Sustainability **2014**, *6*, 8980-9006; doi:10.3390/su6128980

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

An Entropy-Perspective Study on the Sustainable Development Potential of Tourism Destination Ecosystem in Dunhuang, China

Huihui Feng [1,2], Xingpeng Chen [1,*], Peter Heck [2] and Hong Miao [3]

[1] College of Earth and Environmental Sciences, Lanzhou University, Lanzhou 730000, China; E-Mail: fhh_ld2008@163.com

[2] Institute for Applied Material Flow Management (IfaS), Trier University of Applied Science, Birkenfeld 55761, Germany; E-Mail: p.heck@umwelt-campus.de

[3] School of Resources and Environment, Ningxia University, Yinchuan 750000, China; E-Mail: miao_h@nxu.edu.cn

* Authors to whom correspondence should be addressed; E-Mail: chenxp@lzu.edu.cn; Tel.: +86-931-891-2404; Fax: +86-931-891-1843.

External Editor: Bing Xue

Received: 31 August 2014; in revised form: 25 November 2014 / Accepted: 27 November 2014 / Published: 5 December 2014

Abstract: This paper analyzed the characteristic of the tourism destination ecosystem from perspective of entropy in Dunhuang City. Given these circumstances, an evaluation index system that considers the potential of sustainable development was formed based on dissipative structure and entropy change for the tourism destination ecosystem. The sustainable development potential evaluation model for tourism destination ecosystem was built up based on information entropy. Then, we analyzed each indicator impact for the sustainable development potential and proposed some measures for the tourism destination ecosystem. The conclusions include: (a) the requirements of Dunhuang tourism destination ecosystem on the natural ecosystem continuously grew between 2000 and 2012; (b) The sustainable development potential of the Dunhuang tourism destination ecosystem was on an oscillation upward trend during the study period, which is dependent on government attention, and pollution problems were improved.

Keywords: sustainable tourism; tourism destination ecosystem; entropy change; entropy; China

1. Introduction

Sustainable tourism (ST) is an important part of global sustainable development (SD) [1]. The rapid development of tourism has brought great benefits to tourism destinations, while a variety of other problems are emerging, such as, resources and environmental issues and poor management of the tourism industry. Generally, as a reception carrier, the tourism destination of tours concentrates all elements of tourism on an effective framework, which is the most vital part for examining the impact of tourism. Hence, research for sustainable development of tourism destinations could improve the overall efficiency of tourism and optimize the ecological services related to the tourism. Until now, a number of organizations and academics have paid attention to this topic as well as achieved great progress in research methods and practices.

Particularly, their research focus on the following contents [2–12]: (a) The concept of ST [13–22], for example, Hunter suggested that the concept of ST be redefined in terms of an over-arching paradigm which incorporates a range of approaches to the tourism/environment system within destination areas [13]. Swarbrooke [14] and Aall [17] noted that ST is not just about protecting the environment; it is also concerned with economic viability and social justice, and a suitable balance must be established between these three dimensions to guarantee its long-term sustainability. Sharpley point that there has been significant differences between the concepts of ST and SD, the principles and objectives of SD cannot be transposed onto the specific context of tourism [15]. Hardy argued that ST has traditionally given more focus to aspects related to the environment and economic development, which should be more focused on community involvement [4]. Gianna noted the need to very clearly distinguish between the concept of ST and the idea of tourism as one possible tool to support sustainability at multiple levels [16]. Saarinen concluded that perspectives of the resource-based tradition and the community-based tradition have their advantages in different use contexts and they can complement each other, but in respect to the idea of sustainability and the future challenges of humanity, they all share the same major limitation, which is the strong focus on the local scale [18]. Moyle and McLennan noted that the frequency of occurrence of sustainability as a concept has slightly increased in strategies over the past decade. At the same time, there has been a shift in the conceptualisation of sustainability, with thinking evolving from nature-based, social and triple bottom line concepts toward a focus on climate change, responsibility, adaption and transformation [20]; (b) The indicators of ST [23–41], for example, McElroy constructed a "Composite Tourism Penetration Index" from per capita visitor spending, daily visitor densities per 1000 population and hotel rooms per square kilometer. They tested it on 20 small Caribbean islands and yielded three levels of increasing penetration [26]. McCool and Moisey provided a tourism industry perspective on what items could be sustained and what indicators should be used to monitor for sustainability policies [27]. Wang analyzed the principle of indicators of ST, constructed the indicators of ST, the indicator weight and selected the comprehensive evaluation method [40]. Ward and Butler investigated how to monitor sustainable tourism development (STD) in Samoa. It described some of the methodological considerations and processes involved in the development of STD indicators and particularly highlighted the importance of formulating clear objectives before trying to identify indicators, the value of establishing a multi-disciplinary advisory panel, and the necessity of designing an effective and flexible implementation framework for converting indicator results into management action [31]. Ko proposed that the "Barometer of tourism sustainability" (BTS) model represents the comprehensive level of tourism sustainability in a given destination, combining human and natural indicators into an index of sustainable tourism development, without trading one off against the other. The "AMOEBA of tourism sustainability indicators" (ATSI) model was introduced to complement the BTS analysis and to illustrate individual levels of sustainability of tourism indicators [24]. Chris and Sirakaya employed a modified Delphi technique to constructed indicators from political, social, ecological, economic, technological and cultural dimensions for community tourism development (CTD) [25]. Schianetz and Kavanagh proposed the methodological framework for the selection and evaluation of sustainability indicators for tourism destinations, the systemic indicator system (SIS) this framework takes the interrelatedness of sociocultural, economic and environmental issues into account [33]. Reddy engaged in the identification, selection and evaluation of sustainability indicators for rapid assessment of tourism development in Andaman and Nicobar Islands of India (ANI). These indicators are developed and assessed mainly for developed countries and evaluated a feasible bottom-up approach based on local knowledge [38]. Blancas and Gonzalez introduced an indicator system to evaluate sustainability in established coastal tourism destinations, as well as developing a new synthetic indicator to simplify the measurement of sustainability and facilitate the comparative analysis of destination ranking [30]. Buckley suggested that the indicators of ST should include: population, peace, prosperity, pollution, protection [6]. Oyola and Blancas presented an indicator system to evaluate ST at cultural destinations. Also, they suggested a method based on goal programming to construct composite indicators. Then, they proposed three basic practical uses for these indicators: the formulation of general action plans at a regional level, the definition of short-term strategies for destinations and the establishment of destination benchmarking practices [36]. Delgado and Saarinenc examined the significant role of indicators based on literature review in tourism planning and management. The indicator type (set or index) needs to be carefully selected depending on the situation under analysis and the purpose underpinning the study. However, indicator effectiveness to achieve the ideals of sustainable tourism development is affected by the ambiguity in the definition of the concept of ST and problems associated with data availability and baseline knowledge. The main challenge is to overcome strategic guidelines and political and theoretical proposals of indicators and achieve practical applications for the sustainable development of tourism [23]; (c) Ecological security and environment carrying capacity for tourism [42–54], for instance, Ahn used the limits of acceptable change (LAC) framework as a guide to examine and inform the process of ST on a regional scale. Also, he examined resident attitudes toward tourism development in general, toward desirable types of tourism services, toward local conditions and finally, toward perceptions about if and how conditions might change due to tourism [42]. Gössling provided a methodological framework for the calculation of ecological footprints (EF) related to leisure tourism. Based on the example of the Seychelles, it reveals the statistical obstacles that have to be overcome in the calculation process and discusses the strengths and weaknesses of such an approach [44]. Hunter attempted to connect, conceptually, the realms of ST and EF thinking. It is argued that primary research should focus on calculating the TEF associated with individual tourism products, throughout the product's life-cycle. As well as bringing another dimension to our understanding of tourism's actual ecological demand, it is also argued that the concept of the TEF may be used to clarify theoretical aspects of the sustainable tourism debate, helping to rejuvenate this debate in the process [47]. Cui put out the tourism bearing capacity index and its arithmetic model of operation. He defined the tourism environmental bearing capacity as the bearing intensity of tourism destinations during a period which does not do harm to the present and future people in its current state and which can be accepted by the residents. The bearing intensity of tourism destinations mainly includes the tourist density, the tourism land use intensity and the tourism income value [50]. Xiao constructed the models of general ecological security coefficient (GESC) of island tourism destination and special ecological security coefficient (SESC) of island tourism destinations, and then the assessment framework and judgment criterion were proposed on the ecological security of island tourist destination (ESITD) and island tourist sustainable development (ITSD). Furthermore, the models of island tourist ecological footprints were established based on the idea of EF and an empirical analysis of Zhoushan Islands, China was conducted [51]. Salerno and Viviano describes how the concept of Tourism Carrying Capacity (TCC) has shifted from a uni-dimensional approach to incorporating environmental, social and political aspects. Then, an empirical analysis of internationally popular protected area used by trekkers, the Mt. Everest Region, was conducted [52]. Zhong examined the applicability of the model to China's Zhangjiajie National Forest Park. At the same time, both external and internal factors affecting the park's tourism development as well as the environmental, social, and economic changes of the area are also discussed [53]; (d) The development pattern of ST [55–60] was examined by Rodríguez along with an analysis of the life cycle of Tenerife (Canary Islands, Spain), and two types of strategic decisions are considered: the political–legal decisions of the regional government to regulate tourism activity and the decisions to regrade supply, developed by the administrative institutions related to tourism activity in this destination [55]. Keitumetse devised a Community-Based Cultural Heritage Resources Management (COBACHREM) model that merges the technical and academic approaches to illustrate a symbiosis between cultural and natural resources for sustainable resources conservation at community levels [57]. Rizio explored a forest ecosystem and identified its potential flows of utility, addressing those which best satisfy tourism activities and recreational purposes; to identify the most appropriate tools to manage the flows of utility based on sustainable principles which integrate tourism activities [58]; (e) With regards to perception of residents and visitors [61–75], for example, Xuan studied residents' perceptions of the economic, socio-culture, environment impacts of tourism and residents' attitudes to tourism development in Hainan and Sanya, China. It was concluded that the residents are more aware of positive tourism impacts than negative impacts, and they support tourism development with some reasonable attitudes [61]. Choi and Sirakaya too developed and validated a scale assessing residents' attitudes toward sustainable tourism (SUS-TAS). Then, they administered a 51-item scale of resident attitudes toward sustainable community tourism and 800 households in a small tourism community in Texas. Psychometric properties of SUSTAS along with its practical and theoretical implications are discussed within the framework of sustainable tourism development [65]. Nicholas and Thapa examined visitors' perspectives and support for sustainable tourism development in the Pitons Management Area (PMA) in St. Lucia. Specifically, the focus was on visitors' environmental, economic, and social attitudes based on a sustainable tourism development framework and the effect and best predictive validity of attitudes on support for sustainable tourism development were explored [68]. Bimonte and Punzo analysed how distinct groups of residents, characterised by different levels of involvement in tourism-related activities, perceived the tourism phenomenon, and to check whether there exists a latent or potential ground for conflicts between groups of residents [75]. Cottrell and Vaske examined the relative influence of four sustainability dimensions (environmental, economic, socio-cultural, and institutional) in predicting resident satisfaction with sustainable tourism development in Frankenwald Nature Park, Germany. Structural equation modeling supported the hypothesis that all four dimensions were significant predictors of satisfaction. The economic dimension was the strongest predictor, followed by the institutional, social, and environmental dimensions. Findings indicate that all four dimensions should be included for a holistic approach to planning and monitoring sustainable tourism development [69]. Sörensson and Friedrichs used importance-performance analysis (IPA) to examine the performance of one particular tourist destination with regard to social and environmental sustainability, and to establish whether international tourists and national tourists differ in the sustainability factors they consider important [70]. Dorcheh and Mohamed reviewed existing literature on local perceptions of tourism development and its process. It also discusses influential theories and explains the social exchange theory as an effective framework for sustainable cultural tourism [71]. Miller and Merrilees examined tourists' pro-environmental behaviours in four major categories: recycling; green transport use; sustainable energy/material use (lighting/water usage), and green food consumption. They explored five major antecedents to those categories: habitual behaviour, environmental attitudes, facilities available, a need to take a break from environmental duties, and sense of tourist social responsibility. Also, the poorly understood belief that pro-environmental behaviour weakens when residents become tourists was examined [73]; (f) With regards to research for stakeholders [76–84], Hardy and Beeton argued that the nexus involves an understanding of stakeholder perceptions, and applies this to the Daintree region of Far North Queensland, Australia, to determine whether tourism in the region is operating in a sustainable or maintainable manner. In order to do this, an iterative approach was taken and local people, operators, regulators and tourists were interviewed, and content analysis applied to management and strategic documents for the region. The results illustrate the importance of understanding stakeholder perceptions in facilitating sustainable tourism [83]. Timur and Getz examined the concept of sustainable tourism development in urban destinations. Both qualitative and quantitative data were employed, from interviews and questionnaires undertaken in Victoria and Calgary, Canada, and San Francisco, USA. Respondents representing the three clusters of the tourism industry, local government and the host environment were examined on their interpretation of "sustainable tourism", sustainability goals and barriers to achieving sustainable tourism in urban destinations. Results revealed important similarities and differences among key stakeholders, and particularly a lack of appreciation for a triple bottom line approach among the tourism industry respondents [81]. Vellecco and Mancino demonstrate that in lacking shared responsibility, conflicts and tensions inside the local community paralyse innovative environmental behaviors when they ought really to be turned into opportunities for debate so that shared strategies and solutions may be identified in three Italian areas [78]. Holden found that although stakeholders shared positive perceptions of the economic benefits of tourism, its continued use for sustainable development is uncertain. Key challenges include a lack of confidence in the economic certainty of tourism and its use for out-migration, a maturing tourism market, and challenges to the local control of natural resources with external hegemonic forces [80]. Dabphet and Scott explored the diffusion of the sustainable tourism development concept among stakeholders in the tourism destination of Kret Island, Thailand. It is argued that both interpersonal and media communication and the identification of key actors in the community are needed to effectively diffuse sustainable tourism ideas among destination stakeholders. The results validate the use of diffusion theory as a means to understand the transfer of the sustainable tourism development concept among stakeholders, and they also provide information useful for the design of information dissemination programs [82]; (g) In regard to relevant policy for ST [85–94], for instance, Farsari and Butler explored policies for sustainable tourism development and potential interrelationships between policy considerations. Such policies have been characterized as *ad hoc* and incremental, lacking a clear orientation towards sustainable development, and the complex relationships underpinning them have rarely been considered in decision-making for sustainable tourism [87]. Dodds and Butler found that although respondents were aware of sustainable tourism, the individual advantage from exploiting shared pooled or shared resources is often perceived as being greater than the potential long-term shared losses that result from the deterioration of such resources, which means that there is little motivation for individual actors (whether governments, elected officials, or individual operators), to invest or engage in protection or conservation for more sustainable tourism [86]. Yasarataa and Altinay noted key political actors' interests and how to mitigate personal interests to facilitate and maintain sustainable tourism development in small states North Cyprus, Turkish [92]. Whitford and Ruhanen recommends that there cannot be a "one size fits all" framework for indigenous tourism development to suit all circumstances. Policies need to draw upon indigenous diversity and, in a consistent, collaborative, coordinated and integrated manner, provide the mechanisms and capacity-building to facilitate long-term sustainable indigenous tourism [93]. Solstrand suggest that the environmental and socio-cultural sustainability of marine angling tourism (MAT) in Norway and Iceland requires a complex socio-ecological systems perspective, with interactive governance strategies leading management policies. Sustainability requires that a management strategy not only focuses on the economic aspects; priority must also be given to minimizing multi-stakeholder conflicts and providing sufficient resource data to protect vulnerable fish stocks [89]. Xu and Sofield examined the situation that little guidance is provided to promote sustainability principles in tourism development strategies in China. In the future, a pro-active sustainability approach should be integrated with environmental concerns to allow tourism to participate constructively in the national transformation to a sustainable society [90].

Due to tourism research involved in geography, ecology, environmental science, sociology and so on, also combined with different scales covering the micro to the macro [2], the research focus on the multi-index comprehensive evaluation method (MICEM), tourism carrying capacity (TCC), tourism environment impacts assess (TEIA), ecological footprint analysis of tourism (EFT), life cycle assessment (LCA), limits of acceptable change (LAC) and Geographic Information Systems (GIS) [95–97]. The MICEM could quantify the level of tourism sustainable development, which employed AHP and Delphi method by the level of sustainable development and other potential targets. However, selection indicator and its weights usually by personal decision-making [33,39,98–101]. TCC could comprehensively measure the carrying capacity of tourism destinations such as ecology, resources, psychological and space, which employed remote sensing (RS), field measurements, questionnaire and Delphi method, *etc.* However, it has a characteristic of randomness and subjectivity when assessing environmental carrying capacity [102–104]. TEIA is an effectively method to analysis the effect of tourism on ecological environments by mathematical statistical analysis methods form microscopic view, which construct assessment index system and select assessment model based on environmental background to monitoring the feedback mechanism for impact of tourism environmental. However, it's usually ignoring the effectiveness of monitoring and feedback mechanism [105,106]. EFT constructs the tourism ecological footprint according to various data of per capita consumption by bottom-up questionnaire and investigates statistics. The consequent was directly comparable based on productive land area; it is a global standards value [56]. It is suitable to research on a small-scale since the ecological burden is likely to be passed on by interregional trade in tourism destination [43,47,107]. LCA could identify the stage of development of the tourism destination and solve some problems [49]. It is difficult to quantify the environmental problems in sustainable development [108,109]. The theoretical framework for LAC include identifying the issues and concerns, and defining and describing the types of tourism opportunities, *etc.* in the planning area. It could solve the contradiction between development of tourism and conservation of resources, which is mostly influenced by the decisions of programmer makers and managers [42,110]. GIS are now recognized widely as a valuable tool for which applications for regional tourism planning have not mushroomed as in other fields. This is also reflected in the field of sustainable tourism. Nonetheless, sustainable tourism decision-making and carrying capacity estimation has a lot to benefit from using such technologies. GIS can be used for managing the various information needs, estimating indicators, and generally assisting decision making in the planning phase, as well as, in the monitoring and evaluation phases [111]. Therefore, researchers have used diverse methodologies with more quantitative analysis, as for each method there are certain advantages and disadvantages [112]. Current studies are using more comprehensive approaches. Previous literatures show that a tourist destination is a relatively complete artificial ecosystem; the ecological is a basis for sustainable development [113]. However, relevant research has failed to exhaustively analyze the structures, considering the functions and evolutionary mechanisms of the compound tourism destination ecosystem. This is indeed a shortcoming of those research studies. Entropy, as a measure of system dissipation or disorganization, has been used to analyze social systems in various contexts [114–118]. In relation to tourism [119–123], for example, Bailey noted that Social Entropy Theory (SET) was a very general macro sociological systems theory [114]. Kenneth and Bailey point out that the most recent applications of entropy are in social entropy theory and macro accounting theory [115]. Stepanic jr and Stefancic hold that the established level of analogy between certain characteristics of social systems and part of thermodynamic formalism in the simplified model encourage one to assume that even deeper analogies might be drawn to construct more complete and detailed models of social systems [116]. Wilson describes entropy in urban and regional modelling introducing a new framework for constructing spatial interaction and associated location models [117]. Cabral and Augusto summarized entropy multifaceted character with regard to its implications for urban sprawl, and propose a framework to apply the concept of entropy to urban sprawl for monitoring and management. Hao point out that the phenomenon of the increase of entropy also exists in the tourism destination's ecological system [121]. Zhao proposed the conception and mainly indicates that research can broaden insights on tourism systems' carrying capacities through entropy change analysis from the view of the tourism system's entropy principle under the tourism dissipative structure mechanism [122]. Qian noted that the tourism environment system was an open system. It is unceasingly exchanging material and energy with the outside. It is impossible to achieve the absolute balance through introduction of the negative entropy flow [123]. Relevant research has indicated that tourism destination ecosystems are a typical dissipative structure. Therefore, there is certain feasibility in analyzing its evolution and sustainable development potential from the perspective of entropy. Given the analysis above and based on the relevant former research, this study based on the structure, function and characteristic of tourism destination ecosystems, applied information entropy theory for Dunhuang city which combines analysis entropy with information entropy to establish a tourist destination quantitative ecosystem model for evaluating the potential of sustainable development of Dunhuang tourism. It could offset the disadvantage of indistinct strategies and lack of specificity in some degrees in the sustainable development of tourism destinations.

2. Study Area

Dunhuang City is located in the border area of Gansu, Qinghai and Xinjiang Provinces, as the western end of the Hexi Corridor in Gansu Province, China. It belongs to a typical arid oasis region with unique geographical, historical and cultural status. In history, Dunhuang was an important hub on the ancient Silk Road and the point of integration of Eastern with Western civilization. To some extent, it is known as "human Dunhuang" owing to the intersection and coordination of the world's four major cultural systems [124]. It is rich in tourism resources, with Mogao Grottoes called the "Pearl of Oriental Art", Mingsha Mountain known as "desert spectacle", Crescent Lake and other tourism resources. All these places promote the development of tourism resources. In 2012, the number of visitor arrivals was 0.312 million people-times and the total income was 2.687 billion Yuan [125]. However, this explosive growth has brought a series of severe problems for cultural heritage, such as, tourists' periodic overload. Because of those intensive human activities, the weak regional environment, and the global climate, there has been a shortage of water resources, as the core of the regional ecological problems, which continue to worsen [126]. Therefore, it is very necessary to study the potential of sustainable development of the Dunhuang tourism destination ecosystem.

3. Methodology

Entropy, firstly proposed by German physicist R Clausius [127,128], is the unique macroscopic quantity in thermodynamics and statistical physics. In 1948, Shannon introduced this concept into information theory and named it "information entropy" [129]. Generally speaking, information entropy theory is based on probability and statistics to reflect the degree of disorder and quantify the evolution direction of the system. When analyzing the complexity and uncertainty of problems, it can be used as a multi-dimensional method to quantify and determine the comprehensive benefits [130,131]. According to theory of dissipative structures by I. Prigogine [132–134], an open system, which is far from equilibrium during the process of exchanging matter and energy with outside environments, has the tendency of entropy growth; hence, this system, only by constantly introducing negative entropy from the outside flow in order to offset internal positive entropy, will finally have a new and ordered direction for further development. That means that the large entropy of the system corresponds to the low degree of order and *vice versa*.

3.1. Entropy Change and Dissipative Structure of the Tourism Destination Ecosystem

The tourism destination ecosystem is a special ecosystem of areas with rich tourism resources and occurrences, that is established based on the original nature or artificial ecosystem during tourism development [121]. As the spatial carrier between tourist activities and the ecological environment, tourism definition of ecosystems involves the continuous exchange of materials, energy and information with external environments. It also makes irreversible the non-equilibrium processes inside the system, which is always producing positive entropy, inflowing negative entropy with the characteristics of openness, which is far from equilibrium, nonlinearity and ordered fluctuation [122,123]. Tourism destination ecosystem is a typical dissipative self-organizing system that possesses dissipative characteristics and analyzes the evolutionary process of entropy changes.

The tourism destination ecosystem development and evolution is led mainly by the evolution of its socioeconomic ecosystem under normal conditions. Given this progression, this study analyzes the interactions between the tourism destination socioeconomic ecosystem and its natural ecosystem and other regions by analyzing the entropy change process of the tourism destination socioeconomic ecosystem. This involves analyzing the evolutionary process and developmental trend of the tourism destination ecosystem, as well as evaluating the sustainable development potential of the tourism destination ecosystem.

According to the dissipative structure theory [135], there are two parts of entropy changes in tourism destination ecosystems. The first one is the entropy flow caused by the tourism destination socioeconomic ecosystem's exchange of materials, energy and information with external environments *etc.*; it reflects the carrying capacity of the tourism destination nature ecosystem for its socioeconomic ecosystem. Another part is the entropy production caused by irreversible non-equilibrium processes inside the system, which reflects its regeneration potential and could indicate the vitality of the tourism destination ecosystem. The total entropy change of the system is the summation of entropy production and entropy flow, reflecting the overall level of development in the tourism destination ecosystem [136]. The environment is affected by the development of tourism and associated activities as part of the evolution in becoming a tourism destination ecosystem. This is a result of the increase in disorder of entropy production, which is caused by de-vegetation, water pollution, soil fertility, air quality degradation, biodiversity decline and the assimilation features of traditional culture, *etc.* inside of the tourism destination ecosystem. The total entropy changes of the system and disordered parameters will increase if the tourism destination ecosystem does not exchange moderate amounts of material, energy and information with external environments, so the entropy flow does not offset entropy production. This will result in some negative effects for the tourism destination ecosystem, such as an increase in disorder within the system, lack of power, regulatory failure and weaker functioning.

The analysis of entropy changes in tourism destination ecosystems describes the state of tourism system and changes during the exchange of recourses with an external system. The amount or size of entropy not only expresses the level of internal system resources' effective utilization, but also reflects the elastic changes of system affordability. The change in size of the system entropy refers to higher or lower effective utilization rates in the evolutionary process of the tourism destination ecosystem's exchange of materials and energy with external environments [122].

3.2. Indicator System Establishment

The indicator system is an effective tool for measuring and evaluating the tourism sustainable development level. There are lots of indicators that play a more important role for tourism sustainable development. Depending on the principles of scientific city, comprehensiveness, dynamics, hierarchy, maneuverability and perceptiveness [137,138], using the references from Indicators of Sustainable Development for Tourism Destinations: A Guidebook (WTO, 2004) [139], European Tourism Indicator System For Sustainable Destinations (EU, 2013) [140], ecological civilization city construction indicator system of Dunhuang city and related research results [23–41,141], the article establishes tourism destination ecosystem sustainable development analysis and indicators system evaluation according to three aspects. They are the structure, function and characteristic of tourism destination ecosystems; the entropy production and entropy flow in the process of system operation; and the ecological environment pollution and destruction during the tourism industry development within the system. The article selected two parts of the entropy production and entropy flow; four aspects that are the supportive entropy input index, the stressful entropy output index, the consumption metabolism index of entropy and the regenerate metabolism index of entropy; 29 representative index (Table 1).

Table 1. Index system hierarchy of sustainable development potential evaluation.

Criterion	Sub-Criterion	Indicators	Measurements
Entropy flow	Supportive entropy input index (A)	Number of travel agencies (A1)	unit
		Number of direct engaged persons in tourism industry (A2)	person
		Number of star-rated hotels (A3)	unit
		Number of beds in star-rated hotels (A4)	bed
		Passenger-kilometers by highways (A5)	10^4 passenger-km
		Passenger-kilometers by railways (A6)	10^4 passenger-km
		Passenger-kilometers by civil aviation (A7)	10^4 passenger-km
		Annual water supply (A8)	10^4 t
	Stressful entropy output index (B)	Number of visitor arrivals (B1)	10^4 person-times
		Transport expenditure as percentage of tourism expenditure (B2)	%
		sightseeing expenditure as percentage of tourism expenditure (B3)	%
		Hotels expenditure as percentage of tourism expenditure (B4)	%
		Catering expenditure as Percentage of tourism expenditure (B5)	%
		Water used by tourists (B6)	10^4 t
Entropy production	Consumption metabolism index of entropy (C)	Total wastewater discharged (C1)	10^4 t
		Industrial wastewater discharged (C2)	10^4 t
		Emission of disulfide (C3)	t
		solid wastes discharged (C4)	10^4 t
		waste discharge by tourists (C5)	t
		Carbon emission by tourism (C6)	t
	Regenerate metabolism index of entropy (D)	Number of training institutions for tourism (D1)	unit
		Direct engaged persons in tourism industry as percentage of employees (D2)	%
		Tourism GDP (D3)	10^4 Yuan
		Tourism GDP as percentage of GDP (D4)	%
		Investment in anti-pollution Projects as percentage of GDP (D5)	%
		Proportion of industrial solid waste treated and utilized (D6)	%
		Rate of harmless garbage disposal (D7)	%
		Green coverage rate in developed areas (D8)	%
		Gardens per capita (D9)	m^2

Supportive entropy input index: Mainly embodies attractiveness and bearing capacity of the tourism destination ecosystem. The tourism destination satisfied the tourists' demands by supporting resources, infrastructures and services, support foundation of tourism development, and promotes communication with the outside and for internal operations. Therefore, here we select the related index that can reflect tourism destination development status quo and potential of its development (basic infrastructure, available water resources, *etc.*).

Stressful entropy output index: Expresses tourism activities putting pressure on the tourism destination ecosystem. During the evolution process of tourism destination ecosystem and tourist industry development, tourists and their consumption (transport, hotels, sightseeing, catering) and tourist industry energy consumption have direct or indirect influence on the tourism local ecological environment, and puts some pressure on system development, as well as slowing down the positive evolution speed of the system.

Consumption metabolism index of entropy: During the evolution process of the tourism destination ecosystem, the discharge of wastes, pollutants produced and a series of ecological problems from tourism activities to some extent weaken the sustainable development potential of the system.

Regenerate metabolism index of entropy: Mainly shows human being's governance capacity of the tourism destination ecosystem. The waste discharge by tourists is above the system bearing capacity, so that some pollution cannot be purified by the system itself; therefore, the system must rely on artificial management policies and scientific technologies. That is why human beings invest into environmental pollution management as a recovery function of tourism destination ecosystem's sustainable development.

According to the established evolution indexes of the tourism destination ecosystem, there is the calculation formula for entropy flow, entropy production and total entropy changes (Table 2).

Table 2. Symbols and formulae of entropy flow, entropy production and total entropy change.

Objective	Symbols and Formula	Means
Supportive entropy input	$\Delta_e S_1$	Disorder of system
Stressful entropy output	$\Delta_e S_2$	Disorder of system
Consumption metabolism of entropy	$\Delta_i S_2$	Disorder of system
Regenerate metabolism of entropy	$\Delta_i S_1$	Disorder of system
Entropy flow	$\Delta_e S_2 - \Delta_e S_1$	Coordination of system
Entropy production	$\Delta_i S_2 - \Delta_i S_1$	Vitality of system
Total entropy change	$(\Delta_e S_2 - \Delta_e S_1) + (\Delta_i S_2 - \Delta_i S_1)$	Order and health of system

3.3. Depending on Entropy Information Evaluation Model Establishment

Based on information entropy's benefits, information entropy's evaluation model is widely used in many scientific fields [136,142]. The tourism research focuses on the following: measuring the weight of an indicator based on the entropy method [143]; analyzing the characteristics and development measures based on information entropy, theory of entropy and dissipative structure [121–123,126,144]. More qualitative analysis was be used and a few calculation methods for entropy of tourism systems. According to the information entropy of Shannon, if we used random variables X represents uncertainty in the system, the discrete random variable could be supposed as x and its value is $X = \{x_1, x_2, \ldots, x_n\}$ $(n \geq 2)$, the probability for each value is $P = \{p_1, p_2, \ldots, p_n\}$ $(0 \le p_i \le 1, i = 1, 2, \ldots, n)$. $\sum P_{i=}1$. The information entropy can be described as follows [131,145,146]:

$$S = -\sum_{i=1}^{n} P_i \ln(\mathrm{P}_i) \tag{1}$$

where S the is information entropy of an uncertain system, P_i is the probability of the random state variable X in the uncertain system.

3.3.1. Measurement for Entropy Flow and Entropy Production of Tourism Destination Ecosystem

According to the measurement models for information entropy theory, we compute a formula for the entropy flow and entropy production based on information entropy theory and models for each year, then analyzed the complexity, coordination order and health for tourism destination ecosystems. Measurement of n indictors in m years, ΔS represents the four types of entropy based on information entropy [130,131,145], *i.e.*, the input supportive type of entropy ($\Delta_e S_1$), the output pressure type of entropy ($\Delta_e S_2$), the consumption metabolic type of entropy ($\Delta_i S_2$) and the regeneration metabolic type of entropy ($\Delta_i S_1$).

$$\Delta S = -\frac{1}{\ln m}\sum_{i=1}^{n}\frac{q_{ij}}{q_j}\ln\frac{q_{ij}}{q_j} \tag{2}$$

where ΔS represents the four types of entropy, q_{ij} is the standardized value of calculated from the raw data, q_j is sum for standardized value of index in j year, m is sum for the number of appraisal events and n is the number of indicators, i is each index, $q_i = \sum_{i=1}^{n} q_{ij}(i = 1, 2, \ldots, n; j = 1, 2, \ldots, m)$.

If the number of index is n, and the number of appraisal events is m, then E_i denotes the indicator-based information of indicator i and can be derived thus:

$$E_i = -\frac{1}{\ln m}\sum_{j=1}^{m}\frac{q_{ij}}{q_i}\ln\frac{q_{ij}}{q_i} \tag{3}$$

where E_i is the information entropy of indicator, q_{ij} is the standardized value calculated from the raw data and q_i is sum for standardized value all appraisal events in i index, $q_i = \sum_{j=1}^{m} q_{ij}(i = 1, 2, \ldots, n; j = 1, 2, \ldots, m)$.

According to the entropy weighting method [142], the entropy weight of i indicator is defined as:

$$\mathrm{Q}_i = (1 - E_i) \Big/ \left(n - \sum_{i=1}^{n} E_i\right) \tag{4}$$

where Q_i is the entropy weight of i, E_i is the indicator-based information entropy of indicator i, n is the number of indicator and $\sum_{i=1}^{n} Q_1 = 1$, $0 \le Q_i \le 1$, $n \ge 2$.

The entropy weight of an indicator is not the most important coefficient of the indicator in regard to decision-making issues. It is instead the relative degree of competition with other indicators when a set of evaluation objects is given and the evaluation indicators are determined, the entropy weighting value is closely related to the evaluation objects. From the information perspective, the entropy weight of an evaluation indicator represents how much useful information an indicator can provide [131,145]. When the entropy weighting of an indicator is larger than other indicators in the evaluation index system for the sustainable development of tourism destination ecosystems, the useful information provided by the indicator could have a greater impact on the system than the other indicators [131].

3.3.2. Sustainable Development Evaluation Model of the Tourism Destination Ecosystem

The index weight was calculated by information entropy, and then integrated to the value of normalization calculated a comprehensive score of values [130,131,146]:

$$G = \sum Q_i X_i \tag{5}$$

where: G is an appraisal score, Q_i is the weighting factor derived from information entropy (described below), X_i is the standardized value between 0 and 1 generated from raw data for each indicator. A larger value of G indicates a better state of the tourism destination ecosystem and a better potential of the tourism destination ecosystem for sustainable development.

4. Data Sources and Processing Method

4.1. Data Sources

Related data applied in this study were extracted from the 10th Five-Year Statistical Yearbook of Dunhuang City [147], 11th Five-Year Statistical Yearbook of Dunhuang City [148], Statistical Yearbook of Dunhuang City between 2011 and 2013 [149], Environmental Quality Bulletin of Dunhuang City between 2006 and 2012 [150]. Some data are obtained from the interview and questionnaire.

4.2. Data Processing Methods

This study adopted the standardize deviation to processing data and the score between [0, 1] when analyzing the evolution and development of the tourism destination socioeconomic ecosystem. The following aspects should be noted in processing data [131,146]: (a) As the entropy change model has used the four types of entropy for vector quantization, there is no need to distinguish between positive and negative indicators to standardize the data processing; (b) The assessment model for the sustainable development potential of the tourism destination ecosystem, which is based on information entropy, has not used vector quantization on different types of indicators, the data processing must distinguish between positive and negative indicators.

For the four indicators, the input supportive type of entropy ($\Delta_e S_1$) *and* regeneration metabolic type of entropy ($\Delta_i S_1$) are positive indicators, the bigger value means more coordination of the system. The output pressure type of entropy ($\Delta_e S_2$) and the consumption metabolic type of entropy ($\Delta_i S_2$) are negative indicators, the bigger value means less coordination of the system. The normalization methods for the positive and negative indicators are listed below:

Normalization method for positive indicators:

$$X_{ij}^{'} = X_{ij} \big/ Max(X_i) \tag{6}$$

Normalization method for negative indicators:

$$X_{ij}^{'} = Min(X_i) / X_{ij} \tag{7}$$

where $X_{ij}^{'}$ is the normalized value of X_{ij}, X_{ij} is the raw data for indicator *i* in *j* year, X_i represents all of the original data for indicator *i*, and $Max(X_i)$ obtains the maximum of indicator *i* by function during the study period, and $Min(X_i)$ obtains the minimum of indicator *i* by function during the study period.

5. Results and Analysis

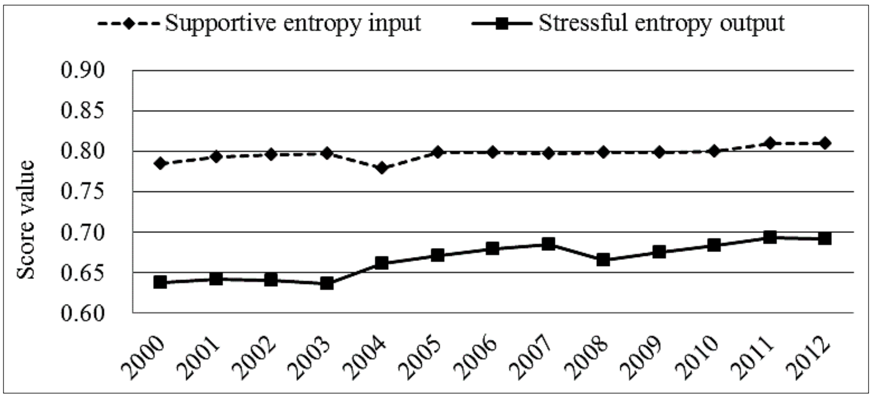
5.1. Entropy Change Analysis

The supportive entropy input showed a trend to remain stable during study period. The stressful entropy output was fluctuated within a slow upward trend (Table 3, Figure 1). For the stressful entropy output with the turning point in 2003 and 2008, the smallest value was in 2003, because the tourism industry was in a state of depression influenced by SARS. In addition, the global financial crisis and snow disaster of South China led to a smaller value in 2008. The burden on tourism destination ecosystems was decreased during those two years. However, the pressure of tourist destinations was increased with the recovery of the tourism industry. The burden of the Dunhuang tourism destination natural ecosystem was increased under the rapid development of tourism and increasing utilization of tourism resources, while the supportive entropy input experienced relatively slow growth. This shows that the pressure was increasing on the tourism destination socioeconomic ecosystem in some degree from 2008.

Table 3. Entropy production and total entropy change of the tourism destination socio-economic ecosystem in Dunhuang city on information entropy.

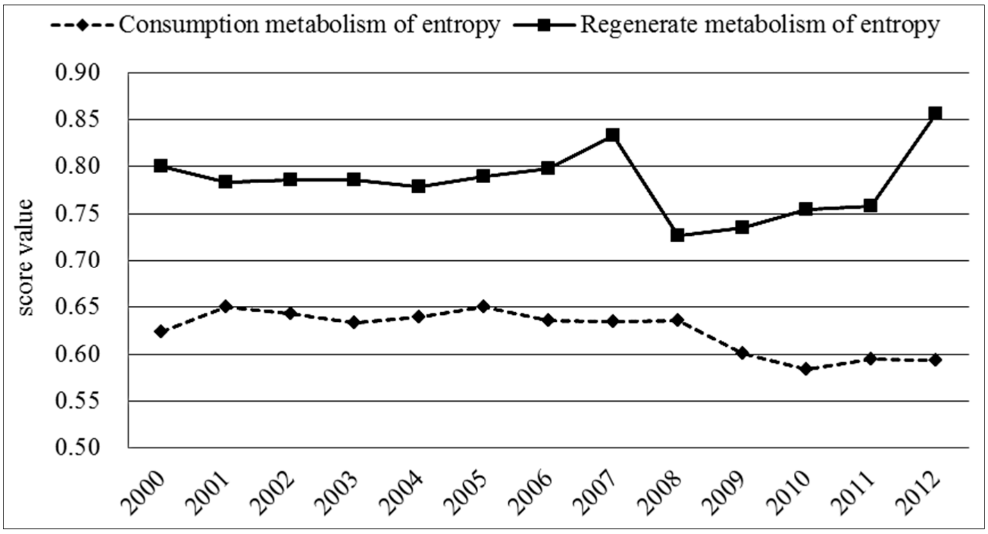
Year	Items						
	Supportive Entropy Input	Stressful Entropy Output	Consumption Metabolism of Entropy	Regenerate Metabolism of Entropy	Entropy Flow	Entropy Production	Total Entropy Change
2000	0.7846	0.6370	0.6243	0.8002	−0.1476	−0.1759	−0.3234
2001	0.7925	0.6418	0.6504	0.7838	−0.1507	−0.1334	−0.2840
2002	0.7958	0.6398	0.6429	0.7864	−0.1559	−0.1435	−0.2994
2003	0.7974	0.6356	0.6330	0.7865	−0.1618	−0.1535	−0.3153
2004	0.7793	0.6607	0.6400	0.7793	−0.1186	−0.1393	−0.2579
2005	0.7980	0.6711	0.6505	0.7893	−0.1269	−0.1389	−0.2658
2006	0.7981	0.6789	0.6357	0.7987	−0.1192	−0.1630	−0.2821
2007	0.7969	0.6850	0.6352	0.8332	−0.1119	−0.1980	−0.3099
2008	0.7980	0.6659	0.6360	0.7271	−0.1321	−0.0911	−0.2233
2009	0.7991	0.6747	0.6010	0.7357	−0.1245	−0.1346	−0.2591
2010	0.7993	0.6831	0.5837	0.7549	−0.1162	−0.1713	−0.2875
2011	0.8095	0.6925	0.5953	0.7581	−0.1171	−0.1628	−0.2798
2012	0.8101	0.6914	0.5933	0.8556	−0.1187	−0.2623	−0.3810

Figure 1. Score trends of the two entropy exchange types of the tourism destination.



The consumption metabolism of entropy showed a slowed trend down between 2000 and 2012, the regenerate metabolism of entropy fluctuated with a sharply upward trend. The turning point of regenerate metabolism of entropy was in 2007, 2008 and 2011, which first increased and then decreased with the turning point in 2007 and slowed down sharply. The minimum value was in 2008 and then showed a slowed upward trend. The turning point was a sharp upward trend in 2011 (Table 3, Figure 2). This indicates that the ecological security was improved, the potential of metabolism was better and the vitality was improved gradually in Dunhuang tourism destination from 2008.

Figure 2. Score trends of the two entropy production types of tourism destination.



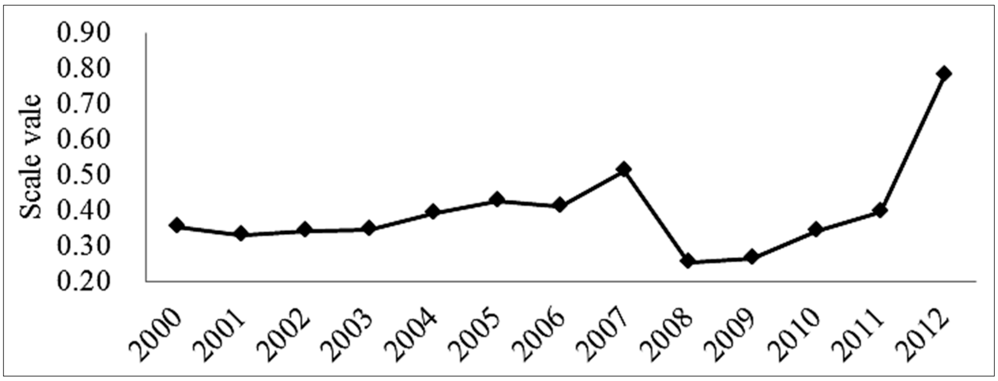
The entropy flow showed fluctuation within a slow upward trend between 2000 and 2012, while the entropy production and total entropy change both sharply fluctuated. The turning points of entropy flow, entropy production and total entropy change were during the period of 2003 and 2008 because the tourism industry was mostly effected by the external environment, with the influences of SARS in 2003 and the global financial crisis and snow disaster of South China in 2008. The entropy flow fluctuated with a slow upward trend, which first decreased and then increased with the turning points in 2003 and 2008. The entropy production and total entropy change sharply fluctuated, first increasing and then decreasing with the turning point in 2003. Also, it first increased and then decreased with the turning point in 2008

(Table 3). This indicates that the Dunhuang tourism destination ecosystem was orderly and healthy during the study period.

5.2. Analysis of Tourism Destination Ecosystem Sustainable Development Potential in Dunhuang

The values of supportive entropy input remained stable between 2000 and 2012. These values indicate the carrying capacity was relatively stable as a socio-economic ecosystem in Dunhuang. The values of stressful entropy output were decreased in 2003 and 2008, which showed that the pressure was increased on the nature ecosystem with the development of tourism (Figure 1). The values of consumption metabolism of entropy fluctuated with a slow downwards trend, and the values of regenerate metabolism of entropy fluctuated with a sharp upward trend. That indicated the metabolism of function was strengthened, which indicates some success in protecting the ecological environment and also its quality was improved (Figure 2). The values of sustainable development potential fluctuated with an upward trend (Figure 3). The lowest value was in 2008 and the highest was in 2012. This phenomenon may be related to external features of the tourism industry, which was in a status of trough influenced by the global financial crisis and snow disaster of Southern China in 2008. The stressful entropy output fluctuated with a downward trend; also the regenerate metabolism of entropy had the lowest value in 2008. The highest value is attributed to government attention and an improvement in ecological security, an increase in investment in anti-pollution projects as percentage of GDP and improved proportion of industrial solid waste treated and utilized.

Figure 3. Score trends of tourism destination ecosystem sustainable development potential.



5.3. Analysis of Sustainable Development Measures Based on the Entropy Weights and Time Sequence Changes of the Indicators

The entropy weights of number of travel agencies, passenger-kilometers by highways and passenger-kilometers railways were largest among the supportive entropy input index in Dunhuang tourism destination ecosystem between 2000 and 2012 (Table 4). These indicate that significant increases of these three indexes had played an important role in strengthening the supportive entropy input system. However, the entropy weights of annual water supply were the smallest, and the entropy weights of passenger-km by civil aviation was smaller, showing some negative effects caused by the sharp decline of annual water supply and decrease of passenger-km by civil aviation in the Dunhuang tourism destination ecosystem. Those two indexes restricted the development of the supportive entropy input system. The shortage of water resources is a limiting factor for development of Dunhuang being located in the arid oasis area of northwest China. The transport passenger-kilometers focused on railways and highway, however, civil aviation supplemented the railway and highway with the development of the economy. The positive aspects of transport (railways, highway and civil aviation) and travel agencies should be improved for the supportive entropy input, as well as coordinating the relationship between water resources and to safeguard water supply by increasing effective use.

The entropy weights of number of visitor arrivals and water used by tourists were largest among the stressful entropy output index during the study period (Table 4). The value of those two indexes significantly increased the pressure of stressful entropy output index of Dunhuang tourism destination ecosystem. Those two indexes should be paid much attention, the number of visitor arrivals reasonably controlled and tourists guided on water use.

Table 4. Information entropy and entropy weights of the sustainable development potential evaluation indicators for the tourism destination ecosystem in Dunhuang.

Indicator Type	Indicator	E_i	Q_i
Supportive entropy input index (A)	Number of travel agencies (A1)	0.9596	0.0295
	Number of direct engaged persons in tourism industry (A2)	0.9936	0.0047
	Number of star-rated hotels (A3)	0.9945	0.0040
	Number of beds in star-rated hotels (A4)	0.9941	0.0043
	Passenger-kilometers by highways (A5)	0.9669	0.0242
	Passenger-kilometers by railways (A6)	0.9674	0.0238
	Passenger-kilometers by civil aviation (A7)	0.9966	0.0025
	Annual water supply (A8)	0.9968	0.0023
Stressful entropy output index (B)	Number of visitor arrivals (B1)	0.9418	0.0426
	Transport expenditure as percentage of tourism expenditure (B2)	0.9919	0.0059
	sightseeing expenditure as percentage of tourism expenditure (B3)	0.9932	0.0050
	Hotels expenditure as percentage of tourism expenditure (B4)	0.9970	0.0022
	Catering expenditure as percentage of tourism expenditure (B5)	0.9906	0.0069
	Water used by tourists (B6)	0.9414	0.0429
Consumption metabolism index of entropy (C)	Total wastewater discharged (C1)	0.9153	0.0620
	Industrial wastewater discharged (C2)	0.8324	0.1226
	Emission of disulfide (C3)	0.9942	0.0043
	solid wastes discharged (C4)	0.9182	0.0598
	waste discharge by tourists (C5)	0.9414	0.0429
	Carbon emission by tourism (C6)	0.9627	0.0273
Regenerate metabolism index of entropy (D)	Number of training institutions for tourism (D1)	0.9683	0.0232
	Direct engaged persons in tourism industry as percentage of employees (D2)	0.9980	0.0014
	Tourism GDP (D3)	0.8609	0.1017
	Tourism GDP as percentage of GDP (D4)	0.9851	0.0109
	Investment in anti-pollution projects as percentage of GDP (D5)	0.8252	0.1279
	Proportion of industrial solid waste treated and utilized (D6)	0.7336	0.1948
	Rate of harmless garbage disposal (D7)	0.9972	0.0020
	Green coverage rate in developed areas (D8)	0.9799	0.0147
	Gardens per capita (D9)	0.9947	0.0039

The entropy weights of industrial wastewater discharged and total wastewater discharged were largest among the consumption metabolism index of entropy between 2000 and 2012 (Table 4). Those indicate that the significant increases of wastewater discharged was strongly influenced by the consumption metabolism index of entropy and increasing the pressure on ecological environments of the tourism destination. The value of entropy weights for waste discharge by tourists was larger than that of carbon emissions, which indicates that the consumption metabolism of tourism destination is influenced more by increase of waste discharge by tourists than carbon emission by tourism. Given these circumstances, scientific controls should be put in place for the waste discharge of tourists.

The value of entropy weights for two indexes (proportion of industrial solid waste treated and utilized and investment in anti-pollution projects as percentage of GDP) were largest among regenerate metabolism index of entropy (Table 4). These show that those two indexes greatly impact the potential of regenerate metabolism system. Pollution should be controlled paying attention to the ecological security of the tourism destination, increasing investment in anti-pollution projects as a percentage of GDP and increasing proportion of industrial solid waste treated and utilized. The values of entropy weights were smallest in regenerate metabolism index of entropy, which include direct engaged persons in tourism industry as percentage of employees, rate of harmless garbage disposal and gardens per capita. These indicate improvement in the potential of regenerate metabolism system by increasing the direct engaged persons in the tourism industry as percentage of employees, improving the rate of harmless garbage disposal and increasing the gardens per capita.

6. Conclusions and Discussion

The analysis of the tourist destination ecosystem entropy change indicates an increase in the diversity and complexity of Dunhuang tourism destination's socio-economic ecosystem with the rapid development of the tourism industry; the demands placed on the natural ecosystem have increased. However, the pollution problems have been controlled, as shown by the overall upward trend for regenerate metabolism during the study period. The vitality of the tourism destination ecosystem was obviously strengthened from 2008. Based on the score of sustainable development potential for the tourism destination ecosystem between 2000 and 2012, the pressure on the natural ecosystem was increased, while the carrying capacity of its socio-economic system also strengthen. The regenerate metabolism system increased due to significant conservation achievements and development of the eco-environment in the Dunhuang tourism destination ecosystem. According to the entropy weight of this indicator and its impact on the sustainable development potential of Dunhuang tourism destination ecosystem, the countermeasures are as follows: Increase the potential of the supportive entropy input system by increasing the travel agencies and transportation; Reduce the pressure on the consumption metabolism system by decreasing the total wastewater discharged and industrial wastewater discharged; Enhance the potential of regenerate metabolism by focusing on the ecological security of the tourism destination, increase investment in anti-pollution projects as percentage of GDP and improve proportion of industrial solid waste treated and utilized.

The paper summarizes the former research results, and then further demonstrates by entropy change analysis, information entropy and negative entropy of dissipative structure system for evaluating the tourism destination ecosystem's sustainable development evolution feasibility. The numerical values show the orderly level of the tourism destination ecosystem demonstrating the system sustainable development potential. Combining the entropy weight of index and times series index will be more targeted for improving measures of Dunhuang tourism destination ecosystem's sustainable development. According to the data's availability, the article selects indexes focusing on supportive, stressful, consumed and regenerate indexes. The tourism destination ecosystem as a society-economics-environment artificial compound ecosystem, the tourists and local residents are significant participants and propellants of tourism sustainable development [27]. Their appreciation of tourism sustainable development plays an important role in system improvement; thus the indexes which are in line with their values should be chosen. On the other hand, using information entropy from the perspective of the development of tourism destination ecosystem evolution to analyze tourism destination sustainable development potential, it is beneficial to vertically analyze a single tourism destination. There are disadvantages in horizontally comparing tourism, and therefore this research must be improved.

Acknowledgments

This research is supported by China Scholarship Council (CSC), The Fundamental Research Funds for the Central Universities (lzujbky-2013-m02), Natural Science Foundation of China (41471462, 41461119).

Author Contributions

Huihui Feng, Xingpeng Chen, Peter Heck and Hong Miao designed the paper and all contributed to data collection and calculation.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. General Assembly of the United Nations. The 19th Special Session for General Assembly of the United Nations resolutions. Available online: http://www.un.org/chinese/ga/spec/19/ar19_1.pdf (accessed on 19 September 1997).
2. Tang, C.; Zhong, L.; Cheng, S. A review on sustainable development for tourist destination. *Prog. Geogr.* **2013**, *32*, 984–992.
3. Butler, R. Sustainable tourism: A state-of-the-art review. *Tour. Geogr.* **1999**, *1*, 7–25.
4. Hardy, A.; Beeton, R.; Pearson, L. Sustainable tourism: An overview of the concept and its position in relation to conceptualizations of tourism. *J. Sustain. Tour.* **2002**, *10*, 475–496.
5. Lu, J.; Nepala, S. Sustainable tourism research: An analysis of papers published in the Journal of Sustainable Tourism. *J. Sustain. Tour.* **2009**, *17*, 5–16.
6. Buckley, R. Sustainable tourism: Research and reality. *Ann. Tour. Res.* **2012**, *39*, 528–546.
7. Liu, Z. Sustainable tourism development: A critique. *J. Sustain. Tour.* **2003**, *11*, 459–475.
8. Berno, T.; Bricker, K. Sustainable tourism development: The long road from theory to practice. *Int. J. Econ. Dev.* **2001**, *3*, 1–18.

9. Swarbrooke, J. *Sustainable Tourism Management*; Biddles Ltd., Guildford and King's Lyun: New York, NY, USA, 1999; pp. 4–5.
10. Bramwell, B.; Lane, B. Sustainable tourism: An evolving global approach. *J. Sustain. Tour.* **1993**, *1*, 1–5.
11. Smith, S. *Tourism Analysis: A Handbook*; Longman: London, UK, 1995; pp. 295–299.
12. Wight, P. Tools for sustainability analysis in planning and managing tourism and recreation in the destination. In *Sustainable Tourism: A Geographical Perspective*; Hall, C., Lew, A., Eds.; Addison Wesley Longman: New York, NY, USA, 1998; pp. 75–91.
13. Hunter, C. Sustainable tourism as an adaptive paradigm. *Ann. Tour. Res.* **1997**, *24*, 850–867.
14. Saarinen, J. Traditions of sustainability in tourism studies. *Ann. Tour. Res.* **2006**, *33*, 1121–1140.
15. Sharpley, R. Tourism and sustainable development: Exploring the theoretical divide. *J. Sustain. Tour.* **2000**, *8*, 1–19.
16. Gianna, M.; Laurie, M. There is no such thing as sustainable tourism: Re-conceptualizing tourism as a tool for sustainability. *Sustainability* **2014**, *6*, 2538–2561.
17. Aall, C. Sustainable tourism in practice: Promoting or perverting, the quest for a sustainable development. *Sustainability* **2014**, *6*, 2562–2583.
18. Saarinen, J. Critical sustainability: Setting the limits to growth and responsibility in tourism. *Sustainability* **2014**, *6*, 1–17.
19. Hunter, C. Aspects of the Sustainable Tourism Debate from a Natural Resources Perspective. In *Sustainable Tourism: A Global Perspective*; Harris, R., Griffin, T., Williams, P., Eds.; Butterworth-Heinemann: Oxford, UK, 2002; pp. 4–5.
20. Moyle, B.; McLennan, C.; Ruhanen, L.; Weiler, B. Tracking the concept of sustainability in Australian tourism policy and planning documents. *J. Sustain.* **2014**, *22*, 1037–1051.
21. Farrell, B.; Ward, L. Reconecptualizing tourism. *Ann. Tour. Res.* **2004**, *31*, 274–295.
22. Lansing, P.; Vries, P. Sustainable tourism: Ethical alternative or marketing ploy? *J. Bus. Ethics* **2007**, *72*, 77–85.
23. Delgado, A.; Saarinenc, J. Using indicators to assess sustainable tourism development: A review. *Tour. Geogr.* **2014**, *16*, 31–47.
24. Ko, T. Development of a tourism sustainability assessment procedure: A conceptual approach. *Tour. Manag. Issue* **2005**, *26*, 431–445.
25. Chris, H.; Sirakaya, E. Sustainability indicators for managing community tourism. *Tour. Manag.* **2006**, *27*, 1274–1289.
26. McElroy, J. Tourism penetration index in small Caribbean islands. *Ann. Tour. Res.* **1998**, *25*, 145–168.
27. McCool, S.; Moisey, R.; Nickerson, N.P. What should tourism sustain? The disconnect with industry perceptions of useful indicators. *J. Travel Res.* **2001**, *40*, 124–131.
28. Moore, S.; Polley, A. Defining indicators and standards for tourism impacts in protected areas: Cape Range National Park, Australia. *Environ. Manag.* **2007**, *39*, 291–300.
29. Castellani, V.; Sala, S. Sustainable performance index for tourism policy development. *Tour. Manag.* **2010**, *31*, 871–880.
30. Blancas, F.; Gonzalez, M.; Lozano-Oyola, M.; Pérez, F. The assessment of sustainable tourism: Application to Spanish coastal destinations. *Ecol. Indic.* **2010**, *10*, 484–492.

31. Twining, L.; Butler, R. Implementing STD on a small island: Development and use of sustainable tourism development indicators in Samoa. *J. Sustain. Tour.* **2002**, *10*, 363–387.
32. Roberts, S.; Tribe, J. Sustainability indicators for small tourism enterprises—An exploratory perspective. *J. Sustain. Tour.* **2008**, *16*, 575–594.
33. Schianetz, K.; Kavanagh, L. Sustainability indicators for tourism destinations: A complex adaptive systems approach using systemic indicator systems. *J. Sustain. Tour.* **2008**, *16*, 601–628.
34. Fernández, J.; Sánchez, R. Measuring tourism sustainability: Proposal for a composite index. *Tour. Econ.* **2009**, *15*, 277–296.
35. Blackstock, K.; White, V.; McCrum, G.; Scott, A.; Hunter, C. Measuring responsibility: An appraisal of a scottish national park's sustainable tourism indicators. *J. Sustain. Tour.* **2008**, *16*, 276–297.
36. Oyola, M.; Blancas, F.; González, M.; Caballero, R. Sustainable tourism indicators as planning tools in cultural destinations. *Ecol. Indic.* **2012**, *18*, 659–675.
37. Blancas, F.; Oyola, M.; González, M.; Guerrero, F.M.; Caballero, R. How to use sustainability indicators for tourism planning: The case of rural tourism in Andalusia (Spain). *Sci. Total Environ.* **2011**, *412–413*, 28–45.
38. Reddy, M. Sustainable tourism rapid indicators for less-developed islands: An economic perspective. *Int. J. Tour. Res.* **2008**, *10*, 557–576.
39. Miller, G. The development of indicators for sustainable tourism: Results of a Delphi survey of tourism researchers. *Tour. Manag.* **2001**, *22*, 351–362.
40. Wang, L. On the indicator system of sustainable development of tourism and the evaluating method. *Tour. Tribune* **2001**, *16*, 67–70.
41. Wan, Y. The method and indicates of evaluation on sustainable development for tourism. *Stat. Decis.* **2006**, *2*, 10–12.
42. Ahn, B.; Lee, B.; Shafer, C.S. Operationalizing sustainability in regional tourism planning: An application of the limits of acceptable change framework. *Tour. Manag.* **2002**, *23*, 1–15.
43. Hunter, C.; Shaw, J. The ecological footprint as a key indicator of sustainable tourism. *Tour. Manag.* **2007**, *28*, 46–57.
44. Gössling, S.; Hansson, C.; Hörstmeier, O.; Saggel, S. Ecological footprint analysis as a tool to assess tourism sustainability. *Ecol. Econ.* **2002**, *43*, 199–211.
45. Martín-Cejas, R.; Sánchez, P. Ecological footprint analysis of road transport related to tourism activity: The case for Lanzarote Island. *Tour. Manag.* **2010**, *31*, 98–103.
46. Mehdi, M.; Jerome, B. Ecotourism *versus* mass tourism: A comparison of environmental impacts based on ecological footprint analysis. *Sustainability* **2012**, *4*, 123–140.
47. Hunter, C. Sustainable tourism and the touristic ecological footprint. *Environ. Dev. Sustain.* **2002**, *4*, 7–20.
48. Yang, G.; Li, P. Touristic ecological footprint: A new yardstick to assess sustainability of tourism. *Acta Ecol. Dinica* **2005**, *25*, 1475–1480.
49. Castellani, V.; Sala, S. Ecological footprint and life cycle assessment in the sustainability assessment of tourism activities. *Ecol. Indic.* **2012**, *16*, 135–147.
50. Cui, F.; Liu, J.; Li, Q. Study of the theory and application of tourism bearing capacity index. *Tour. Tribune* **1998**, *22*, 41–44.

51. Xiao, J.; Yu, Q.; Liu, K.; Chen, D.; Chen, J.; Xiao, J. Evaluation of the ecological security of island tourist destination and island tourist sustainable development: A case study of Zhoushan Islands. *Acta Geogr. Sin.* **2011**, *66*, 842–852.
52. Salerno, F.; Viviano, G.; Manfredi, E.C.; Caroli, P.; Thakuri, S.; Tartari, G. Multiple Carrying Capacities from a management-oriented perspective to operationalize sustainable tourism in protected areas. *J. Environ.* **2013**, *128*, 116–125.
53. Zhong, L.; Deng, J.; Xiang, B. Tourism development and the tourism area life-cycle model: A case study of Zhangjiajie National Forest Park, China. *Tour. Manag.* **2008**, *29*, 841–856.
54. Yang, Y.; Luo, S.; Wang, X. Tourist destination life cycle early warning system research based on "Inflection Point" theory, China. *Popul. Resour. Environ.* **2009**, *19*, 110–113.
55. Rodríguez, J.; Parra-López, E.; Yanes-Estévez, V. The sustainability of island destinations: Tourism area life cycle and teleological perspectives: The case of Tenerife. *Tour. Manag.* **2008**, *29*, 53–65.
56. Yang, G. Targeting model of sustainable development in eco-tourism. *Hum. Geogr.* **2005**, *20*, 74–77.
57. Keitumetse, S. Cultural resources as sustainability enablers: Towards a community-based cultural heritage resources management (COBACHREM) model. *Sustainability* **2014**, *6*, 70–85.
58. Dina, R.; Geremia, G. A sustainable tourism paradigm: Opportunities and limits for forest landscape planning. *Sustainability* **2014**, *6*, 2379–2391.
59. Karatzoglou1, B.; Spilanis, I. Sustainable tourism in Greek islands: The integration of activity-based environmental management with a destination environmental scorecard based on the adaptive resource management paradigm. *Bus. Strategy Environ.* **2010**, *19*, 26–38.
60. Lu, M. *Evaluation Pattern on the Sustainability of Tourist Destination*; Central China Normal University: Wuhan, China, 2001.
61. Xuan, G.; Lu, L.; Zhang, J. Residents' perception of tourism impacts in coast resorts: The case study of Haikou and Sanya Cities, Hainan Province. *Sciatica Geogr. Sonica* **2002**, *22*, 741–746.
62. Su, Q.; Lin, B. Classification of residents in the tourist attractions based on attitudes and behaviors: A case study in Xidi, Zhouzhuang and Jiuhua Mountain. *Geogr. Res.* **2004**, *23*, 104–114.
63. Zhao, Y.; Li, D.; Huang, M. On the residents' perceptions and attitudes towards tourism development in tourist destinations overseas: A review. *Tour. Tribune* **2005**, *20*, 85–92.
64. Huang, Y.; Huang, Z. A study on the structural equation model and its application to tourist perception for agri-tourism destinations: Taking southwest minority areas as an example. *Geogr. Res.* **2008**, *27*, 1455–1465.
65. Choi, H.; Sirakaya, E. Measuring residents' attitude toward sustainable tourism: Development of sustainable tourism attitude scale. *J. Travel Res.* **2005**, *43*, 380–394.
66. Wearing, S.; Wearing, M. Understanding local power and interactional processes in sustainable tourism: Exploring village-tour operator relations on the Kokoda Track, Papua New Guinea. *J. Sustain.* **2010**, *18*, 61–76.
67. Haukeland, J.; Grue, B.; Veisten, K. Turning national parks into tourist attractions: Nature orientation and quest for facilities, Scandinavian. *J. Hosp. Tour.* **2010**, *10*, 248–271.
68. Lucia, S.; Nicholas, L.; Thapa, B. Visitor perspectives on sustainable tourism development in the pitons management area world heritage site. *Environ. Dev. Sustain.* **2010**, *12*, 839–857.

69. Cottrell, S.; Vaske, J.; Roemer, J.M. Resident satisfaction with sustainable tourism: The case of Frankenwald Nature Park, Germany. *Tour. Manag. Perspect.* **2013**, *8*, 42–48.
70. Sörensson, A.; Friedrichs, Y. An importance–performance analysis of sustainable tourism: A comparison between international and national tourists. *J. Destin. Mark. Manag.* **2013**, *2*, 14–21.
71. Dorcheh, S.; Mohamed, B. Local perception of tourism development: A conceptual framework for the sustainable cultural tourism. *J. Manag. Sustain.* **2013**, *3*, 31–39.
72. Cottrell, S.; Vaske, J. Resident perceptions of sustainable tourism in Chongdugou, China. *Soc. Nat. Resour. Int. J.* **2007**, *20*, 511–525.
73. Miller, D.; Merrilees, B. Sustainable urban tourism: Understanding and developing visitor pro-environmental behaviors. *J. Sustain. Tour.* **2014**, *5*, 1–21.
74. Chen, C.; Chen, S.; Hong, T. The destination competitiveness of Kinsmen's tourism industry: Exploring the interrelationships between tourist perceptions, service performance, customer satisfaction and sustainable tourism. *J. Sustain. Tour.* **2011**, *19*, 247–264.
75. Bimonte, S.; Punzo, L. Tourism, residents' attitudes and perceived carrying capacity with an experimental study in five Tuscan destinations. *Int. J. Sustain.* **2011**, *14*, 242–261.
76. Waligo, V.; Clarke, J.; Hawkins, R. Implementing sustainable tourism: A multi-stakeholder involvement management framework. *Tour. Manag.* **2013**, *36*, 342–353.
77. Jamal, T.; Stronza, A. Collaboration theory and tourism practice in protected areas: Stakeholders, structuring and sustainability. *J. Sustain. Tour.* **2009**, *17*, 169–189.
78. Vellecco, I.; Alessandra, M. Sustainability and tourism development in three Italian destinations: Stakeholders' opinions and behaviors. *Serv. Ind. J.* **2010**, *30*, 2201–2223.
79. Spenceley, A. Requirements for sustainable nature-based tourism in transfrontier conservation areas: A southern African Delphi consultation. *Tour. Geogr.* **2008**, *10*, 285–311.
80. Holden, A. Exploring stakeholders' perceptions of sustainable tourism development in the Annapurna Conservation Area: Issues and challenge. *Tour. Hosp. Plan. Dev.* **2010**, *7*, 337–351.
81. Timur, S.; Getz, D. Sustainable tourism development: How do destination stakeholders perceive sustainable Urban Tourism? *Sustain. Dev.* **2009**, *17*, 220–232.
82. Dabphet, S.; Scott, N.; Ruhanen, L. Applying diffusion theory to destination stakeholder understanding of sustainable tourism development: A case from Thailand. *J. Sustain. Tour.* **2012**, *20*, 1107–1124.
83. Hardy, A.; Beeton, R. Sustainable tourism or maintainable tourism: Managing resources for more than average outcomes. *J. Sustain. Tour.* **2001**, *9*, 168–192.
84. Larson, P.; Poudyal, N. Developing sustainable tourism through adaptive resource management: A case study of Machu Picchu. *J. Sustain. Tour.* **2012**, *20*, 917–938.
85. Dodds, R. Sustainable tourism and policy implementation: Lessons from the case of Calviá, Spain. *Curr. Issues Tour.* **2007**, *10*, 296–322.
86. Dodds, R.; Butler, R. Barriers to implementing sustainable tourism policy in mass tourism destinations. *Int. Multidiscip. J. Tour.* **2010**, *5*, 35–53.
87. Farsari, Y.; Butler, R.; Prastacos, P. Sustainable tourism policy for Mediterranean destinations: Issues and interrelationships. *Int. J. Tour.* **2007**, *1*, 58–78.
88. Pigram, J. Sustainable tourism—Policy considerations. *J. Tour. Stud.* **1990**, *1*, 2–9.

89. Solstrand, M. Marine angling tourism in Norway and Iceland: Finding balance in management policy for sustainability. *Nat. Resour. Forum* **2013**, *37*, 113–126.
90. Xu, H.; Sofield, T. Sustainability in Chinese development tourism policies. *Curr. Issues Tour.* **2013**, *10*, 30–38.
91. Michael, C. *Local Government and Tourism Public Policy: A Case of the Hurunui District, New Zealand*; Lincoln University: Lincoln, UK, 2013.
92. Yasarataa, M.; Altinay, L.; Burns, P.; Okumus, F. Politics and sustainable tourism development—Can they co-exist? Voices from North Cyprus. *Tour. Manag.* **2010**, *31*, 345–356.
93. Whitford, M.; Ruhanen, L. Australian indigenous tourism policy: Practical and sustainable policies? *J. Sustain. Tour.* **2010**, *18*, 475–496.
94. Halla, C. Policy learning and policy failure in sustainable tourism governance: From first- and second-order to third-order change? *J. Sustain. Tour.* **2011**, *19*, 649–671.
95. Bahaire, T.; White, M. The application of geographical information systems (GIS) in sustainable tourism planning: A review. *J. Sustain. Tour.* **1999**, *7*, 159–174.
96. Boers, B.; Cottrell, S. Sustainable tourism infrastructure planning: A GIS-supported approach. *Tour. Geogr.* **2007**, *9*, 1–21.
97. Bunruamkaew, K.; Murayama, Y. Site suitability evaluation for ecotourism using GIS & AHP: A case study of Surat Thani province, Thailand. *Procedia Soc. Behav. Sci.* **2011**, *21*, 269–278.
98. White, V.; McCrum, G.; Blackstock, K.L.; Scott, A. Indicators and sustainable tourism: Literature review. *Tour. Manag.* **2006**, *27*, 1274–1289.
99. Ivan, K.; Mikulić, J. Research note: Measuring tourism sustainability: An empirical comparison of different weighting procedures used in modelling composite indicators. *Tour. Econ.* **2014**, *20*, 429–437.
100. Mikulića, J.; Kožićb, I.; Krešić, D. Weighting indicators of tourism sustainability: A critical note. *Ecol. Indic.* **2015**, *48*, 312–314.
101. Delgado, T.A.; Palomeque, F.L. Measuring sustainable tourism at the municipal level. *Ann. Tour. Res.* **2014**, *49*, 122–137.
102. Coccossis, H.; Mexa, A. *The Challenge of Tourism Carrying Capacity Assessment: Theory and Practice*; Ashgate, Basingstoke: Hampshire, UK, 2004; pp. 277–288.
103. Simón, F.; Narangajavana, Y.; Marqués, D.P. Carrying capacity in the tourism industry: A case study of Hengistbury Head. *Tour. Manag.* **2004**, *25*, 275–283.
104. Juradoa, E.; Tejadab, M.T.; García, F.A.; González, J.C.; Macías, R.C.; Peña, J.D.; Gutiérrez, F.F.; Fernández, G.G.; Gallego, M.L.; García, G.M.; *et al*. Carrying capacity assessment for tourist destinations. Methodology for the creation of synthetic indicators applied in a coastal area. *Tour. Manag.* **2012**, *33*, 1337–1346.
105. Green, H.; Hunter, C.; Moore, B. The environmental impact assessment of tourism development. In *Perspectives on Tourism Policy*; Johnson, P., Thomas, B., Eds.; Thomson Learning: Boston, MA, USA, 1992; pp. 29–47.
106. Green, H.; Hunter, C.; Moore, B. Assessing the environmental impact of tourism development: Use of the Delphi technique. *Tour. Manag.* **1990**, *11*, 111–120.
107. Peng, J.; Wu, J.; Jiang, Y.-Y.; Ye, M.-T. Shortcomings of applying ecological footprints to the ecological assessment of regional sustainable development. *Acta Ecol. Sin.* **2006**, *26*, 2716–2722.

108. Haywood, K. Can the tourist-area life cycle be made operational? *Tour. Manag.* **1986**, *7*, 154–167.
109. Guinee, J.; Heijungs, R.; Huppes, G.; Zamagni, A.; Masoni, P.; Buonamici, R.; Ekvall, T.; Rydberg, T. Life cycle assessment: Past, present, and future. *Environ. Sci. Technol.* **2011**, *45*, 90–96.
110. McCool, S. Planning for sustainable nature dependent tourism development: The Limits of Acceptable Change system. *Tour. Recreat. Res.* **1994**, *19*, 51–55.
111. Avdimiotis, S.; Mavrodontis, T.; Dermetzopoulos, A.S.; Riavoglou, K. GIS applications as a tool for tourism planning and education: A case study of Chalkidiki. *Tourism (Zagreb)* **2006**, *54*, 405–413.
112. Schianetz, K.; Kavanagh, L.; Lockington, D. Concepts and tools for comprehensive sustainability assessments for tourism destinations: A comparative review. *J. Sustain. Tour.* **2007**, *15*, 369–389.
113. Lacitignola, D.; Petrosillo, I.; Cataldi, M.; Zurlini, G. Modelling socio-ecological tourism-based systems for sustainability. *Ecol. Model.* **2007**, *206*, 191–204.
114. Bailey, K. Social entropy theory: An overview. *Syst. Pract.* **1990**, *3*, 365–382.
115. Swanson, G.A.; Kenneth, D.B. Social Entropy Theory, Macro Accounting, and Entropy Related Measures, 2006. Available online: http://www.isssbrasil.usp.br/isssbrasil/pdfs/2006-247.pdf (accessed on 30 July 2014).
116. Stepanic, J.; Stefancic, H.; Zebec, M.S.; Perackovic, K. Approach to a quantitative description of social systems based on thermodynamic formalism. *Entropy* **2000**, *2*, 98–105.
117. Wilson, A. Entropy in urban and regional modelling: Retrospect and prospect. *Geogr. Anal*. **2010**, *42*, 364–394.
118. Cabral, P.; Augusto, G.; Tewolde, M.; Araya, Y. Entropy in urban systems. *Entropy* **2013**, *15*, 5223–5236.
119. Leiper, N. Industrial entropy in tourism systems. *Ann. Tour. Res.* **1993**, *20*, 221–226.
120. Sabkbar, H.; Ahmad, A.; Karimian, T. Spatial tourism planning in Isfahan by entropy model. *Agrochimica* **2014**, *58*, 67–82.
121. Hao, C. A Tentative analysis of entropy and dissipative structure in tourist destination ecological system. *J. Taiyuan Norm. Univ. (Soc. Sci. Ed.)* **2010**, *9*, 66–68.
122. Zhao, L.; Zhang, W. Applied research of dissipative structure theory on tolerance threshold of tourism system-on the basis of tourism system entropy principle. *Tour. Forum* **2010**, *3*, 10–16.
123. Qian, Y. Application of the dissipative structure theory in the traveling environment management. *J. Anhui Agric. Sci.* **2006**, *34*, 5006–5007.
124. Ministry of Agriculture of the People's Republic of China. This Is the Time to Be Excavated of Dunhuang Culture: The Report for Culture Industry of Dunhuang, Gansu Province. Available online: http://www.agri.gov.cn/dfv20/GS/ncwh/dtzx/201306/t20130603_3480954.htm (accessed on 3 June 2013).
125. Statistics Report for Economic and Social Development of Dunhuang City in 2012. Available online: http://zwgk.dunhuang.gov.cn/ReadNews.asp?NewsID=2367 (accessed on 28 July 2014).
126. It is Urgent Time to Combating Desertification in Dunhuang by Expert's Opinions. Available online: http://news.xinhuanet.com/local/2010-09/11/c_12542051.htm (accessed on 14 September 2010).
127. Xing, X. Evolution equation for physical entropy and information entropy. *Sci. China (Ser. A)* **2001**, *31*, 78–84.
128. Li, X. The entropy in Socio-economic system. *J. Syst. Dialectics* **1996**, *10*, 84–87.
129. Shannon, C. A mathematical theory of communication (1–2). *Bell Syst. Tech. J.* **1948**, *27*, 623–656.

130. Zhang, Y.; Yang, Z.; Li, W. Measurement and evaluation of interactive relationships in urban complex ecosystem. *Acta Ecol. Sin.* **2005**, *25*, 1734–1740.
131. Lin, Z.; Xia, B. Analysis of sustainable development ability of the urban ecosystem in Guangzhou City in the perspective of entropy. *Acta Geogr. Sin.* **2013**, *68*, 45–57.
132. Leife, R. Understanding organizational transformation using a dissipative structure model. *Hum. Relat.* **1989**, *42*, 899–916.
133. Kondoh, Y. Function for dissipative dynamic operators and the attractor of the dissipative structure. *Phys. Rev. E* **1993**, *48*, 2975–2979.
134. Dooley, K. A complex adaptive systems model of organization change nonlinear dynamics. *Psychol. Life Sci.* **1997**, *1*, 69–97.
135. Zhan, K.; Sheng, X. *Prigogine and Theory of Dissipative Structure*; Shanxi Science & Technology Press: Xi'an, China, 1998.
136. Lu, L.; Bao, J. The course and mechanism of evolution about Qiandao Lake based on the theory of dissipative structure. *Acta Geogr. Sin.* **2010**, *65*, 755–768.
137. Valentin, A.; Spangenberg, J. A guide to community sustainability indicators. *Environ. Impact Assess. Rev.* **2000**, *20*, 381–392.
138. Dai, Y. Sustainable development indexes systems in tourist cities. *Yunnan Geogr. Environ. Res.* **2006**, *18*, 35–39.
139. Indicators of Sustainable Development for Tourism Destinations: A Guidebook. Available online: http://www.e-unwto.org/content/x53g07/fulltext?p=a6a03d7c67d24258bf5c4ae9e96b6530&pi=0#section=890050&page=2&locus=40 (accessed on 1 October 2004).
140. European Tourism Indicator System Toolkit for Sustainable Destinations. Available online: http://ec.europa.eu/enterprise/sectors/tourism/sustainable-tourism/indicators/documents_indicators/eu_toolkit_indicators_en.pdf (accessed on 10 February 2013).
141. Niu, Y. The study on index system of sustainable tourism. *Chn. Pop. Resour. Environ.* **2002**, *12*, 42–45.
142. Zhang, J.; Singh, V. *Theory and Applications of Information Entropy*; China Water Power Press: Beijing, China, 2012; pp. 79–80.
143. Yang, X. Evaluation research of sustainable development of tourism based on the information entropy and AHP. *Sci. Technol. Eng.* **2008**, *22*, 6176–7004.
144. Jiang, C.; Zhang, Y. Study on the mechanism of evolution about island resorts system based on the theory of dissipative structure: A case study of Meizhou Island. *Chin. Agric. Sci. Bull.* **2013**, *29*, 213–220.
145. Di, Q.; Han, X. Sustainable development ability of China's marine ecosystem in the perspective of entropy. *Sci. Geogr. Sin.* **2014**, *34*, 6664–6671.
146. Chen, Y.; Liu, J. An index of equilibrium of urban land-use structure and information dimension of urban form. *Geogr. Res.* **2001**, *20*, 146–152.
147. Dunhuang City Bureau of Statistics. *10th Five-Year Statistical Yearbook of Dunhuang City*; Wang, W., Ed.; Juelun Culture Communication Co., Ltd.: Xiamen, China, 2006; pp. 252–305.
148. Dunhuang City Bureau of Statistics. *11th Five-Year Statistical Yearbook of Dunhuang City*; Ren, B., Ed.; Sanmenxia Culture Communication Co., Ltd.: Sanmenxia, China, 2011; pp. 258–309.

149. Dunhuang City Bureau of Statistics. *2011 Statistical Yearbook of Dunhuang City*; Dunhuang City Bureau of Statistics: Dunhuang, China, 2012.
150. Dunhuang Municipal Environmental Protection Bureau. *Environmental Quality Bulletin of Dunhuang City (2006–2012)*; Dunhuang Municipal Environmental Protection Bureau: Dunhuang, China, 2013.