect backward linkage multiplier (ς_{151}, 0.0239)	Benefit	–	1.4202	1.2858	2.3642
		Domestic indirect backward linkage multiplier (ς_{152}, 0.0162)	Benefit	–	1.3453	0.9637	1.9629
		Imported indirect backward linkage multiplier (ς_{153}, 0.0233)	Benefit	–	0.0085	0.0501	0.0142
	Direct forward linkage multiplier (ς_{16}, 0.0402)	Total direct forward linkage multiplier (ς_{161}, 0.0132)	Benefit	–	0.2307	0.5119	0.4493
		Domestic direct forward linkage multiplier (ς_{162}, 0.0132)	Benefit	–	0.2307	0.5119	0.4493
		Imported direct forward linkage multiplier (ς_{163}, 0.0138)	Benefit	–	0.0785	0.4084	0.2826
	Indirect forward linkage multiplier (ς_{17}, 0.0445)	Total indirect forward linkage multiplier (ς_{171}, 0.0134)	Benefit	–	0.3261	0.9127	0.7427
		Domestic indirect forward linkage multiplier (ς_{172}, 0.0177)	Benefit	–	0.3261	0.4534	0.7427
		Imported indirect forward linkage multiplier (ς_{173}, 0.0135)	Benefit	–	0.0995	0.3273	0.4272

Continue of Table 3

1-level criteria	2-level criteria	3-level criteria	Type	Unit	2002	2007	2012
Environmental (ς_2, 0.1690)	Energy consumption (ς_{21}, 0.0416)	Domestic energy consumption (ς_{211}, 0.0129)	Cost	Mtce	2.4602	2.3630	7.4395
		Imported energy consumption (ς_{212}, 0.0157)	Cost	Mtce	0.0005	0.0793	0.1354
		Total energy consumption (ς_{213}, 0.0129)	Cost	Mtce	2.4607	2.4423	7.5749
	Carbon dioxide emission (ς_{22}, 0.0413)	Domestic carbon dioxide emission (ς_{221}, 0.0129)	Cost	Mt	2967.5208	3129.0235	7669.5295
		imported carbon dioxide emission (ς_{222}, 0.0154)	Cost	Mt	0.8485	138.6824	247.8253
		Total carbon dioxide (ς_{223}, 0.0130)	Cost	Mt	2968.3693	3267.7059	7917.3548
	Methane emission (ς_{23}, 0.0447)	Domestic methane emission (ς_{231}, 0.0130)	Cost	Mt	0.2864	0.2602	0.5209
		Imported methane emission (ς_{232}, 0.0187)	Cost	Mt	0.0001	0.0112	0.0152
		Total methane emission (ς_{233}, 0.0130)	Cost	Mt	0.2865	0.2714	0.5361
	Nitrous oxide (ς_{24}, 0.0415)	Domestic N_2O emission (ς_{241}, 0.0129)	Cost	Mt	0.0996	0.0941	0.2296
		Imported N_2O emission (ς_{242}, 0.0156)	Cost	Mt	0.0000	0.0041	0.0071
		Total N_2O emission (ς_{243}, 0.0129)	Cost	Mt	0.0996	0.0982	0.2367
Social (ς_3, 0.2126)	Tourist facilities (ς_{31}, 0.0922)	Total Number of Tourist Hotels (ς_{311}, 0.0162)	Benefit	Hotel	252	414	674
		Total Number of Hotel Rooms (ς_{312}, 0.0158)	Benefit	Room	30852	56812	94361
		Total Number of Beds (ς_{313}, 0.0153)	Benefit	Beds	58581	105002	162664.
		Room Occupancy Rate (ς_{314}, 0.0132)	Benefit	%	0.5870	0.5731	0.5840
		Total Number of Travel Agencies (ς_{315}, 0.0316)	Benefit	Agency	150	155	369
	Employment multiplier (ς_{32}, 0.0262)	Direct employment remuneration coefficient (ς_{321}, 0.0132)	Benefit	–	0.1491	0.0974	0.1646
		Indirect employment remuneration coefficient (ς_{322}, 0.0130)	Benefit	–	0.4139	0.2248	0.4341
	Tourism Consumption (ς_{33}, 0.0943)	Direct consumption coefficient (ς_{331}, 0.0199)	Benefit	–	0.1276	0.2063	0.1050
		Domestic direct consumption coefficient (ς_{332},0.0196)	Benefit	–	0.1276	0.2017	0.1050
		Imported direct consumption coefficient (ς_{333}, 0.0149)	Benefit	–	0.0133	0.1000	0.0557
		Indirect consumption coefficient (ς_{334}, 0.0129)	Benefit	–	0.5270	0.3866	0.5271
		Domestic indirect consumption coefficient (ς_{335}, 0.0130)	Benefit	–	0.4781	0.3602	0.4627
		Imported indirect consumption coefficient (ς_{336}, 0.0140)	Benefit	–	0.0489	0.0265	0.0644

End of Table 3

1-level criteria	2-level criteria	3-level criteria	Type	Unit	2002	2007	2012
Culture (ς_4 ,0.2277)	The culture exchange impact (ς_{41}, 0.0516)	Tourist reception number (ς_{411}, 0.0172)	Benefit	Mpt	11.2474	18.4550	33.2037
		Inbound tourist reception number (ς_{412}, 0.0131)	Benefit	Mpt	0.4568	0.7532	0.8156
		Nationality amount of the foreign tourists (ς_{413}, 0.0214)	Benefit	Mpt	0.090	0.0011	0.0020
	Direct backward linkage multiplier between tourism and culture (ς_{42}, 0.0529)	Total direct backward linkage multiplier (ς_{421}, 0.0200)	Benefit	–	0.0032	0.0019	0.0015
		Domestic direct backward linkage multiplier (ς_{422},0.0199)	Benefit	–	0.0032	0.0019	0.0015
		Imported direct backward linkage multiplier (ς_{423}, 0.0129)	Benefit	–	0.0000	0.0000	0.0000
	Indirect backward linkage multiplier between tourism and culture (ς_{43}, 0.0405)	Total indirect backward linkage multiplier (ς_{431}, 0.0137)	Benefit	–	0.0048	0.0034	0.0008
		Domestic indirect backward linkage multiplier (ς_{432}, 0.0139)	Benefit	–	0.0048	0.0032	0.0007
		Imported indirect backward linkage multiplier (ς_{433}, 0.0129)	Benefit	–	0.0000	0.0000	0.0000
	Direct forward linkage multiplier between tourism and culture (ς_{44}, 0.0409)	Total direct forward linkage multiplier (ς_{441}, 0.0136)58	Benefit	–	0.0004	0.0024	0.0017
		Domestic direct forward linkage multiplier (ς_{442}, 0.0136)	Benefit	–	0.0004	0.0024	0.0017
		Imported direct forward linkage multiplier (ς_{443}, 0.0137)	Benefit	–	0.0000	0.0022	0.0014
	Indirect forward linkage multiplier between tourism and culture (ς_{45}, 0.0417)	Total indirect forward linkage multiplier (ς_{451}, 0.0139)	Benefit	–	0.0006	0.0043	0.0028
		Domestic indirect forward linkage multiplier (ς_{452}, 0.0139)	Benefit	–	0.0006	0.0043	0.0028
		Imported indirect forward linkage multiplier (ς_{453}, 0.0138)	Benefit	–	0.0001	0.0031	0.0020

Note: * Abbreviation interpretation: Mtce = million tons of coal equivalent; Mpt = million person-time; Mt = million tons.

2.1. Economic impacts

For the total tourism revenue, it continues growing at a rate of 100% every five years from 2002 to 2012. Especially, Hainan's domestic tourism revenue in 2012 is triple that of 2007. In terms of the output multiplier for the tourism-oriented sectors, the direct and indirect output multiplier of 2002 are 2.4202, 2.5706 respectively. In 2007, they decrease to 2.2858, 2.38319, but in 2012, output multiplier of tourism sector rises to 3.3642, 3.52879. Among the output multipliers of six tourism-oriented sectors, wholesale & retail trade, accommodation, tour and transportation are the four sectors that have the greatest impact on the output effects of the local economy. The average direct and indirect output multiplier of these for sectors are wholesale & retail trade (2.2414, 2.3848), accommodation (2.7634, 2.9257), transportation(2.9082, 2.9791), tour(2.9938, 3.0815). Tour is the most productive tourism-oriented sector.

For the value-added of tourism-oriented sectors, the value-added brought by tourism sectors continuously increases from 0.8072 Billion Yuan in 2002, 1.5983 Billion Yuan in 2007 to 3.5632 Billion Yuan in 2012. Direct and indirect value-added multiplier of tourism-oriented sectors are 2002 (0.3752, 0.9673), 2007 (0.4216, 0.7585), 2012 (0.4090, 0.8451). And the contribution rate of value-added of tourism sector all accounts for more than 19% in total domestic product. Among them, the wholesale & retail trade(0.5569, 0.9602) and entertainment (0.5433, 0.9632) sectors produce slightly higher return to local value-added on average than other tourism-oriented sectors. Transportation and tour have relatively low rankings compared to the other sectors, ranking 5th and 6th respectively. For the tourism international trade, although tourism service trade has always been in surplus, the value-added brought by tourism trade decreases from 2007 to 2012. The value-added brought by tourism trade in 2002 is 0.2271 Billion Yuan, 2007 is 0.2487 Billion Yuan and 2012 is 0.1866 Billion Yuan.

For the linkage multiplier between tourism-oriented sectors and other sectors, as same as other studies (Hanly, 2012; Pratt, 2015b), the forward linkages for the tourism-oriented sectors of Hainan are slightly weak than the backward linkages. In terms of the backward multiplier, The backward linkage multiplier of tourism continues to rise from 2002 to 2012, and the indirect backward multiplier of six tourism-oriented sectors are greater than 1, tour's backward linkage ranks the first across six tourism-oriented sectors, demonstrating that tourism-oriented sectors have strongly demands for goods or service from other sectors (Pratt, 2015b). The maximum forward linkage multiplier is transportation. This may be due to where the economies are in Hainan with those economies experiencing strong tourism growth having strong transportation forward linkages.

2.2. Environment impacts

In terms of energy consumption, in order to support the tourism economic activities over from 2002 to 2012, it is counted that Hainan consumed 0.0258 Mt raw coal, 0.0088 Mt coke, 0.3489 Mt gasoline, 1.9109 Mt kerosene, 1.0872 Mt diesel, 0.5403 Mt Fuel oil, 0.0796 Liquefied Mt petroleum gas, 0.4024 Mt Natural gas and 3.0150 bkwh Electricity (it can be seen in Table 4). This translated to the emission of 14153.43007 Mt CO_2, 1.09402Mt CH_4, 0.434442 Mt N_2O. The top three contributing tourism-oriented sectors during the 2002 to 2012, the 2002 are "wholesale & retail trade (52.67%)", "transportation (16.61%)", "food serving(16.96%)", the 2007 are "transportation(49.13%)", "wholesale & retail trade(17.39%)", "tour(12.76%)"; the 2012 are "transportation (51.26%)", "wholesale & retail trade (21.92%)", "food serving (10.64%)". Transportation is the most energy-consuming tourism-related sector.

For domestic and imported energy consumption effect, the proportion of the imported energy consumption in total energy consumption for tourism-oriented sectors has increased continually from 2002 (2.8611%), 2007 (4.2441%) to 2012 (3.1302%), the amount of the domestic energy consumption has also grew, especially the 2012 domestic energy consumption is the triple of 2007. For the energy efficiency, the 2002 energy consumption intensity is 0.03802 Mtce/Billion yuan, 2007 is 0.03835 Mtce/Billion Yuan, 2012 is 0.02755 Mtce/Billion Yuan, it shows a trend that first increased then decreased with the increased tourism output, it embodies the development of tourism and technological progress.

Table 4. The amount of energy consumption of tourism in Hainan

	Raw coal (Mt/a)	Coke (Mt/a)	Gasoline (Mt/a)	Kerosene (Mt/a)	Diesel (Mt/a)	Fuel oil (Mt/a)	Liquefied petroleum gas (Mt/a)	Natural gas (Mt/a)	Electricity (bkwh/a)
2002	0.0258	0	0.0842	0.3629	0.1327	0.0744	0.0196	0	0.438
2007	0	0.0088	0.15	0.6465	0.2365	0.1325	0.0350	0.2743	0.952
2012	0	0	0.1147	0.9015	0.7180	0.3334	0.0250	0.1281	1.625
Total	0.0258	0.0088	0.3489	1.9109	1.0872	0.5403	0.0796	0.4024	3.0150

Note: * Mt/a = million tons annual.

For the GHG emission (CO_2, CH_4, N_2O), the amount of GHG emission for CO_2, CH_4, N_2O generated by tourism sectors also increased annually. Total carbon dioxide emissions rose from 2967.5208 Mt in 2002, 3129.0235 Mt in 2007 to 7669.5295 Mt in 2012. Total methane emission also increased from 0.2865 Mt in 2002 to 0.5361 Mt in 2012. Total nitrous oxide emitted 0,0996 Mt in 2002, 0,0982 Mt in 2007, and 0.2367 Mt in 2012. Especially, the imported carbon dioxide emission fast during 2002 to 2012. "Transportation", "tour", "wholesale and retail trade", and "food serving" are high GHG emission intensity tourism sectors. As to the GHG emission intensity, the CO_2 emission intensity of 2002 is 7.1 Mt/Billion Yuan, 2007 is 69.6 Mt/Billion Yuan, 2012 is 50.7 Mt/Billion Yuan. The methane emission intensity of the tourism sectors for 2002, 2007, 2012 are 0.00056 Mt/Billion Yuan, 0.00563 Mt/Billion Yuan, 50.66366 Mt/Billion Yuan. The nitrous oxide emission intensity of the tourism-oriented sectors for 2002, 2007, 2012 are 0.00021 Mt/Billion Yuan, 0.00205 Mt/Billion Yuan, 0.00145 Mt/Billion Yuan. Except for methane emission intensity, carbon dioxide emission intensity and nitrous oxide emission intensity shows a trend of first increasing and then decreasing.

2.3. Social impacts

For the impact on the tourist facilities, Tourist facilities are the fundamental for receiving tourists to visit and other activities. The more popular the tourist facilities, the more mature the tourism industry. On the other hand, it also means that more and more people participate

Table 5. Sectors categories and descriptions of adjusted IO table

NO.	Sector Name	NO.	Sector Name
T1	Food serving	016	Manufacturing of general and special equipment
T2	Accommodation	017	Transportation equipment manufacturing
T3	Transportation	018	Electrical machinery and equipment manufacturing
T4	Tours	019	Communications equipment, computers and other electronic equipment manufacturing
T5	Wholesale & retail trade	020	Instrument manufacturing
T6	Entertainment	021	Other manufacturing industries
01	Agriculture, forestry, animal husbandry and fishery	022	Production and supply of electric power and hot pow
02	Coal mining and washing	023	Fuel gas production and supply
03	Oil and Gas Exploitation	024	Water production and supply
04	Metal mining and dressing	025	Construction
05	Non-metallic Mines and Other Mining	026	Other transport and warehousing
06	Food Manufacturing and Tobacco Processing	027	Computer Services and Software
07	Textiles	028	Banking, securities and other financial activities
08	Textile, garment, shoes, caps, leather and its products	029	Realty
09	Timber processing and furniture manufacture	030	Leasing
010	Paper making and paper products	031	Research and experimental development
011	Oil processing, coking& nuclear fuel processing	032	Synthetic technique service
012	chemical industry	033	Education and health
013	Nonmetallic Mineral Products	034	Public administration, social security and social welfare
014	Metal smelting and rolling	035	News, radio, culture and sports
015	Metal Products	036	Other services

in the process of tourism products and services, and the social acceptance is higher. From 2002 to 2012, there are more and more tourist hotels, hotel rooms, beds and travel agencies in Hainan, and the room occupancy rates all exceed 55%, these values show the social acceptance is increasing. For the impact on the employment, as many experts believe, tourism expenditure stimulates many demands for labour to produce those goods and services required by tourist. As seen in Table 3, the direct and indirect employment remuneration coefficient for 2012 ranked first, then followed by the 2002, and 2007 is the smallest. For the sectors perspective, the top three contributing tourism-oriented sectors on the employment of 2002 are "entertainment (0.3839, 0.5678)", "food serving (0.17486, 0.4605)", "transportation

(0.2542, 0.4538)", respectively. 2007 are "accommodation (0.1943, 0.3569)", "entertainment (0.1682, 0.3121)", "food serving (0.0944, 0.3648)". 2012 are "entertainment (0.3289, 0.6163)", "accommodation (0.2003, 0.5029)", and "food serving (0.2889, 0.6667)". It can be seen that the entertainment, accommodation, food serving, and transportation are the main tourism-oriented sectors for absorbing employment. It shows tourism is a labor-intensive industry.

For the impact of the tourism consumption, this value measures how much output of tourism brought by household consumption in Hainan. As seen in the Table 3, the direct and indirect consumption coefficients that reflect direct and indirect stimulating effect of household consumption on tourism production show 2007 (0.1276, 0.5270) is the largest followed by the 2002 (0.2063,0.3866), 2012 (0.1050, 0.5271). The top three sectors are food serving (0.4187, 0.794334), wholesale& retail trade (0.1721, 0.425658) and tours (0.1216, 0.456085). Viewing from the structure of residents' tourism consumption, the proportion of tourism consumption in total regional resident's consumption shows that the 2007 (0.0452) is the largest followed by the 2002 (0.0381), 2012 (0.0224). The top three sectors are the "wholesale & retail trade (0.0615)", "food serving (0.0381)", "transportation (0.0143)". It is noted that wholesale & retail trade, food serving and transportation are tourism consumption hot spots of the Hainan's residents. Comparing the proportion of tourism consumption in Hainan's rural residents' consumption with urban residents', it is easy to find that the proportion of the tourism in urban resident is always higher than that in rural resident, and their trends are consist with the previous.

2.4. Culture impacts

The development of the tourism can promote the dissemination of tourism destination culture and the exchange of different local cultures. In the meantime, tourists are the disseminators of culture. As can be seen from Table 3, the total and inbound tourist reception number increase dramatically, and the nationality amount of the foreign tourists also increased rapidly. This process is accompanied by intensive exchanges of different cultures. However, from the perspective of integration of tourism and cultural sectors, the forward and backward linkage multipliers of tourism and cultural sectors in Hainan are very low. It reveals that Hainan's tourism development is still at the primary stage, and the integration between tourism and cultural sectors is relatively low. For the backward linkage between tourism and culture sector, the 2002 is the largest, followed by 2007, and the 2012 is last. The top three sectors for 2002, 2007 and 2012 are the "accommodation", "wholesale & retail trade" and "entertainment". In terms of the forward linkage multiplier, the 2007 ranks the first, the 2002 ranks the second, and the 2012 is the last. The top three sectors are "accommodation", "tours" and "wholesale & retail trade". Moreover, the forward linkage multipliers are greater than the backward linkage multipliers.

2.5. Results of MCDMS

After analyzing the impacts of tourism development on Hainan's economy, environment, society and culture, four MCDM methods (WSM, TOPSIS, ELECTRE, and PROMETHEE) are used to estimate the overall performance of tourism in Hainan for 2002, 2007 and 2012.

Firstly, the Shannon's entropy is applied to calculate the weight of criteria, the result of criteria weights can be seen in Table 3. It shows that economic is the most important consideration for the comprehensive estimating of tourism in Hainan, followed by cultural, social and environmental dimensions. In addition, the top five important criteria are total number of travel agencies (x_{315}, 0.0316), total indirect backward linkage multiplier (x_{151}, 0.0239), total indirect backward linkage multiplier (x_{151}, 0.0239), direct output multiplier (x_{121}, 0.0239), and imported indirect forward linkage multiplier (x_{153}, 0.0233). And then four MCDM methods (WSM, TOPSIS, ELECTRE, and PROMETHEE) are applied to the data. The results of rankings are presented in Table 6. The overall performance of tourism in Hainan shows a trend of first increasing from 2002 to 2007 and then decreasing from 2007 to 2012. 2007 is the best year for the comprehensive estimating of tourism sectors in Hainan. The rankings of these four method are same except for WSM.

Table 6. The results of rankings in different methods

Rank	WSM	TOPSIS	ELECTRE	PROMETHEE
1	2002	2007	2007	2007
2	2007	2012	2012	2012
3	2012	2002	2002	2002

3. Sensitivity analysis of weights

Since the criteria weights significantly affect the results of rankings, the change of weights value should be evaluated. In this paper, two types of the sensitivity analysis referring to the literature (Lee & Chang, 2018) are used to reveal how the rankings changes due to the variation of criteria weights, which mainly explore the influence of single criterion weight change and four dimensions criteria weights change on the results.

First, all single criterion weight is adjusted with 5% , 10%, 20% , 50%, 100% increasing and decreasing. In order to fix the criteria weights equal to 1, the remaining criteria must be proportionally reduced when a criterion weight increases, i.e., when criterion changes Δ, the weights of the remaining criteria need to be changed according to the formula $\omega'_j = {}^{\omega_j}\!\big/_{\sum_{j=1}^{n}\omega_j \pm \Delta}$. Each criterion is analyzed using the four MCDM methods, WSM, TOPSIS, ELECTRE and PROMETHEE in that order. The results show the change of single criterion weight has little influence on the comprehensive evaluation results.

Table 7. Criteria weights under different scenarios

Criteria	Scenario 1 Equal weight	Scenario 2 Economic weight	Scenario 3 Social weight	Scenario 4 Culture weight	Scenario 5 Environment weight
Economic	0.25	0.5	0.167	0.167	0.167
Social	0.25	0.167	0.5	0.167	0.167
Culture	0.25	0.167	0.167	0.5	0.167
Environment	0.25	0.167	0.167	0.167	0.5

Second, the economic dimension based on entropy weight method is the most important in four evaluation dimensions. In order to consider the weight changes of four dimensions, five scenarios listed in Table 7 are taken into account. In scenario 1, every dimension is treated as identical. The following four scenarios focus on the economic, social, cultural or environmental dimensions, respectively. The rankings in terms of different methods and scenarios are shown in Tables 8–9. when more attention is paid to the dimension of social impacts, the overall performance of tourism industry in Hainan from 2002 to 2012 is getting better year by year. It reflects the growing maturity of tourism facilities in Hainan. But on the contrary, when more importance is attached to the environment impacts of tourism, the overall performance of tourism sectors in Hainan from 2002 to 2012 is deteriorating year by year. It reflects that energy consumption and greenhouse gas emissions are increasing year by year, causing more and more damage to the environment. When cultural dimension is more valued and four dimensions are identical, the overall performance shows a trend of first rising and then falling.

Table 8. The rankings in terms of different methods and scenarios

Scenario	Method	Rank			Scenario	Method	Rank		
		1	2	3			1	2	3
Scenario 1 Equal weight	WSM	2012	2007	2002	Scenario 4 Culture weight	WSM	2012	2007	2002
	TOPSIS	2007	2012	2002		TOPSIS	2007	2012	2002
	ELECTRE	2007	2012	2002		ELECTRE II	2007	2012	2002
	PROETHEE	2007	2012	2002		PROETHEE	2007	2012	2002
Scenario 2 Economic weight	WSM	2012	2007	2002	Scenario 5 Environment weight	WSM	2002	2007	2012
	TOPSIS	2007	2012	2002		TOPSIS	2002	2007	2012
	ELECTRE	2007	2012	2002		ELECTRE	2002	2007	2012
	PROETHEE	2007	2012	2002		PROETHEE	2002	2007	2012
Scenario 3 Social weight	WSM	2012	2007	2002					
	TOPSIS	2012	2007	2002					
	ELECTRE	2012	2007	2002					
	PROETHEE	2012	2007	2002					

Table 9. Aggregate rankings in different scenarios

Criteria	Scenario 1 Equal weight	Scenario 2 Economic weight	Scenario 3 Social weight	Scenario 4 Culture weight	Scenario 5 Environment weight
1	2007	2007	2012	2007	2002
2	2012	2012	2007	2012	2007
3	2002	2002	2002	2002	2012

Discussion and conclusions

In this paper, an approach integrating IO model with MCDM method is proposed to evaluate the comprehensive impacts of tourism sectors on economy, environment, society, and culture in Hainan. An empirical analysis for Hainan is conducted for illustration and verification. Generally, the major contributions of this work can be summarized into the following three aspects. First, an extended IO mathematics framework is constructed to estimate the various domestic, imported, direct, and indirect multipliers of tourism sectors. Second, four MCDM methods are applied to evaluate the comprehensive impacts of tourism considering four dimensions of economy, environment, society, and culture. More than one MCDM methods and more than one evaluation dimensions can provide more robust comprehensive evaluation of impacts of tourism sectors. Third, based on the proposed methodology, an empirical study reveals the changes of tourism development in Hainan from 2002 to 2012.

In this empirical study, the proposed methodology is implemented to evaluate the comprehensive impacts of tourism sectors in Hainan during 2002–2012. Generally, the overall performance of tourism sectors in Hainan shows a trend of first increasing from 2002 to 2007 and then decreasing from 2007 to 2012. 2007 is the best year for comprehensive impacts of tourism sector in Hainan. Economic dimension is the most important consideration for the comprehensive impacts evaluation of tourism sectors in Hainan. Two types sensitivity analysis of weights show the change of single criterion weight has little influence on the comprehensive evaluation results. But it is different when the weights of four different dimensions change as shown as Table 10. When cultural dimensions is more valued and four dimensions are treated identical, the comprehensive evaluation results show a trend of first rising and then falling. When more attention is paid to the social dimension, the overall performance of tourism sectors in Hainan gets better year by year from 2002 to 2012. But when more importance is attached to the environmental dimension, the overall performance of tourism sectors in Hainan gets worse year by year.

For the economic dimension impacts, both domestic and inbound tourism revenues of Hainan increased significantly from 2002 to 2012. Value-added brought by tourism sectors increased from 0.8072 Billion Yuan in 2002, 1.5983 Billion Yuan in 2007 to 3.5632 Billion Yuan in 2012. The backward linkage multiplier of tourism sectors is greater than the forward linkage multiplier. And the indirect backward multiplier of tourism sectors are greater than 1. Tour's backward linkage multiplier ranks the first across six tourism-oriented sectors. The maximum forward linkage multiplier is transportation. The backward linkage multiplier of tourism sectors continues to rise from 2002 to 2012. But output multiplier of tourism sectors increased from 2002 to 2007, and decreased from 2007 to 2012. And the value-added of tourism export trade decreased from 0.2271 Billion Yuan in 2002 to 0.1866 Billion Yuan in 2012.

For the environmental dimension impacts, in order to support tourism sectors development in Hainan, the amount of both domestic and imported energy consumed is increasing every year. Especially domestic energy consumption rose sharply in 2012.The amount of GHG emission for CO_2, CH_4, N_2O generated by tourism sectors also increased annually. Total carbon dioxide emissions rose from 2967.5208 Mt in 2002, 3129.0235 Mt in

2007 to 7669.5295 Mt in 2012. Total methane emission also increased from 0.2865 Mt in 2002 to 0.5361 Mt in 2012. Total nitrous oxide emitted 0.0996 Mt in 2002, 0.0982 Mt in 2007, and 0.2367 Mt in 2012. Especially, the imported carbon dioxide emission fast during 2002 to 2012. "Transportation", "tour", "wholesale and retail trade", and "food serving" are high GHG emission intensity tourism sectors.

For the social and culture dimensions impacts, tourist reception number increased from 11.2474 Mpt in 2002, 18.4550 Mpt to 33.2037 Mpt. The rapid increasing in the number of tourists is conducive to the cultural exchanges in Hainan. And tourism facilities in Hainan become more and more mature during 2002 to 2012. For the employment effects, Hainan's direct and indirect tourism employment remuneration coefficients in 2012 are 0.1646 and 0.4341. Entertainment, accommodation, food serving, and transportation are the main tourism-oriented sectors for absorbing employment. But focus on the tourism consumption structure of Hainan, the consumption proportion of the tourism of urban resident is always higher than that of rural resident. And the forward and backward linkage multipliers of tourism and cultural sectors in Hainan are very low. It reveals that Hainan's tourism development is still at the primary stage. According that, this study proposes the following recommendations for Hainan's tourism development policy.

1. Increasing the value-added of tourism export trade. Economic dimension is the most important dimension, but the results show the development of tourism economy in Hainan slows down from 2007 to 2012, especially for the value-added brought by tourism trade. Although there are always tourism trade surplus from 2002 to 2012, the amount of the trade surplus brought by tourism trade in Hainan is decreasing from 2002 to 2012 with the decreasing of the value-added of the tourism export trade. In the future, it has a trend to become a tourism trade deficit. Therefore, it is suggested that the government of Hainan should accelerate the upgrading of tourism industry structure to attract more inbound tourists to consume Hainan's tourism products and increase the value-added of tourism export trade to balance the import and export trade of tourism and even maintain the tourism trade surplus.
2. Strengthening the integration of tourism and cultural sectors. Culture is the second important dimension. But the forward and backward linkage multipliers of tourism and cultural sectors in Hainan are very low. It reveals that Hainan's tourism development is still at the primary stage. So it is necessary for Hainan to accelerate the integration between the tourism and cultural sector. For example, developing the local folk tourism cultural products, creating the special tourism cultural originality goods.
3. Increasing the propaganda of green tourism concept. Imported carbon dioxide emission, imported N_2O emission are slight sensitive criteria. In Scenario 5, the results of rankings change absolutely. And the overall performance of tourism industry in Hainan from 2002 to 2012 is deteriorating year by year. It reflects the negative impacts of tourism industry on Hainan's environment are increasing. In order to protect environment, it is suggested that Hainan should promote green tourism and encourage more tourism enterprises to provide low-carbon tourism products. Some incentives and penalties should be used to achieve the purpose of energy saving and emission reduction, such as tourism carbon tax or environmental tax.

4. Stimulating the tourism consumption of local residents and dealing with the relationship between local residents and foreign tourists. The proportion of the tourism consumption in the local residents (including the urban and rural resident) shows firstly increased and then decreased. There are two main reasons for this phenomenon. On the one hand, the total tourist reception number all exceeded the population of Hainan from the 2002 to 2012, which has caused certain pressure on the tourism consumption space and living space of the local resident. On the other hand, due to the simplification of tourism production structure in Hainan, local resident's interest in local tourism products has gradually declined. So it is important to balance the relationship between the local resident and foreign tourists and provide local residents with special tourism projects and weekend tourism products to stimulate the tourism consumption brought by local residents.

Table 10. The results of sensitivity analysis using different scenarios and reasons

Scenario	Rankings	Description of possible reasons
Scenario 1-four dimensions are consider equally important	$2007 \succ 2012 \succ 2002$	The number of the good performance criterion is more than the number of the bad performance criterion
Scenario 2-economic dimension is the most important	$2007 \succ 2012 \succ 2002$	The overall impacts on the economic is good except for the the value-added of the tourism trade
Scenario 3-social dimension is the most important	$2012 \succ 2007 \succ 2002$	The tourism has a good social impact on Hainan except for the tourism consumption impact on local resident's consumption
Scenario 4--cultural dimension is the most important	$2007 \succ 2012 \succ 2002$	The forward and backward linkage between tourism and culture sector in Hainan are low, and there is a big gap between 2012 and 2007
Scenario 5-environment dimension is the most important	$2002 \succ 2007 \succ 2012$	The energy consumption and GHG emission (CO_2, CH_4, N_2O) increased annually. But the intensity of them decreased annually, the energy consumption and GHG emissions per tourism output are decreasing

Table 11. Tourism product features of some famous international islands

Islands	Product features
Hawaii	Pay attention to the authentic cultural experience and provide tourism products with unique national customs
Jeju	Natural sightseeing, cultural experience, combination of golf and tourism, tax-free shopping policy
Okinawa Jima	Natural scenery, cultural experience, Japanese traditional celebration experience, Promotion of Japanese Special Products
Bali	Natural sightseeing, ocean sports, cultural experience, Eco-tourism
Singapore	Sports Tourism, Agricultural Tourism, Cultural Tourism, Urban Experience
Hong Kong	Tax-free shopping, theme parks, urban cultural experience, sports gambling
Macao	Cultural Experience and Gambling Industry

Tourism is often accredited as having positive impacts on local area due to the connection with economic development, such as promoting the local economy development, realizing poverty alleviation, reducing the gap between urban and rural development. However with the rapid development of tourism, the impacts about environment, society and culture are becoming key factors to evaluate the comprehensive performance of tourism in a region. Since the implementation of the policy of international tourism island in Hainan in 2009, tourism has entered a period of rapid development in Hainan. For the tourism infrastructure, the total number of tourist hotels and beds has increased to 674,162664 in 2012. The 654-kilometer high-speed railway around the island linked 12 coastal cities in Hainan to make it convenient for tourist to travel. For the tourism revenue and output multiplier, the tourism revenue has increased continually at the same consumption price index level. Economic output based on $1 spending in tourism sectors is growing. For the linkage between tourism sector and other sectors, tourism sector has promoted the development of other sectors, such as agriculture, forestry, animal husbandry and fishery, food manufacturing, computer services and software industry, electricity and heat, financial activities and other sectors. But for the inbound tourism, the number of the inbound tourist has not increased significantly since the implementation of the policy in 2009. Simultaneously, the value-added of tourism trade brought by inbound tourists is decreasing. The international tourism island policy has little effect on the inbound tourism in Hainan. Further more, the backward and forward linkage multipliers between tourism and culture sectors of Hainan are so weak that it lacks unique tourism products to attract inbound tourists. And the environmental pollution caused by tourism is also becoming more and more serious. There are several challenges in the development of tourism in Hainan. Comparing some similar international tourism islands as a frame of reference as seen in Table 11, it is not difficult to find that these islands do their efforts to attract inbound tourist, all in the line with basic principle of "the more ethnic, the more the world " to create unique tourist attractions integrating the tourism with the local culture. Therefore, speeding up the integration between the tourism and culture sectors is the important and main content for the Hainan's tourism development in the future. Moreover, the green tourism is the another future direction for the development of tourism development in Hainan.

Author contributions

In this work, Ping-Ping Lin and Deng-Feng Li conceived the study and were responsible for the design and development of the data analysis. Ping-Ping Lin, Bin-Qian Jiang and Gao-Feng Yu were responsible for data collection and analysis. Ping-Ping Lin wrote the first draft of the article. Deng-Feng Li, Ping-Ping Lin and An-Peng Wei revised the article.

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