Lecture Notes in Networks and Systems 337

Ernesto León-Castro · Fabio Blanco-Mesa ·
Victor Alfaro-García · Anna Maria Gil-Lafuente ·
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Soft Computing and Fuzzy Methodologies in Innovation Management and Sustainability

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Preface

This volume constitutes a new and original contribution to the development of new modeling, analytic and implementation approaches, and tools and techniques which can not only be useful for but also give a new boost to dealing with various problems faced by the world in which sustainability is a key concern. Various aspects of sustainability are discussed in the contributions in the volume but, basically, sustainability is here meant as an ability to satisfy present needs of the world without jeopardizing, or endangering, the satisfaction of needs of the future generation. Of course, these needs can be very diverse, and sustainability should be considered from various perspectives, notably: economic, environmental and social.

It is obvious that sustainability needs innovation. There is a simple reason for this because the satisfaction of growing needs of the humans, in view of both a steep population growth and growing needs and aspirations of both individuals and human groups who get richer and richer in most countries, implies a need for some new solutions. This calls both for new, more effective and efficient production and manufacturing technologies, and new solutions related to, for instance, management or organization, at all levels.

In this volume there is a collection of papers which show deep analyses of various aspects of some interesting projects and case studies related to sustainability, notably related to some economic pillar of sustainability. In particular, the context of tourism or agriculture which are relevant for countries in Latin America is what the volume focuses on. Here, again, relevant innovative approaches are needed. For the analysis of these problems, novel formal and algorithmic tools and techniques are proposed, for instance, some advanced aggregation operators exemplified by the OWAs (ordered weighted averaging operators), fuzzy logic based classifiers, etc.

An interesting and original part of the volume is Part II in which a conceptually new approach is used to recognize and study various aspects of sustainability and innovation, and also of related topics, by analyzing the scientific literature on this topic. Scientific papers in journals, books, research reports or articles in conference proceedings can easily be downloaded from various bibliometric databases, notably the Web of Science and Scopus, and then can be analyzed by using data analytic and data mining tools and techniques complemented by visualization. In such a way one

can obtain information on which topics are popular, who are the most productive or cited researchers, which research groups or institutions are the most active, etc. This information can be useful for both some present day analyses and strategic, or even policymaking related analyses and decisions.

Part I "Analyses of Aspects of Economic, Social and Technological Development" is concerned with the use of various tools and techniques of computational intelligence, artificial intelligence, data sciences, data mining and related fields for the formulation, analysis and solution of various problems related to the economic, social and technological development, with an emphasis on both theoretical analyses and practical problems, notably related to case studies of Latin America.

Martín Isimayrt Huesca-Gastélum, Alicia Delgadillo-Aguirre, Martín León-Santiesteban and Ernesto León-Castro ("Ranking of Innovation and Sustainability of Tourist Destinations in Sinaloa: An Analysis with the Ordered Weighted Average Operator") are concerned with the classification of innovation and sustainability of tourist destinations in the State of Sinaloa in Mexico. They use the ordered weighted average operator (OWA), a powerful and widely employed aggregation operator. The use of the OWA operator makes it possible to order the recreation sites according to a relative importance of each criterion assumed. The results indicate the city of Culiacán as the best recreation place from the point of view of these criteria, while the municipality of Cosalá is found to be the worst one. This result can be useful for local authorities and policymakers by suggesting where to allocate resources.

A. J. Villa Silva, L. A. Pérez Domínguez, E. Martínez Gómez and R. Romero López ("Dimensional Analysis under Pythagorean Fuzzy Set with Hesitant Linguists Term Entropy Information") deal with the method of dimensional analysis (DA) which considers an association of all the criteria involved in a problem and makes it possible to capture interrelations that usually occurs in multi-criteria decision-making problems. The authors use the so-called Pythagorean fuzzy sets (PFSs), a recently introduced tool for handling fuzziness and vagueness that is viewed to yield a greater flexibility for decision-makers who are to provide evaluations and assessments and also may have difficulty for the specification of weights when information available is unknown and incomplete which can notably happen while applying tools and techniques of multi-criteria decision-making (MCDM). The use of a combination of three important tools is proposed: the dimensional analysis, Pythagorean fuzzy sets and entropy measure for hesitant fuzzy linguistic term sets for problems with a lack of, or scarcity of information on qualitative criteria, interrelationship among the multiple criteria, and weights. The analyses are illustrated in examples.

Ingrid Nineth Pinto López, Cynthia M. Montaudon Tomas and Alicia L. Yáñez Moneda ("Conditions of Technology Access for Remote Work in the Quaternary Sector in Mexico in Times of COVID-19") perform an analysis of conditions of an access to technology for teleworking that professionals in the quaternary sector in Mexico face. The quaternary sector is meant, as usually, by businesses and industries providing information related services, such as computing, ICT (information and communication technologies), consultancy, R&D (research and development, notably in scientific fields), and related types of activities. Data collection for the analyses has been performed between five and seven months after the Covid-19

related lockdown measures have been ordered in Mexico, so that professional activities have been moved to telework (distant) mode. The data have been collected for 966 participants in 27 of the 32 states of Mexico. Valuable results are obtained on the conditions of access to technology, training and tools required to work remotely.

Pavel Anselmo Alvarez ("Study of the Geographical Marginality in a Mexican Region Using the MR-sort Method") studies the geographical marginality in the State of Sinaloa in Mexico. The marginality evaluation of municipalities is developed by employing a multi-criteria decision-making based sorting method. More specifically, the MR-sort method is used to classify the municipalities into four categories of marginality. The results obtained indicate three municipalities with the highest marginality level due to low performance in education and income factors. The analysis suggests that low performance has a negative impact on the marginalization and leave the population in the state of a higher value of marginality.

Rubén Chávez, Federico González, Victor Alcaraz and Jesús Ricard Ramos ("Strategic Diagnostics of Stress and Impulse Control for Second Order Change: Inclusion of Forgotten Effects in Diffuse Cognitive Maps") are concerned with the determination of strategic cognitive factors that impact the so-called Second Order Change (SOC) which, roughly speaking, boils down to doing something fundamentally different than done before, and which can be decisive for a transformation of organizational systems. A methodology based on the Fuzzy Cognitive Maps (FCM) and the Forgotten Effects (FE) model is proposed. The inclusion of the FEs makes it possible to reduce inference errors in the inference matrix with an objective to provide certainty to the inference matrix when applying the FE model. First, the elements are separated into two matrices containing positive and negative elements. The negative element matrix is then temporarily transformed into a state of positive elements so that both matrices can undergo a fuzzification-inferential-defuzzification process in the FE model. Then, the matrix of temporarily positive elements returns to its original (negative) state. Finally, both matrices are added to obtain an adjusted inference matrix to be applied in the fuzzy cognitive map model. In the case study presented the cognitive factors that impact the behavior of the personnel of four companies are found, starting with two highly correlated factors: the stress tolerance and impulse control, using the absolute Hamming distances.

Walayat Hussain, José M. Merigó, Fethi Rabhi and Honghao Gao ("Aggregating Fuzzy Sentiments with Customized QoS Parameters for Cloud Provider Selection Using Fuzzy Best Worst and Fuzzy TOPSIS") are concerned with a very important problem of dealing with the hesitancy of consumers who are faced with an abundance of services (and the same for products) amplified even more when multiple service providers offer the same type and quality of services. To make an informed choice the decision-makers have to take into account and combine multiple factors and aspects. Sentiment mining is here increasingly popular as one of the key techniques to determine the service quality and get an insight into business. It can help service providers precisely deduce a consumer's emotions to then find an optimal service provider matching the request. Though there is much literature on the Quality of Service (QoS) of the offered services in cloud service selection, there are a very

few of them which consider a user's experience of a consumer in the decision-making process. Moreover, a very few works are on the combination of the Quality of Experience (QoE) and the customized Quality of Service (QoS). This problem is dealt with here by aggregating the consumer's sentiments with customized QoS parameters to choose an optimal service provider. The fuzzy Best Worst Method (BWM) is employed to determine the weights of selection criteria and then the fuzzy TOPSIS is used to handle uncertain linguistic preferences. The results obtained confirm the applicability and effectiveness of the approach.

Jhesus Wilson Panca Galindo, Blanca Roldán-Clarà and Alfredo Pelayo Calatayud Mendoza ("Economic Benefits to Conserve the Tourism Potential of Chifron Beach in the District of Capachica, Puno, Peru") are concerned with the Chifron beach in the Capachica district, Puno, Peru, which is a popular tourist attraction. It should be subject to a critical conservation due to environmental pollution by solid wastes, visual contamination from graffiti painted on the rocks, and alteration of beaches by the extraction of sand for construction that threaten the quality of the beach and water and have a negative impact on neighboring households. This work deals with an attempt to stimulate economic benefits for conserving the Chifron beach by trying to identify a socioeconomic profile of visitors and to determine a proper entrance fee to the beach by using a survey and contingent valuation method. The survey concerns 252 visitors among whom 54% are male, 53% are married, 76% have higher education, 66% work in private or public institutions, 34% have their own businesses, 27% are residents of rural areas and 73% live in urban areas of different cities. To summarize the results obtained, 94% of the tourists agreed that the beach should be cleaned and sanitary services be available. However, 66% of the surveyed tourists rated the cleanliness and hygiene of the sand as poor, and 64% considered the cleanliness and hygiene of the shoreline as poor while 59% of the tourists rated the landscape at the beach as very good. As found, 63% of the visitors would be willing to pay an entrance fee for the conservation of the beach. This means that is though the conservation condition of the Chifron beach is critical, there is a willingness to pay for visiting the beach as long as it is in optimal conditions, that is, with a clean sand and shoreline, and with appropriate sanitary facilities. Moreover, the analysis showed that the monthly income and educational level of visitors is directly proportional to the willingness to pay for a conservation fee, and the hypothetical cost of visiting the beach is inversely proportional to that willingness to pay.

Feng Chung Wu, Huei Diana Lee, Newton Spolaôr, Moacir Fonteque Junior, Weber Shoity Resende Takaki, Claudio Saddy Rodrigues Coy, João José Fagundes, Raquel Franco Leal, Renato Bobsin Machado and Maria de Lourdes Setsuko Ayrizono ("Monitoring Videocolonoscopy Examinations in Real-time via Internet") are concerned with the use of computational technologies in medicine, more specifically with the support of the establishment of collaboration networks among professionals in medical centers, clinics and hospitals, notably after the advent and expansion of the Internet. These networks can help the experts located in different locations to monitor and discuss medical procedures in real time, as well as to collect, store and share multimedia data associated with these procedures. An innovative method in telemedicine and a computational system is proposed that allows experts to interact in

real time by text, audio and video, as well to perform a real-time gathering and sharing of videocolonoscopic images and videos with authorized users via the Internet. These multimedia data are stored and published into a centralized server implemented taking into account security concerns. The results obtained confirm that the proposed system can be an alternative to support collaboration among experts and institutions that offer videocolonoscopy or other types of video-based examinations and medical procedures to patients.

Antonio Kido Cruz and M. C. Felipe Andoni Luna Campos ("Economic Growth and Universities: Empirical Evidence for Mexico") discuss and estimate the relationship between the economic growth in the states of Mexico (EGM) and the number of colleges and universities (NU). In order to prove the existence of a long-term association among the variables considered, yearly data from 1995 to 2015 are used and a fixed effects data panel model is employed. The results obtained show that a 100% increase in the number of public universities is positively and significantly related to the growth of 38.2% in the GDP per capita. The proposed analysis can potentially be useful for the design of public policies of higher education in various countries.

Juan C. Ruiz-Torres and Gina P. Fonseca-Cifuentes ("ABC Costing System Applied to a SME specializing in Dairy Production in Colombia") discuss how to develop a methodology for the implementation of management accounting associated with the Activity Based Costing (ABC) which is a method fo reassigning overhead and indirect costs to products and services. The work is focused on an example of a Colombian Small and Medium Enterprize (SME) specializing in dairy products.

Nine stages for the construction of the cost system are assumed. As a result of the analyses, the determination of the cost of the agricultural products as well as the measurement of biological assets are performer according to the international IAS 41 standard which basically states that a biological asset is any living plant or animal owned by business, and their measurement is at a fair value minus selling costs. An important conclusion obtained is that the system costs make it possible to make appropriate decisions and optimize processes and to increase profitability.

María Eugenia Estrada-Chavira, Sylja Viridiana Guerrero-García, Maribel Rocío Hernández-Velázquez and Guillermo Arredondo-García ("Did Mexico Lose the Fight of Tomato Exports in the Times of USA Tariff, Facing the Umsca?") are concerned with the problem implied by introducing in 2019 a 17.5% tariff on the tomato imports from Mexico which has strongly affected the tomato market. The objective of this work is to measure the demand price elasticity of tomatoes for two periods: with the tariff and without the tariff. The price elasticity is calculated using the logarithmic regression. It is shown that the tomato price elasticity is elastic in both periods but is higher in the period with tariff. That means that if the tomato price changes, then the volume of the demand diminishes more than proportionally. In the beginning the producers, exporters and both the American and Mexican economies lose because the consumer price of the product increases. As a conclusion, it is stated that since Mexico does not have a strong international presence on the tomato market around the world, except for the USA, then it is highly advisable to extend the exportation to other markets, notably the Asian markets.

Miriam Edith Pérez-Romero, Martha Beatriz Flores-Romero, and Victor G. Alfaro-García ("Tourism Competitiveness Theory Perspectives Through the Application of Counter-expertise Methods") deal with a comparison of opinions of two groups of experts regarding the relationship between causes and effects of the competitiveness of tourist destinations. Formally, the formation of two groups of experts, those who investigate the touristic activity and those who work in the tourism sector are first undertaken. Both groups evaluate cause-effect relationships using the forgotten effects theory. The results are then compared using the counter-expertise technique. Finally, the results are grouped via a frequency distribution to facilitate its interpretation and analysis. The application of the counter-expertise technique shows that the distance between the opinions of the two groups of experts is from 0.00% to 18.75% in direct incidences and from 0.00% to 16.25% in indirect incidences. The frequency distribution shows that the data is highly skewed to the right so that most of the results are in the lowest values, that is, the distance between the opinions of the two groups of experts is small in most cases, and therefore, information provided by the experts appears to be valid. In both cases of using the direct incidents and forgotten effects, the environmental commitment cause appears to be important.

Norma Laura Godínez-Reyes, Rodrigo Gómez-Monge, Gerardo Gabriel Alfaro-Calderón, and Argelia Calderón-Gutiérrez ("Sustainable Value: An Empirical Research in Large Firms") deal with the determination of the extent to which the environmental, social and governance indicators can explain corporate efficiency which is gauged by the return on assets (ROA), return on equity (ROE) and return on sales (ROS). To find the validity of the corporate efficiency measurement first a model of three linear regressions with panel data is developed. This model tests whether the environmental (E), social performance (S) and corporate governance (G) variables for the companies considered can explain the profitability of these companies for the period 2014–2017. The results obtained show that the sustainable value (S) explains the profitability—or return on sales (ROS)—with a high degree of significance, whereas it explains the corporate efficiency to a moderate extent. The corporate governance (G) is the most significant variable for the generation of a sustainable value. As a result it is shown that the generation of sustainable values makes it possible for the companies to meet their profitability goals and to mitigate environmental and social impacts. That is, the model can be useful for measuring the corporate efficiency in sustainable companies.

Part II: Bibliometric analyses of main research directions

This part of the volume is quite novel and is rarely included in research reports, books and volumes on the topics considered. Basically, the authors use bibliometric data from well-known systems which include scholarly data on publications, authors, etc. exemplified by the Web of Science, Scopus or Google Scholar. These data are analyzed by advanced data mining methods which makes it possible to extract much information about various important aspects like the main areas and topics of research and their impact on the community as shown by, for instance, the number of citations, the main researchers and research groups working on specific topics, an application potential of particular papers and research directions, etc. Needless to say that these

analyses can yield much information that can be very useful for both usual productivity analyses of research efforts and also for scientific policymaking to support promising fields.

Marlenne Velázquez Cázares, Sergio Alvarado-Altamirano, Ernesto León-Castro, and Fabio Blanco-Mesa ("A Bibliometric Analysis of Corporate Social Responsibility and Competitiveness") are concerned with the corporate social responsibility and its relationship to the competitiveness which is an important field of study, both for companies and institutions, and more generally the society. The paper focuses on a comprehensive presentation of the main contributions in these subjects via a bibliometric analysis. Specifically, a wide range of bibliometric indicators is employed using the Web of Science (WoS) Core Collection and complemented with the Scopus database. The leading journals, authors, research groups and institutions, countries, and even articles are considered. The results confirm a growing relevance of the research field and find both the most influential authors and the most productive authors. Moreover, leading countries, in the sense of the largest number of publications and citations, are shown. As a conclusion, it is stated that the relationship between the corporate social responsibility and competitiveness is a more and more relevant field of study that contributes to the development of new theories, approaches and applications.

Pavel López-Parra, Anselmo Alvarez-Carrillo, Ernesto León-Castro, Marlenne Velázquez Cázares and Manuel Muñoz Palma ("A Bibliometric Analysis of Robustness and MCDA") are concerned with some important aspects, both for theory and practice, of Multicriteria Decision Aiding (MCDA) which can be described as an important area of operations research that offers the methodology, algorithms and implementations for the formulation and solution of complex decision-making problems with multiple conflicting criteria. An important aspect is here robustness, and its related analyses are used to find a more precise solution within the methodologies of MCDA, as well as those less vulnerable to uncertainties, imprecision or imperfect and missing data. The purpose of this work is to present an overview of this topic from the perspective of bibliometric analysis using the Scopus and Web of Science databases. Using a large number of indicators, relevant information about journals, authors, countries and institutions is derived. The results obtained list the most productive and influential authors, research groups and countries, as well as indicate the usefulness of these results for various aspects of research analyses and policymaking.

Denisse Ballardo-Cárdenas, Ernesto León-Castro, Fabio Blanco-Mesa, and Ramón Martínez-Huerta ("A Bibliometric Analysis on Innovation Management Research") deal with an analysis of information on scientific research publications related to innovation management available using the Web of Science Core Collection database, more specifically published from 1982 to 2018. The documents analyzed included articles, reviews and notes. The approach proposed graphically maps the bibliographic material by using the VOS viewer software, a popular software used for such bibliometric analysis, to obtain a more illustrative and in depth analysis of data and relations between them. The paper identifies leading and most inspiring publications, the most productive authors, the most productive countries, the most

productive institutions and analyzes the evolution of their output and activities over time.

Rodrigo Gómez Monge, Víctor G. Alfaro-García, Irma C. Espitia-Moreno, Dalia García-Orozco, and Manuel Ricardo Romo de Vivar Mercadillo ("Environmental Sustainability: A 10-year Bibliometric Analysis of the Developments in Management, Business, Finance and Economics") are concerned with a much talked about and extremely relevant general problem of sustainability which is understood basically as the satisfaction of needs of people living in the present times without jeopardizing the resources for future generations. This general goal calls for various systems, economic, social, technological, etc., to be designed for a proper transformation, consumption, strategic coordination and allocation of resources. A bibliometric analysis proposed is designed to find core academic developments indexed in the Web of Science scientific database from 2010 to 2019. The results obtained show the leading authors, papers, journals, organizations, countries, etc. which are relevant for the field of sustainable management, business, finance and economics. Trends, connections and networks using analytical and statistical tools are obtained. The use of the VOS viewer software provides a fast and comprehensible visual representation of the retrieved core documents.

Abraham Nuñez Maldonado and Martha Beatriz Flores Romero ("A Bibliometric Analysis of Sustainable Tourism Research for the Period 1991–2019") present a bibliometric analysis of sustainable tourism by analyzing 28 years of research published between 1991 and 2019, using the Web of Science database. The analysis focuses on the results obtained by using the bibliometric review software, Rstudio. This makes it possible to obtain in a comprehensible form various useful results exemplified by the most cited papers and authors, the most productive and influential researchers, institutions and countries, to just mention a few. The results obtained indicate that sustainable tourism attracts much attention of the research community reflected by an exponential growth of scientific papers on the topic.

Adriana Paulina Aranzolo-Sánchez, Donaji Jiménez-Islas, and Miriam Edith Pérez-Romero ("Research Growth on Bioethanol: A Bibliometric Analysis") provide a bibliometric analysis of research on bioethanol using the Web of Science and Scopus databases for the period of 1990 to 2019. The logistic equation is used to quantitatively describe the growth of publication volume reported in both databases. The results show that the Scopus database exhibits the rate of publications of 0.31 per years and for the WoS database this rate is 0.29 per year, and—in general—the logistic equation is found appropriate for the problem considered. The method also makes it possible to find the leading countries who produce the highest number of publications.

We strongly believe that the high quality, interesting and inspiring contributions included in this volume will be of much interest and use for a wide research community. The contributions concern many questions that are important not only for researchers and scholars, but also practitioners, notably economic analysts and policymakers. All these people can find in the volume very much of useful material that can help in their operational, strategic and policy related activities.

We wish to thank all the contributors for their great works. Special thanks are due to anonymous referees whose deep and constructive remarks and suggestions have helped to greatly improve the quality and clarity of the contributions.

And last but not least, we wish to thank Dr. Tom Ditzinger, Dr. Leontina di Cecco and Mr. Holger Schaepe for their dedication and help to implement and finish this important publication project on time, while maintaining the highest publication standards.

Baja California, Mexico — Ernesto Leon-Castro
Tunja, Colombia — Fabio Blanco-Mesa
Morelia, Mexico — Victor Alfaro-Garcia
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Contents

Analyses of Aspects of Economic, Social and Technological Development

Ranking of Innovation and Sustainability of Tourist Destinations in Sinaloa: An Analysis with the Ordered Weighted Average Operator

Huesca-Gastélum Martín Isimayrt, Delgadillo-Aguirre Alicia, León-Santiesteban Martín, and León-Castro Ernesto

Abstract The objective of this work is to classify the innovation and sustainability of tourist destinations in Sinaloa through the ordered weighted average operator (OWA). The application of this method allows to order the recreation sites according to the relative importance of each criterion. The results indicate the city of Culiacán as the recreation place with the best levels in its evaluation, while the municipality of Cosalá turned out to be the lowest valued establishment. This information is useful for policy makers because they will be able to allocate their resources based on their areas of opportunity. Finally, the document demonstrates the application of the OWA operator to measure innovation and sustainability of tourist attractions in Sinaloa, Mexico.

Keywords Innovation · Sustainability · Tourist destinations · OWA operator

1 Introduction

According to [33], in recent years tourism has experienced rapid growth around the world, where the extensive diversification of recreational spaces has managed to turn it into a sector it is an important economic factor for the host communities, but it has also caused those responsible for planning it to include certain innovative and sustainable strategies within the administration of these leisure spaces.

In the same way, due to globalization, innovation and sustainability have been positioned as relevant aspects for the competitiveness of tourist attractions [25]. Therefore, in such a globalized and competitive context, it is up to the management of entertainment venues to implement increasingly innovative and sustainable actions to guarantee the best possible results over time [33].

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Hence, innovation and sustainability are considered by tourist attractions to improve their competitiveness and remain active in an increasingly diversified world [2, 5, 26, 27, 35]. For these reasons, in recent years tourist destinations have been studied from different disciplines [36].

However, there is still little empirical evidence that considers these factors in the questions of recreation places [23]. In addition, a large number of academics argue that research on these dimensions is limited, so there is a need for further elaboration of documents focused on the evaluation of these phenomena, as well as on the theoretical contribution regarding innovation and sustainability studies tourism [5, 6, 30].

Hence, the objective of this study is to classify the innovation and sustainability of tourist destinations in Sinaloa through the ordered weighted average (OWA) operator. The use of this technique allowed not only the classification of recreation sites according to their innovative capacity and sustainable competence, but also managed to highlight the relative importance of the criteria based on the expectations, knowledge and aptitude of the decision maker.

To achieve the purpose of this research, it was decided to use the approach proposed by [6], as well as the framing presented by [8] because they are the best options to measure and characterize the innovation and sustainability of recreational spaces, but also because they have been used in various publications in recent years.

Finally, this article begins with the presentation of the theoretical framework on the aforementioned dimensions. Subsequently, the OWA operator is defined and the use of this method is presented to classify recreational sites in Sinaloa according to their innovation and sustainability. Finally, the main conclusions of the document are summarized and the references used are indicated.

2 Theoretical Framework

2.1 A Literature Review of the Innovation and Sustainability of Tourist Destinations

As pointed out by [32], due to globalization, tourism managed to position itself as a fast-growing industry worldwide and according to [7], different countries have considered it as one of their main economic activities due to its great capacity to generate benefits in the host communities.

For [41], it is due to this relevance that competition between tourist destinations around the world has increased, but more regions have also decided to resort to travel proclivity to incorporate them as an important element in their economic work, as they recognize the benefits at stake [10, 13]. Therefore, the proper management of this industry could make it a key element to achieve broader social objectives [9].

On the other hand, recreational sites are in constant competition with each other due to the growth in tourist mobility. Consequently, recreation venues should strive to

be more competitive [14, 41] because as travel increases, competition among tourist attractions also increases.

Hence, the potential of the recreational vocation of any host community strongly depends on its ability to maintain an advantage in the delivery of goods and services to its visitors [11]. According to [28], for this reason entertainment venues need more flexible approaches to be effective in this competitive process [28].

On the one hand, they intend to implement new technologies to be more innovative [16], but on the other, they strive to promote more sustainable entertainment venues [17]. Otherwise, if recreational sites do not pay attention to these elements, all efforts to be more competitive would be in vain [1].

However, it is difficult to evaluate and compare their degree of innovation and sustainability because there is no consensus on the ideal indicators to make this comparison [16, 17]. In addition, most studies have decided to address these factors to estimate good practices, but they have also shown the limitations faced in these aspects and which, in turn, limit the competitiveness of tourist destinations [3].

In this sense, the reflection begins with the exploration of [34], these authors propose a model to evaluate these criteria in some destinations in Portugal through the entropy of information and through different weights that were calculated with alternative approaches such as the Fuzzy Rasch and the hierarchical analytical process (AHP). The results of this application not only showed that there is a heterogeneity between Portuguese attractions in terms of innovation and sustainability, but also evidenced the relationship between these tourist practices.

On the other hand, [31] carried out an investigation to determine the places of recreation that implement sustainable and innovative strategies in the province of Fars, Iran. To achieve this purpose, the authors used ordered weighted average (OWA) algorithms and fuzzy quantifiers. The results showed that almost the entire study area applied few innovative and sustainable instruments.

In the same way, [16] applied a methodology that allowed them not only to compare the innovation and sustainability of tourist destinations in Spain, but also facilitated the generation of a ranking of destinations according to these criteria. This analysis was done through the hierarchical analytical process (AHP) and the ordered weighted average (OWA). Among the most relevant findings is the fact that leisure sites can develop innovative and sustainable ideas with little resources, but with more efficient management processes.

Similarly, [40] applied the induced ordered weighted average (IOWA) operator to determine the level of innovation and sustainability presented by 13 cities in China. The results of this evaluation indicated that the innovative and sustainable development of most of the localities was poor. Where the performance values were below 0.5 and only Beijing and Tianjin managed to be above this parameter.

Finally, [21] used the analytical hierarchy process (AHP) and the ordered weighted average operator (OWA) to evaluate and prioritize tourist sites based on their innovative and sustainable capabilities. The study was carried out in the area of La Vera, Spain and its results showed the application of these fuzzy logic techniques to compare these geographical areas. Furthermore, this method of analysis proposes

an approach to improve the attitudes of local residents regarding the management of tourist destinations.

However, the utility approaches are the one proposed by [8], as well as that presented by [6], since these authors have developed some indicators that allow assessing the innovation and sustainability of the recreation sites at the local and regional levels. For this reason, this document opts to use these theoretical perspectives. In addition, with the proposal of this study the theoretical and methodological lag is reduced, therefore, it contributes to the generation of knowledge from this perspective in question.

2.2 Innovation and Sustainability in the Tourist Destinations of Mexico

Currently, tourism is experiencing significant changes that are the product of globalization and a variety of new trends in tourism demand [12]. Hence, tourist destinations around the world must compete with each other to maintain their participation in the tourism market [15].

This implies that innovation and sustainability strategies are key factors to retain this competitive validity, but they have also become essential criteria for evaluating the competitiveness of recreational sites [22]. On the other hand, around the world there is a growing demand related to the analysis of this question, since different methodological proposals are visualized that try to evaluate the competition of certain tourist destinations through indexes and ranking made up of these two dimensions [16].

For example, the [37] measures the competitiveness of the travel and tourism sector every two years through 14 main dimensions. Among these pillars is that of innovation, as well as the criterion of sustainability. In the same way, said evaluation is carried out by means of an index that is calculated as an average of all the pillars considered.

The results show that Mexico ranks 19 in this competition index (see Table 1). Where its level is characterized by having exceptional natural and cultural resources that, effectively combined, manage to offer relatively strong price competitiveness, but also favors the high percentage achieved [37].

However, if the innovation criterion is analyzed, the Mexican case is located in position 81 with a total of 4.4 points. Now, looking at the pillar related to sustainability, this nation is affected in the ranking, since it reaches 108th place with a 3.9 score [37]. Consequently, the Aztec government will have to pay more attention to these issues, otherwise, its performance in the competitiveness index could be affected.

Similarly, the [20] carried out a measurement on these aspects in the Mexican states through an index made up of 6 components and 160 indicators. In this way,

Table 1 Travel and tourism competitiveness index

Rank	Country	Score
1	Spain	5.4
2	France	5.4
3	Germany	5.4
19	Mexico	4.7
20	Norway	4.6
70	Ecuador	3.9
71	Azerbaijan	3.8
138	Liberia	2.6
139	Chad	2.5
140	Yemen	2.4

these parameters offer the states the possibility of analyzing and evaluating their competitiveness through a ranking.

The results indicate that the best evaluated states according to this index are Mexico City, Nuevo León and Querétaro. In contrast, the territories of Chiapas, Oaxaca and Guerrero constitute the worst evaluated entities in their performance. In this sense, with regard to the question of innovation and sustainability, it is possible to affirm that Mexico City remains with the first place in the ranking, this tourist destination being the best compared to the rest [20].

Along the same lines, the [18] developed a state competitiveness index to analyze the 32 Mexican states according to various criteria, among which innovation and sustainability stand out. This classification was made up of 100 indicators that were categorized into 10 sub-indices and made it possible to identify the strengths as well as the weaknesses of each state. The analysis shows Mexico City, Querétaro and Chihuahua as the most competitive entities.

Likewise, the results based on the sustainable criterion also show that Mexico City obtained the first place in this criterion, while Oaxaca was the entity that was located in the last position. On the other hand, in relation to the innovation aspect, the state of Querétaro remains number one in the ranking. For its part, Tabasco is positioned as the worst federal entity [19].

Finally, the [18] developed an index to classify the 73 most important cities in Mexico according to 70 indicators that were grouped into 10 dimensions. This parameter was created with the intention of identifying the opportunities and challenges of each urban area to create and attract talent and investment. In general, the results show the Ciudad del Carmen and the Piedras Negras municipality as the best-evaluated cities.

On the contrary, the towns of Tecomán and La Piedad-Pénjamo were evaluated as the worst tourist destinations based on this global index. However, analyzing the criteria related to sustainability, the best city evaluated was Aguascalientes, while Toluca was ranked as the worst performing one. However, the ranking changes if the

innovation factor is observed, since in the first position is the Valle de Mexico and as last place is Tuxtla Gutiérrez [19].

3 The Ordered Weighted Average Operator

An operator that can be used to aggregate information is the OWA operator introduced by [38]. This operator let you aggregate information between the maximum and the minimum and since then many applications have been made [4, 39]. The definition is as follows.

Definition 1
An OWA operator of dimension n is a mapping OWA : $R^n \to R$ with an associated weight vector W of dimension n such that $\sum_{j=1}^{n} w_j = 1$ and $w_j \in [0, 1]$, according to the following formula:

$$\mathrm{OWA}(a_1, a_2, \ldots, a_n) = \sum_{j=1}^{n} w_j b_j, \tag{1}$$

where b_j is the jth largest element of the collection a_i.

Note that we can distinguish between the descending OWA (DOWA) and the ascending OWA (AOWA) operator. This difference is related by $w_j = w^*_{n-j+1}$, where w_j is the jth weight of the DOWA operator and w^*_{n-j+1} the jth weight of the AOWA operator.

Decisions within OWA operators can be generated under different criteria, the most important of which are the following.

1. Optimistic criterion. It assumes that the most favorable state will be presented, in such a way that the most favorable result of each alternative must be selected and from the results obtained select the most favorable of all. In such a way that this criterion is based on a maxim that is formulated

$$Decision = Max\{E_i\} = Max[Max\{Max\{a_j\}]$$

2. Pessimistic or Wald criterion. It maintains that the decision maker must select the alternative that provides the highest level of security, in such a way that our decision must be the most favorable result among the most unfavorable for each alternative. This method is known as max min and its formula is

$$Decision = Max\{E_i\} = Max[Min\{a_j\}]$$

3. Hurwics criterion. It consists of weighing the best and worst case respectively with an optimistic coefficient and another pessimistic one, subsequently the

values are added and the alternative that proposes a better result is chosen. The formula for this criterion is

$$Decision = Max\{E_j\} = Max[\alpha Max\{a_j\} + (1-\alpha)Min\{a_j\}]$$

where $\alpha + (1-\alpha) = 1$.

4. Laplace's criterion. It is based on the principle of insufficient reason, in such a way that the same degree of probability is associated with the different scenarios, provided that there are no indications to the contrary. The formula is

$$Decision = Max\{E_j\} = Max\left[(1/n)\sum_{j=1}^{n} a_j\right]$$

4 Measurement of the Innovation and Sustainability in the Tourist Destinations in Sinaloa with the OWA Operator

To measure a ranking of tourist destinations based in Sinaloa based on the OWA operator, there are some steps that must be follow.

Step 1. Because the purpose is to rank the tourist destinations based on innovation and sustainability, these two items will be the main criterions and for each of them different indicators have been defined based on the theoretical framework presented in Section II. This information is presented in Table 2.

Step 2. For each of the indicators proposed in Table 1, the information for each of the 18 municipalities for Sinaloa were obtained (See Table 2). The data is presented in Table 3.

Step 3. To give an actual value to each indicator, it was decided that the highest value will have the value of 1 and the others one will be evaluated in function of that. In this sense, the value for each indicator will be $Result = \frac{Value}{MaxValue}$. The information is presented in Table 4.

Step 4. The next step will be giving importance to the criterions by a weighting vector. This vector will be the one used to calculate the results using the OWA operator. For the criterions and because innovation presents many municipalities does not present results in the indicators the weights will be 30% and sustainability will be 70%. The sum of all indicators will be the evaluation for each criterion (See Table 5).

Step 5. The OWA operator is calculated based on the information provided. For this article, the weighted average, the OWA maximum and OWA minimum will be calculated. The results are presented in Tables 6, 7 and 8.

Table 2 Indicators to measure the innovation and sustainability in tourism destinations

Identifier	Description	Category
INN	Innovation	Criteria
NEI	Number of educational institutions dedicated to the training of human resources for innovation purposes	Indicator
PII	Public investment for innovation	Indicator
NCR	Number of companies that receive public resources for innovation issues	Indicator
ARD	Amount of R&D expenditure	Indicator
NRP	Number of registered patents	Indicator
SUS	Sustainability	Criteria
NTR	Number of tourism related jobs	Indicator
PIC	Public investment aimed at various cultural aspects	Indicator
NIW	Number of inhabitants with access to water	Indicator
CRE	Complaints received on environmental matters	Indicator
PDW	Percentage of dwellings with waste disposal	Indicator

Table 3 Municipalities of Sinaloa, Mexico

Identifier	Municipality
A1	Ahome
A2	Angostura
A3	Badiraguato
A4	Choix
A5	Concordia
A6	Cosalá
A7	Culiacán
A8	El Fuerte
A9	Elota
A10	Escuinapa
A11	Guasave
A12	Mazatlán
A13	Mocorito
A14	Navolato
A15	Rosario
A16	Salvador Alvarado
A17	San Ignacio
A18	Sinaloa

Table 4 Results of each identifier for each municipality

Identifier	A1	A2	A3	A4	A5	A6	A7	A8	A9
INN									
NEI	6	0	0	0	0	0	19	0	0
PII	0	0	0	0	0	0	0	0	0
NCR	3	0	0	0	0	0	0	2	0
ARD	0	0	0	0	0	0	0	0	0
NRP	0	0	0	0	0	0	3	0	0
SUS									
NTR	170,982	14,964	6104	7238	8220	3556	366,171	33,752	23,070
PIC	30,700,072	0	2,200,000	0	1,200,000	0	10,025,000	1,660,000	9,549,000
NIW	449,033	47,203	31,819	32,987	27,127	16,292	905,152	100,445	53,856
CRE	20	4	0	0	0	0	13	0	10
PDW	124,209	13,246	8167	8698	7459	3840	247,718	26,435	13,721
Identifier	A10	A11	A12	A13	A14	A15	A16	A17	A18
INN									
NEI	0	0	10	0	0	0	0	0	0
PII	0	0	6,500,000	0	0	0	0	0	0
NCR	0	0	1	6	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
NRP	0	0	2	0	0	0	0	0	0
SUS									
NTR	22,002	101,770	209,914	13,421	63,709	18,640	29,804	6,609	22,023

(continued)

Table 4 (continued)

Identifier	A1	A2	A3	A4	A5	A6	A7	A8	A9
PIC	1,536,000	9,000,000	94,500,000	–	–	–	2,200,000	6,494,000	1,600,000
NIW	59,436	295,353	502,282	45,351	153,937	53,763	81,101	21,438	88,655
CRE	1	3	18	–	2	–	–	7	3
PDW	15,186	77,005	146,485	12,223	38,965	14,540	22,569	6,046	22,342

Table 5 Values for each indicator for each municipality

Identifier	A1	A2	A3	A4	A5	A6	A7	A8	A9
INN									
NEI	0.32	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
PII	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NCR	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00
ARD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRP	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
SUS									
NTR	0.47	0.04	0.02	0.02	0.02	0.01	1.00	0.09	0.06
PIC	0.32	0.00	0.02	0.00	0.01	0.00	0.11	0.02	0.10
NIW	0.50	0.05	0.04	0.04	0.03	0.02	1.00	0.11	0.06
CRE	1.00	0.20	0.00	0.00	0.00	0.00	0.65	0.00	0.50
PDW	0.50	0.05	0.03	0.04	0.03	0.02	1.00	0.11	0.06
Identifier	A10	A11	A12	A13	A14	A15	A16	A17	A18
INN									
NEI	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00
PII	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
NCR	0.00	0.00	0.17	1.00	0.00	0.00	0.00	0.00	0.00
ARD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRP	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
SUS									
NTR	0.06	0.28	0.57	0.04	0.17	0.05	0.08	0.02	0.06
PIC	0.02	0.10	1.00	0.00	0.00	0.00	0.02	0.07	0.02
NIW	0.07	0.33	0.55	0.05	0.17	0.06	0.09	0.02	0.10
CRE	0.05	0.15	0.90	0.00	0.10	0.00	0.00	0.35	0.15
PDW	0.06	0.31	0.59	0.05	0.16	0.06	0.09	0.02	0.09

Table 6 Value for each criterion

Identifier	A1	A2	A3	A4	A5	A6	A7	A8	A9
INN	0.82	0.00	0.00	0.00	0.00	0.00	2.00	0.33	0.00
SUS	2.79	0.35	0.11	0.09	0.10	0.04	3.76	0.33	0.78
Identifier	A10	A11	A12	A13	A14	A15	A16	A17	A18
INN	0.00	0.00	2.36	1.00	0.00	0.00	0.00	0.00	0.00
SUS	0.25	1.16	3.62	0.14	0.60	0.17	0.29	0.48	0.42

Table 7 Weighted average results

A1	A2	A3	A4	A5	A6	A7	A8	A9
2.20	0.24	0.08	0.06	0.07	0.03	3.23	0.33	0.55
A10	A11	A12	A13	A14	A15	A16	A17	A18
0.18	0.81	3.24	0.40	0.42	0.12	0.20	0.34	0.29

Table 8 OWA maximum results

A1	A2	A3	A4	A5	A6	A7	A8	A9
2.20	0.24	0.08	0.06	0.07	0.03	3.23	0.33	0.55
A10	A11	A12	A13	A14	A15	A16	A17	A18
0.18	0.81	3.24	0.74	0.42	0.12	0.20	0.34	0.29

Table 9 OWA minimum results

A1	A2	A3	A4	A5	A6	A7	A8	A9
1.41	0.10	0.03	0.03	0.03	0.01	2.53	0.33	0.23
A10	A11	A12	A13	A14	A15	A16	A17	A18
0.08	0.35	2.74	0.40	0.18	0.05	0.09	0.15	0.12

Step 6. Finally, the ranking and the analysis of the information it is done. The ranking is presented in Table 9.

With the results obtained in Table 10, it is interesting that the Top 3 of the municipalities are always presented and in the same order that is Mazatlan, Culiacan and Ahome. This is important because it is possible to visualize that these three municipalities have an specific rank even when the weights are changed. After that, some interesting changes are presented such is the case of Mocorito, that can go from 7 to 4th depending on the operator that it is used, another similar municipality that have some important changes are Navolato, El Fuerte, Elota and San Ignacio. Finally, from ranking 10–18th there is no important change in the ranking.

With this analysis can be seen that the way that information is analyzed and the importance that is given to each indicator can change the ranking that each municipality has. Also, because of the information from some municipalities are 0, the results from tank 10–18th does not change at all, presenting an important challenge for that municipalities to obtain some results in the medium term to increase their results and increase their position in the ranking.