



Improving the Poverty-Alleviating Effects of Bed and Breakfast Tourism Using Z-DEMATEL

Liu Chu-Hua¹ · Huang Sun-Weng^{2,3,6,7} · Hsieh Mei-Ting⁴ · Lin Chiao-Bing⁵ · Tzeng Gwo-Hshiung⁶

Received: 1 December 2022 / Revised: 1 December 2022 / Accepted: 1 February 2023 / Published online: 22 March 2023
© The Author(s) under exclusive licence to Taiwan Fuzzy Systems Association 2023

Abstract Bed and breakfast (B&B) tourism stimulates the economic development of underdeveloped areas. However, although Taitung is a renowned B&B hotspot, it is the poorest area in Taiwan. This phenomenon has prompted studies on the contribution of B&B tourism to counties. Previous literature related to B&B tourism has the lack of non-economic measures typically results in contradictory phenomena. In addition, most studies have been empirical and have incorporated expert opinions, which are susceptible to human semantical uncertainty and incomplete expression. To overcome these limitations, a framework based on

human-land interactions focused on cultural landscape, locality, and regional revitalization was constructed in present study. An advanced decision method, Z-DEMATEL, in which Z-numbers and decision-making trial and evaluation laboratory (DEMATEL) are combined, was applied. The expression confidence and consistency were evaluated through information integration using exclusive semantic, confidence, and perception scales. Subsequently, the DEMATEL was used to analyze the internetwork relations between Dimensions/Criteria. In the overall dimensions, the locality was a nexus of interrelations, while the cultural landscape was a cause. In each dimension, such nexus and cause-starter were identified using specific criteria. The findings were synthesized as improvement plans for easy indexing. Therefore, the results can improve poverty alleviation through B&B tourism.

✉ Huang Sun-Weng
t107379004@ntut.org.tw

Liu Chu-Hua
liu32lee@mail.knu.edu.tw

Hsieh Mei-Ting
mhsieh@gm.lhu.edu.tw

Lin Chiao-Bing
ibntraveler@outlook.com

Tzeng Gwo-Hshiung
ghtzeng@gm.ntpu.edu.tw

Keywords B&B tourism · Information integration · Z-numbers · Z-DEMATEL

1 Introduction

The United Nations World Tourism Organization (UNWTO) [1] launched sustainable tourism as an effective tool for eliminating poverty (ST-EP). The sustainable development goals (SDGs) of tourism state that “tourism growth” benefits the poor. Tourism is assigned as a tool for alleviating poverty in all its forms [2–4]. Therefore, bed and breakfast (B&B) tourism is considered to be an efficient practice for elevating rural tourism [5, 6] and alleviating poverty in remote areas [3]. However, widespread poverty has remained in some remote areas with high B&B tourism growth [6]. Taitung area in Taiwan is such a region (Fig. 1).

¹ Kainan University, Taoyuan, Taiwan

² National Taipei University of Technology Department of Industrial Engineering and Management, Taipei, Taiwan

³ China University of Technology Department of Marketing and Logistics, Taipei, Taiwan

⁴ Lunghwa University of Science and Technology, Taoyuan, Taiwan

⁵ Chinese Culture University, Taipei, Taiwan

⁶ National Taipei University Graduate Institute of Urban Planning, New Taipei, Taiwan

⁷ Sanming University, Sanming, China

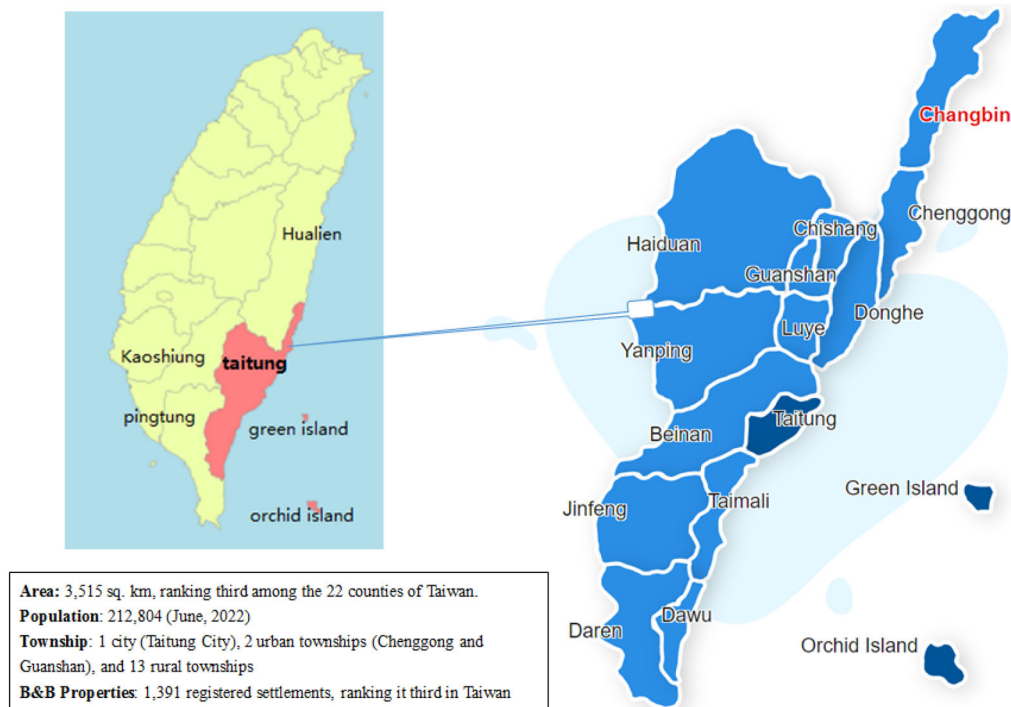


Fig. 1 Map of B&B tourism properties in Taitung

Taitung, a popular tourism destination located in the southeastern Taiwan Island, has remained impoverished for decades. In the past 20 years, the development of tourism has increased the establishment of B&Bs island-wide. The Taitung region is placed third among the 23 counties of Taiwan [7]. However, despite the growth of B&Bs, Taitung has remained the poorest region in Taiwan because of its deteriorating socio-economic status and population loss [8]. Therefore, the dynamic factors that contribute to B&B tourism in Taitung need to be investigated. Furthermore, strategies that can help this destination alleviate its poverty, reduce outward population migration, and benefit from B&B tourism need to be developed.

The literature has generally favored economic indicators for analyzing the dynamic factors responsible for the positive effect of tourism [9, 10]. However, the lack of non-economic measures typically results in contradictory phenomena: less-favored localities experience tourism booms [11]. Therefore, studies should focus on interactions between human activities and land. Such interactions mainly center on “cultural landscapes” [12], the “locality” [13] and “regional revitalization” [6, 14] and manifest in dynamic land–man relationships. It is suggested that the ST-EP and SDG objectives can be achieved by investigating these interactions [1, 4].

Poverty and tourism are multidimensional and complex phenomena [9]. Decision-making trial and evaluation laboratory (DEMATEL) is a widely recognized automated solution for modeling intrinsically complex and

interrelated phenomena [15, 16, 18]. DEMATEL based on multiple-criteria decision-making theory is a simple and efficient tool that uses an expert decision system to analyze and make deductions from real-world cases [15, 19–22].

However, the decision-making evaluation process relies on subjective judgments of experts for analysis and evaluation. The uncertainty and ambiguity of the natural semantic expression of the experts may result in incomplete information [23]. This problem has been addressed using fuzzy theory. For example, Hosseini et al. [24] proposed the use of fuzzy theory for developing recovery solutions for eco-tourism centers, Farooque et al. [25] proposed using fuzzy theory for analyzing barriers to blockchain-based life cycle, and Xu et al. [26] identified critical barriers to the development of hydrogen energy using fuzzy theory. Subsequent studies have expanded the use of Zadeh’s [27] Z-numbers to simultaneously assess real-valued uncertain variables and their reliability (certainty) in our natural language. This method has proven useful in interdisciplinary fields such as the risk evaluation of green supplier selection [28], aircraft landing systems [29], and the selection of travel plans [30] and hotels [31]. Moreover, combined with DEMATEL, Z-numbers has strength of dealing interrelations of criteria in a comparatively simple process. However, few studies have applied the technique on tourism, and even fewer on B&B concerns. This motivates the current research to use this renovated Z-DEMATEL.

Therefore, to the best of our knowledge, this study is the first in which Z-numbers and DEMATEL are used to

examine B&B tourism. The purpose of the study is to: (1) identify the determinants of B&B tourism in Taitung, (2) overcome the uncertainty of expert expression using information integration, (3) apply Z-DEMATEL to precisely identify the interrelations between the determinants, and (4) prepare improved strategies for poverty alleviation and population return. Therefore, this method can contribute to: (1) the use of Z-numbers for identifying the determinants of B&B tourism; and (2) the application of the Z-DEMATEL model for improving policies for poverty alleviation through B&B tourism.

The remainder of this paper is as follows. Section 2 reviews the relevant literature on the methods used to assess B&B tourism performance. Section 3 describes the research methodology and procedure of this study. Section 4 presents the results and discusses the findings and examines their implications. Section 5 concludes the article.

2 Literature Review

The B&B tourism in Taitung region and the dominant factors, cultural landscape, locality, and regional revitalization, were reviewed as the theoretical framework throughout the research. In addition, the strength and appropriateness of Z-DEMATEL was verified for the current study.

2.1 B&B Tourism and Taitung Region

B&B tourism has rapidly grown in the Taitung region since the weekends-off plan was implemented in 2001 to elevate domestic tourism. Because the region is isolated in the southeastern part of Taiwan Island, the infrastructure of Taitung—particularly its traffic system—remains underdeveloped [7]. This may have hindered its development, and the region remains pristine [32]. As a travel hotspot, Taitung was listed as one of Asia's best destinations in 2016 [33] and one of the world's best emerging destinations [34]. Before the outbreak of the COVID-19 pandemic, the number of B&Bs properties in Taitung had increased to 1,330, and the region occupied third place among 23 counties of Taiwan [7].

Despite the booming of B&B industry, the population of Taitung has decreased from 289,451 to 216,781, which contrasts starkly with the 32.5% increase of the Taiwanese population from 1974 to 2019 [35]. Furthermore, according to the [36], Taitung has the largest number of low-income households in the state. This renowned B&B tourism destination has experienced lingering poverty and population loss [37].

The literature states that B&B tourism is an efficient method of alleviating poverty and population loss [38]. Land-based B&B tourism can generate job opportunities

and benefit local communities [14, 39]. This addresses the positive effect of tourism development, particularly according to economic indicators (e.g., income and consumption). However, because of the complexity of poverty and population loss, noneconomic factors (e.g., social exclusion, community cohesion, personal dignity, and empowerment) may influence the interactions between land, human beings, and locality, and thereby influence individual perceptions of the locality [9, 10]. The local perception may reflect the cohesion between the people and the land within the context of B&B tourism environment. The positive effect may extend to reduce poverty and outward migration.

In the current case, the determinants of local perception and methods of generating the positive network effect between them need to be identified. Improvement strategies need to be developed to alleviate poverty and population loss in the region.

2.2 Cultural Landscape, Locality, and Regional Revitalization

From the land–man perspective, the positive effects of B&B tourism, the cultural landscape, locality, regional revitalization, have been identified and conceptualized as the theoretical framework of this study.

2.2.1 Cultural Landscape

The cultural landscape represents a tangible meeting point between nature and mind [40]. Therefore, it represents the interaction between human beings and nature [1]. Cultural geologists first proposed that the cultural landscape represents the formative process of human activity, in which culture is the agent, the natural area is the medium, and the cultural landscape is the result. This represents the evolution of human society and settlement [41]. Environmental determinism argues that under the limits set by nature, humans adapt to numerous possibilities [42]. However, other theories argue that human perceptions are correlated to the cultural landscape; in particular, the cultural landscape represents a sense of place beyond vision but related to mental perception [41, 43]. In both views, the cultural landscape changes because of alteration in landscape ushered by human activity under the influence of opportunities and/or the physical constraints of the natural environment, and the resulting social, economic and cultural forces that arise from both external and internal factors [1]. Consequently, cultural landscape conveys the way of life, identity, and sense of place of the inhabitants, which ensures that people live in the region [1, 42, 44].

In practice, cultural landscapes comprising natural environment and human features function as the primary

attraction, marketing icon, and core tourism experience [45, 46]. Therefore, landscapes have been altered substantially by man-made creations, such as: (1) intentionally designed and created landscapes, (2) organically evolved landscapes, and (3) associative cultural landscapes. Therefore, sustaining land-use by combining natural values and culture through modern techniques has become the objective (The Bureau of Cultural Heritage, Ministry of Culture [44]). A few approaches have been proposed to achieve this objective: (1) phenomenology: focusing on the sense of place, considering the perceptions of people [47]; (2) politics: emphasizing the political-economic forces on the cultural landscape [48]; and (3) culture: focusing on the influence of culture on community cohesion, ideology, and identity [49]. These perspectives have influenced numerous cultural landscape theories.

Sauer (1925) [42] first proposed a cultural landscape process model and illustrated that the culture is the generating factor that functions via the natural landscape (the medium) over time, forming the variations in ways of living, such as population density, mobility, housing plans, structure, production, and communication, and finally producing the cultural landscape (the result) [5]. Subsequently, Zube (1982) [50] proposed the interactive cultural landscape model and emphasized the interactions between humans (expectation, experience, education, motivation, culture, social background, information, and characteristics), the landscape (physical elements, compositional constructs, location context, naturalism, man-made creatures, Gestalts, features, sounds, smells, and people), and outcomes (information, satisfaction, wellbeing, physical activities, stimuli, comforts, opportunities, values, prediction formulae, landmarks, behavioral patterns, and fears).

For the current study, the formation process and perception of physical components proposed by Sauer [41] and Zube [50] provide the implications to the perception of the locality in terms of the cultural landscape resulting from B&B tourism environment in the past 20 years in Taitung region.

2.2.2 Locality

The term “locality” originated from environmental psychology and refers to self-identity to land. This human-land connection is beyond emotional baggage [51], and is composed of conscious and subconscious aspects, such as belief, preference, feelings, values, goals, intentions, and environment [52]. Therefore, locality reflects the behavioral intention of an individual in a physical society or reveals their self-identity and perception in a place [53]. Theories related to locality are generally discussed from three perspectives: (1) essentialism, which considers that ancestry, language, customs, culture, and birth/growth

places determine locality; (2) structuralism, which considers that locality is shaped by community teamwork through successive challenges, difficulties, and conquests; and (3) constructivism, which considers that intrinsic man-made efforts and human mindsets influence locality [54]. These three perspectives may be exclusive or combined depending on the place and time.

In this context, the constituents of locality can vary [52]. Breakwell [50] proposed distinctiveness, continuity, self-esteem, and self-efficacy. Lalli [55] proposed external evaluation, general attachment, continuity of commitment with personal past, and perception of familiarity. Knez [56] identified distinctiveness, place referent continuity, place congruent continuity, self-esteem, and self-efficacy. Droseltis [57] included self-extension, environmental fit, place-self congruity, and emotional attachment. Most of these constructs are commonly addressed to emotional states and place attachment as essential components of locality [58].

Recently, Wang et al. [59] integrated the scales of Breakwell [50], Lalli [55], and Knez [56], and composed a leisure place attachment questionnaire, containing the variants of historical-cultural identity, place identity, distinctiveness, place-attachment, self-efficacy, and commitment. The overall Cronbach’s α they obtained was 0.869, which indicated a high reliance. If the B&B tourism in Taitung is considered as a factor that influences the locality, this value provides a useful measure to detect its influence.

2.2.3 Regional Revitalization

Regional revitalization originated from UNWTO’s initiative of SDGs, which includes 17 primary goals. Goal 1 is poverty reduction and job creation for the socio-economic sustainability of global destinations [14]. UNWTO [3] stated that tourism is well-positioned to foster economic growth and development at all levels and provide income. The sustainable development of tourism and its impact at the community level can be linked with national poverty reduction because with the development of tourism empowers entrepreneurs, small businesses, and empower less-favored groups.

The response to this initiative has been global. For example, the Japanese Regional Revitalization Law was implemented in 2014 to create jobs for youths through tourism entrepreneurship [60]. Numerous Chinese remote villages have alleviated extreme poverty via job creation through tourism entrepreneurs and small businesses [61]. In Taiwan, this concept is described in policy using three dimensions, namely, regions, products, and people, to revitalize the resource advantages of local communities [62].

Thus, regional revitalization can be a national policy, a positive tourism effect generator, and an action toward sustainability. Accordingly, life indices have been

Table 1 Dimensions/ Criteria related to B&B tourism development

Dimension/Criteria	Context
D_1 Cultural landscape	Sources: [1, 41, 44, 47, 49, 50]
C_{11} Humanity and culture	Commonly shared local elements, such as expectation, experience, education, motivation, culture, social association, information network, and characteristics
C_{12} Physical landscapes	Substantial representations, such as physical creatures, elements, man-made landscapes, creatures, appearances, modes, features, sounds, tastes and smells
C_{13} Interaction	Individual–landscape, individual–individual–landscape, or individual–group–landscape interactions expressed in purposive, unique, occasional, or automatic ways
C_{14} Outcomes	Results shared by locals, such as information, satisfaction, benefits, substantial activities, stimuli, comforts, opportunities, values, prospects, distinctive landmarks, overall behavioral tendencies, and worries
D_2 Locality	Sources: [50, 55–58]
C_{21} Place recognition	Recognition of local history, culture, environment, and social changes
C_{22} Self-identity	Identifying with local continuity, congruity, self-extension, self-efficacy, and dignity
C_{23} Commitment	Both emotional attachment and behavioral commitment to a place
D_3 Regional revitalization	Sources: [3, 6, 64, 65]
C_{31} Location distinctiveness	L Locational distinctiveness in comparison to nation, region, and com an community
C_{32} Humanity & creativity	Creativity in terms of design, production, and marketing
C_{33} Skill & entrepreneurship	Locals' training/ education, management skills, entrepreneurship, ownership of capital, and enterprise
C_{34} Poverty reduction & population return	Initiatives using human, natural, and socio–economic resources to encourage community involvement and improve livelihood

proposed to address this in the real-world. For example, [39] proposed the sustainable tourism livelihood approach (STLA), and Li et al. [6]

Extended STLA with socio-ecological system analysis. In Japan, the Plan, Do, Check and Act cycle has been proposed to encourage regional revitalization [63]. Though the measures may vary with regional distinctiveness, they share one commonality: the use of tourism to assess revitalization in social–economic networks energized/created by local commitment.

2.2.4 Cultural Landscape, Locality, and Regional Revitalization

Based on the above discussion, the dynamic factors determining positive B&B tourism development from the perspective of human–land interaction are presented in Table 1.

Furthermore, cultural geographic literature has posited that the cultural landscape shapes the mental landscape, thereby integrating human beings, culture, and the land [12]; the locality provides the identity and enhances the cohesion of locals, and regional revitalization prompts tourism development with job opportunities and empowers community continuity [13]. These factors are inter-influencing, dynamic in formation process, and revive progress toward the SDGs [6, 14] based on human–land interaction, self-identity, and place commitment (Fig. 2).

2.3 Renovated Z-DEMATEL and B&B Tourism

Compared to current fuzzy methods, the emerging Z-DEMATEL is outstanding because it manages both the linguistic uncertainty and the interrelations between criteria in a simple process. This would more precisely detect the certainty of multivariate and group decisions and contribute to improving B&B tourism effects, particularly to the issue of poverty alleviation.

2.3.1 Renovated Z-DEMATEL

Zadeh [27] proposed that in the real-world, expression uncertainty is a universal phenomenon. However, he believes that humans have a remarkable ability of making rational decisions based on information that is uncertain, imprecise, and/or incomplete. Therefore, many techniques based on fuzzy set theory have been proposed, such as interval value fuzzy sets, hesitant fuzzy sets, intuitionistic fuzzy sets, interval value intuitionistic fuzzy sets (IVIFS), type-2 fuzzy sets (IFS2), picture fuzzy sets, spherical fuzzy sets, and neutrosophic sets [65, 66]. Among these, the neutrosophic sets are remarkable because they simultaneously consider a truth-membership, an indeterminacy-membership, and a falsity-membership, and efficiently resolve the ambiguity of natural semantic expression [65]. Therefore, they can overcome the challenges of incomplete, uncertain, and inconsistent information.

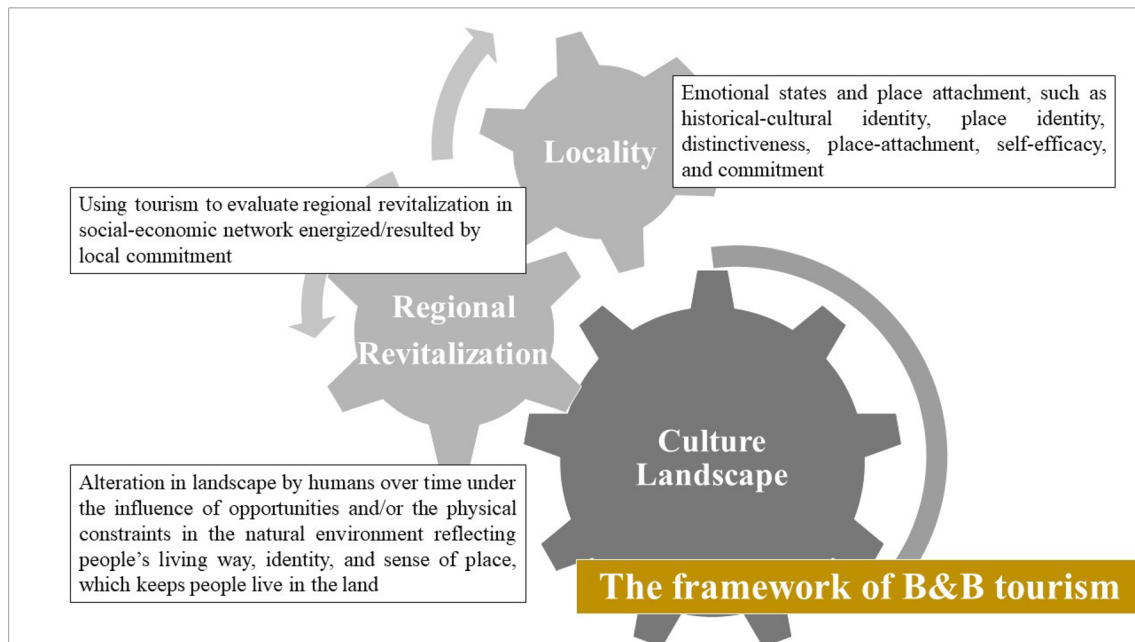


Fig. 2 Essences within the conceptualized framework of B&B tourism positive development

Recently, Z-numbers have attracted considerable research attention for enhancing the confidence of experts/decision-makers in addition to handling information ambiguity and assessment-environment uncertainty [27]. Based on fuzzy theory, Z-numbers simultaneously account for assessment scores and reliability [66]. These parameters are used to control the first component, A , which is a restriction (constraint) on the values which a real-valued uncertain variable may have; and to control the second component, B , which is a measure of the reliability (certainty) of A . Therefore, A and B exist in human natural language [27].

Z-DEMATEL additionally acquires the ability of DEMATEL to manage the inter-feedbacks between criteria through visual construction [19–21]. The model can precisely handle expressions via information integration, using both the exclusive semantic scale and the confidence level to detect expert data. Therefore, this method differs from previous techniques such as fuzzy DEMATEL [24–26] and grey DEMATEL [18, 67]. Specifically, Z-DEMATEL has superiorities compared with the current fuzzy methods. For instance, (1) triangular fuzzy number (TFN) method solves linguistic uncertainty only [27]; (2) Neutrosophic sets simply reflect the decision uncertainty [65]; (3) As to the Analytic Hierarchy Process (AHP) and the best–worst method (BWM), which have been widely used in evaluating systematic priority recently, both regard the criteria are independent to each other in the system and neglect the interaction between the criteria [15, 16, 18]; (4) It takes tedious time/effort to integrate such methods for a case

study; and (5) Turning to Z-numbers, it is able to manage information integration in a simple processing (see Sect. 3) and efficiently overcome the mentioned shortages. Therefore, the Z-DEMATEL can be renovated as compared to these methods.

2.3.2 Appropriateness for Poverty Alleviation of B&B Tourism

Previous studies have considered these fuzzy conditions and used fuzzy DEMATEL to manage hospitality and tourism issues. For instance, Tseng [68] used the model to examine the cause-and-effect relations of hotel service quality. Nisa et al. [69] applied this model to propose the retrenchment strategies of five-star hotels, and Ocampo et al. [70] used it to clarify the causal relationships between job satisfaction and employee engagement of the hotel. Mehrdad [71] combined the model with the ANP to propose the customer satisfaction and the objectives of the organization. Erkal et al. [72] performed IVIF-DEMATEL to determine the importance degrees of the criteria in the Turkish tourism sector. In these studies, imprecise information in the field of tourism was handled using various fuzzy tools. However, few studies have investigated B&B tourism or poverty alleviation using Z-DEMATEL.

The issue of B&B tourism and poverty alleviation is intrinsic to multivariate and group decisions. The management of expert opinions is particularly critical to the present study. Therefore, Z-DEMATEL appears to be appropriate for simultaneously managing expression

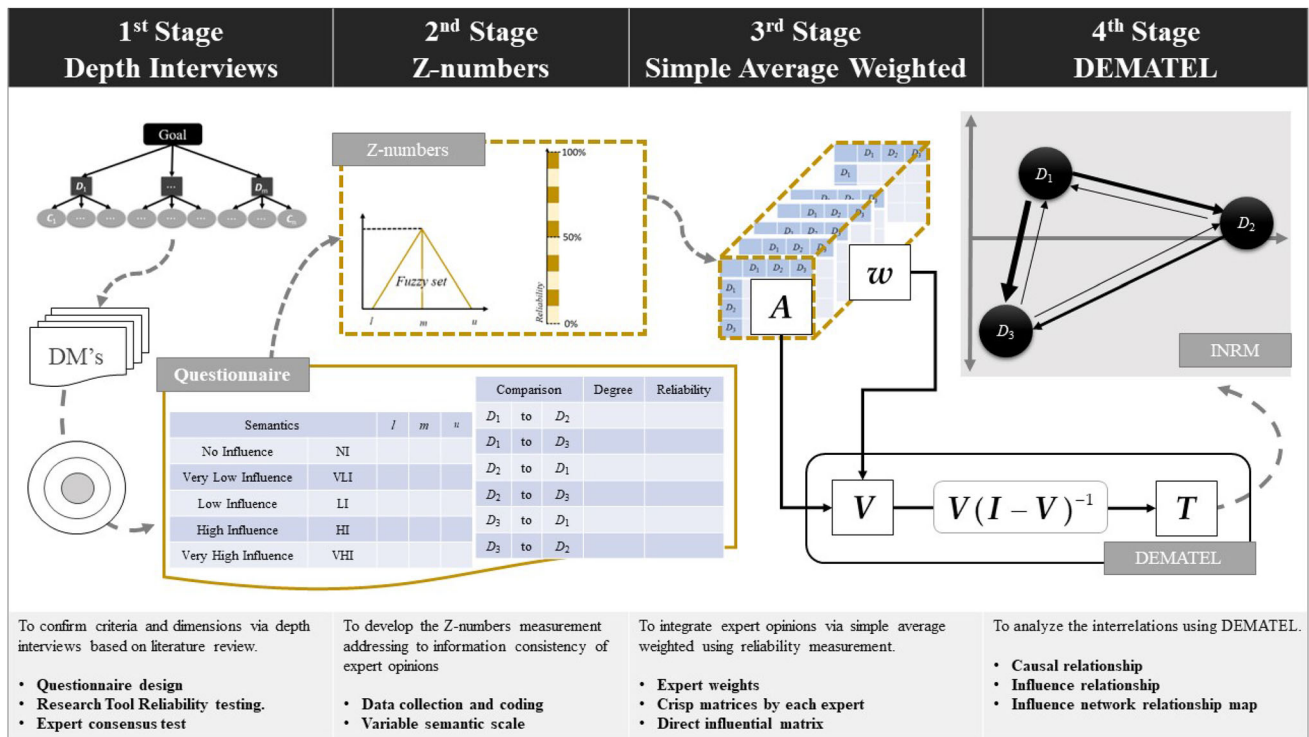


Fig. 3 Process for investigating the poverty-alleviating characteristics of B&B tourism

uncertainty and multiple-criteria. This study may be the first application of Z-DEMATEL for examining B&B tourism.

3 Methodology

In this study, the advanced Z-DEMATEL was used to manage the uncertainty and incompleteness of information collected from B&B tourism experts. The Z-DEMATEL model was constructed as follows.

3.1 Evaluation Construction of Z- DEMATEL

The construction of Z-DEMATEL can be divided into four stages as follows (Fig. 3):

- Stage 1 Confirmation of the criteria and dimensions through in-depth interviews based on literature review (Table 1).
- Stage 2 Determination of the Z-numbers addressing the consistency of information derived from expert opinions.
- Stage 3 Integration of expert opinions via simple average weighting using reliability measurement.
- Stage 4 Analysis of the interrelations using DEMATEL.

3.2 Process for Conducting Z-DEMATEL

The process for conducting Z-DEMATEL was as follows:

1. Establishing natural linguistic expression measurement: Three steps were included: First, the question was defined; thereafter, the natural linguistic expressions of the expert were clarified; and finally, the reliability of expert evaluation regarding the pair-comparison of criteria was assessed.
2. Coding the expression.
3. Coding the reliability degree with mutually influential weight: for the present study, in addition to using pair-comparison to collect influential relationships of Dimensions/ Criteria, reliability assessment was considered. Numerous criteria $C_i = \{C_1, C_2, \dots, C_n\}$ were considered to exist, and the degree of influence of C_i on C_j was established, whereupon each influential degree was assigned an ℓ , the reliability degree of C_i on C_j .
4. Calculating Z-numbers

If Z-numbers $Z = (F, \ell)$. $F = (f, \mu_f) | x \in [0, 1]$ and $r = (x, \mu_r) | x \in [0, 1]$, semantic measure is trigonometric functions, and the reliability is probabilistic in nature.

$$\omega = \frac{\int_x^x \mu_\ell dx}{\int \mu_\ell dx} \tag{1}$$

Using weight ω of reliability, the evaluation score F and the weighted Z-numbers were calculated according to Eq. 2. That is, the radicand ω can be included throughout the calculations as follows:

$$Z^\omega = \{(x, \mu_{F\omega}) | \mu_{F\omega}(x) = \omega\mu_F(x), x \in \omega x\} \tag{2}$$

5. Calculating the impact degree of the crisp score

The impact degrees of the crisp scores were obtained using fuzzy and de-fuzzy weighted Z-numbers as follows:

$$A = [a_{ij}] = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix}_{n \times n} \tag{3}$$

6. Calculating the direct influential matrix: According to the influential degrees, the direct influential matrix was constructed and subsequently integrated with the weighted expert reliability using SAW.

7. Normalizing the direct influential matrix

Use the Eq. 4–5 to normalize the direct influential matrix.

$$V = mV = [v_{ij}] = \begin{bmatrix} v_{11} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & & \vdots & & \vdots \\ v_{i1} & \cdots & v_{ij} & \cdots & v_{in} \\ \vdots & & \vdots & & \vdots \\ v_{n1} & \cdots & v_{nj} & \cdots & v_{nn} \end{bmatrix}_{n \times n} \tag{4}$$

$$m = \min \left\{ 1 / \max_i \sum_{j=1}^n a_{ij}, 1 / \max_j \sum_{i=1}^n a_{ij} \right\}, i, j \in \{1, 2, \dots, n\} \tag{5}$$

8. Obtaining the total influential matrix

Via unlimited inter-influencing calculations, the total matrix emerges. The equations used are Eqs. (6–11).

$$\begin{aligned} T &= V + V^2 + V^3 + \dots + V^k \\ &= V(I + V + V^2 + \dots + V^{k-1})(I - V)(I - V)^{-1} \\ &= V(I - V^k)(I - V)^{-1} \end{aligned} \tag{6}$$

Next, we have the following expression:

$$T = V(I - V)^{-1}, \text{ when } k \rightarrow \infty, V^k = [0]_{n \times n} \tag{7}$$

9. Exploring the influential interrelations between criteria

$$r = (r_1, \dots, r_i, \dots, r_n)' = [t_i]_{n \times 1} = \left[\sum_{j=1}^n t_{ij} \right]_{n \times 1} \tag{8}$$

Calculating the impact degree of criteria

$$d = (d_1, \dots, d_i, \dots, d_n)' = [t_j]_{n \times 1} = \left[\sum_{i=1}^n t_{ij} \right]_{n \times 1}' \tag{9}$$

Calculating the total influence degree: the larger the value, the more influential is the criterion.

$$g = g_i = r_i + d_i \tag{10}$$

Calculating the net influence degree: positive values indicate causes, negative values indicate effects.

$$u = u_i = r_i - d_i \tag{11}$$

10.

Constructing the inter-network relations map

By reflecting g and u onto the coordinate, the overall influential relations were obtained, which indicated the influencing directions for criteria A to B or B to A. Following the directions, the paths were depicted as a visional map, namely, an inter-network relations map (INRM).

3.3 Sampling and Data Collections

In this Z-DEMATEL study, the depth interview commenced with the query “considering the importance/influence of the following factors involving Taitung B&B tourism for poverty reduction, please give your rating in the blanks.” This study was conducted in two phases:

- (1) The initial interview: In this phase, we clarified the content validity of the initial questionnaire based upon the literature review (Table 1), including five experts: three B&B owners, one advocate, one scholar, and one regional official. The Cronbach’s α revealed a high reliability of 0.96, indicating that the tool was appropriate.
- (2) The formal interview: In this phase, we investigated the opinions of regional B&B tourism experts using the modified questionnaires. The experts were qualified with a minimum of 10 years of experience involving regional B&B tourism development. Because of the outbreak of COVID-19, individual on-line interviews were held. Each interview required approximately 60–90 min to complete (Table 2).

Subsequently, the consensus was examined, which indicated a high consensus rate of 0.95 (threshold value 5%) (Qu et al., 2019) (Table 3).

To manage the expert sematic expression, the Z-DEMATEL questionnaire first asked the expert to clarify

Table 2 Expert characteristics of the formal interview survey

Code	Name	Gender	Position	Expert weights
EXP ₁	Chen 1	F	Owner of B&B	0.084
EXP ₂	Chen 2	F	Owner of B&B	0.092
EXP ₃	Hsia	M	Secretary of township	0.080
EXP ₄	Fang	M	Chair of enterprise promotion association	0.090
EXP ₅	Cang	M	Professor	0.086
EXP ₆	Chiang 1	M	Associate professor	0.088
EXP ₇	Yian	M	Secretary of township	0.110
EXP ₈	Lin	F	Owner of B&B	0.094
EXP ₉	Chiang 2	M	Owner of B&B	0.105
EXP ₁₀	Chen 3	M	Chair of small-medium industry association	0.099
EXP ₁₁	Chen 4	M	GM of travel agency	0.072

Expert weight can be calculated according to the confidence values offered by each expert in the formal interview, which represents an individual confidence level in sematic expression

Table 3 Consensus test

	Consensus test	Confidence level (%)	Results
All dimensions	0.018	98	Valid
Cultural landscape	0.024	98	Valid
Locality	0.022	98	Valid
Regional revitalization	0.033	97	Valid

Table 4 Semantics of the experts

Semantics	Crisp	EXP ₁			EXP ₂			EXP...			EXP ₁₁		
		L	M	U	L	M	U	L	M	U	L	M	U
No influence (NI)	0	0.000	0.000	0.000	0.000	0.100	0.200	...	...	...	0.000	0.000	0.000
Low influence (LI)	1	0.500	0.600	0.700	0.200	0.300	0.400	...	...	...	0.000	0.200	0.400
Moderate influence (MI)	2	0.600	0.700	0.800	0.400	0.500	0.600	...	...	...	0.500	0.600	0.700
High influence (HI)	3	0.700	0.800	0.900	0.600	0.700	0.800	...	...	...	0.700	0.800	0.900
Very high influence (VHI)	4	0.800	0.900	1.000	0.800	0.900	1.000	...	...	...	0.700	0.850	1.000

semantic expressions using an exclusive semantic scale that accorded both maximum and minimum scores between 0 and 100 to each of five expressions, namely extreme, high, medium, low, and none. Thereafter, the expert undertook 36 pairwise comparisons of 11 criteria by ticking a preference blank that ranged from Very high influence (VHI) to No Influence (NI) (Table 4).

L for low bound; M for medium bound; U for upper bound.

Simultaneously, the confidence level was detected. The expert was requested to provide a confidence score, ranging from 0 to 100, to each comparison; larger values of which indicated higher confidence levels (Table 5). In this way, the reliability of the information was confirmed.

Finally, according to the values of the exclusive semantic scale and confidence level of each expert, the Z-numbers of the experts were obtained, as listed in Table 6. For instance, EXP1 evaluated that D_1 to D_2 has

“Very High Influence” with 100% confidence level. The data were therefore coded as L, M, U, and R, with values correspondingly 0.800, 0.900, 1.000, and 1.000, respectively. This rule was applied throughout the coding process.

4 Results and Discussions

Using the method of Z-DEMATEL, the results were gained and discussed. Furthermore, the useful improvement strategies were composed for decisions makers.

4.1 Analysis and Discussions

Based on the Z-numbers calculated in Sect. 3, the direct influence matrix A can be established. The total influence matrix T was obtained using Eq. (3–7) (Table 7).

Table 5 Semantics and reliabilities of the experts

	EXP ₁		EXP ₂		EXP...		EXP ₁₁	
	Semantics	Reliability	Semantics	Reliability	Semantics	Reliability	Semantics	Reliability
D_1 to D_2	VHI	100%	VHI	80%	...	...	VHI	80%
D_1 to D_3	MI	50%	VHI	90%	...	...	MI	60%
D_2 to D_1	VHI	100%	HI	70%	...	...	HI	80%
D_2 to D_3	MI	50%	VHI	100%	...	...	HI	80%
D_3 to D_1	VHI	100%	HI	70%	...	...	MI	50%
D_3 to D_2	MI	50%	HI	70%	...	...	MI	50%

Table 6 Z-numbers of the experts

No	Comparison	EXP ₁				EXP ₂				EXP...				EXP ₁₁			
		L	M	U	R	L	M	U	R	L	M	U	R	L	M	U	R
1	D_1 to D_2	0.800	0.900	1.000	1.000	0.800	0.900	1.000	0.800	...	...	...	...	0.700	0.850	1.000	0.800
2	D_1 to D_3	0.600	0.700	0.800	0.500	0.800	0.900	1.000	0.900	...	...	...	...	0.500	0.600	0.700	0.600
3	D_2 to D_1	0.800	0.900	1.000	1.000	0.600	0.700	0.800	0.700	...	...	...	...	0.700	0.800	0.900	0.800
4	D_2 to D_3	0.600	0.700	0.800	0.500	0.800	0.900	1.000	1.000	...	...	...	...	0.700	0.800	0.900	0.800
5	D_3 to D_1	0.800	0.900	1.000	1.000	0.600	0.700	0.800	0.700	...	...	...	...	0.500	0.600	0.700	0.500
6	D_3 to D_2	0.600	0.700	0.800	0.500	0.600	0.700	0.800	0.700	...	...	...	...	0.500	0.600	0.700	0.500

L for low bound; M for medium bound; U for upper bound; R for reliability level

Table 7 Transformation from questionnaire item data to the direct influence matrix *A* and total influence Matrix *T*

Matrix	XXX	XXX	XXX	A	D_1	D_2	D_3	T	D_1	D_2	D_3
XXX		NO.1	NO.2	D_1	0	0.375	0.291	D_1	5.104	5.812	5.492
XXX	NO.3		NO.4	D_2	0.343	0	0.364	D_2	5.597	5.651	5.710
XXX	NO.5	NO.6		D_3	0.296	0.331	0	D_3	5.255	5.634	5.050

Based on the above matrices, the inter-network relations between dimensions and criteria could be calculated (Table 8) and depicted in the INRMs for each dimension (Fig. 4).

This result can be interpreted by inter-network relations, considering the interrelations or cause–effect relationships. According to Table 8, the influence of D_2 (Locality) was outstanding, with the largest *r*, *d*, and *g* values, which implied the critical role of the locality in producing inter-dimensional influence. According to the *r* values, the impacting sequence can be ordered as $D_2 \succ D_1 \succ D_3$, revealing that the locality was the most powerful influencing dimension. According to the *d* values, $D_2 \succ D_3 \succ D_1$, whereby the locality emerged as the most “influenced” dimension. According to the *g* values, the order of influence was $D_2 \succ D_1 \succ D_3$, demonstrating that the locality dominated the total influence by producing as well as receiving influence. This finding is consistent with the review in Sect. 2.2. Locality, as the essence of place attachment and self-identity can usher changes in the cultural landscape and revitalize engagement, and vice versa. The locality plays the role of nexus for interrelations among the dimensions.

In terms of the cause–effect relationship, D_1 (Cultural landscape) emerged as the cause dimension with the largest *u* value of 0.45, followed by D_2 (Locality) and D_3 (Regional revitalization), which had *u* values of 0.39 and 0.313, respectively. Therefore, the cultural landscape impacts the regional revitalization and locality according to the cause–effect analysis. The order of influence was $D_1 \succ D_3 \succ D_2$, suggesting that B&B tourism should holistically create a cultural landscape, empowering local revitalization and resulting in local recognition. This responds the argument that cultural landscapes function as the primary attraction, marketing icon, and core tourism experience [45, 46]. The cultural landscape is the starter pushing the cause–effect chain among the dimensions.

The above analysis can also be applied on the criteria in each dimension. In the D_1 dimension (Cultural landscape), the *g* values of the criteria revealed their order of influence to be $C_{11} \succ C_{13} \succ C_{14} \succ C_{12}$, indicating that C_{11} (Humanity & culture) is the nexus of interrelations and dominates the total influence. C_{14} (Outcomes), which had a negative *u* value, was the effect of the three other criteria, which had positive *u* values. The cause–effect sequence was

Table 8 Interrelations and cause-effect relationships between Dimensions/Criteria

Code	Dimension	<i>r</i>	<i>d</i>	<i>g</i>	<i>u</i>	Cause/effect
D_1	Cultural landscape	16.409	15.956	32.365	0.452	Cause
D_2	Locality	16.958	17.097	34.055	(0.139)	Effect
D_3	Regional revitalization	15.939	16.252	32.191	(0.313)	Effect
C_{11}	Humanity & culture	9.512	8.910	18.422	0.603	Cause
C_{12}	Physical landscapes	8.252	8.025	16.277	0.227	Cause
C_{13}	Interaction	9.225	9.031	18.256	0.194	Cause
C_{14}	Outcomes	8.024	9.048	17.072	(1.024)	Effect
C_{21}	Place recognition	26.001	26.724	52.725	(0.722)	Effect
C_{22}	Self-identity	26.209	24.988	51.197	1.221	Cause
C_{23}	Commitment	26.376	26.875	53.251	(0.499)	Effect
C_{31}	Location distinctiveness	7.812	8.090	15.902	(0.277)	Effect
C_{32}	Humanity & creativity	8.945	9.039	17.984	(0.094)	Effect
C_{33}	Skill & entrepreneurship	8.970	9.313	18.283	(0.343)	Effect
C_{34}	Poverty reduction & population return	8.347	7.633	15.981	0.714	Cause

Vector *r* represents the sum of **influencing** values of Dimensions/Criteria; the larger this value, the greater the influence exerted; Vector *d* refers to the sum of **influenced** values of Dimensions/Criteria; the larger this value, the greater the influence experienced; Vector *g* refers to the **total influence** values of Dimensions/Criteria (sum of influencing and influenced values); the larger this value, the greater the total of exerted and experienced influence; Vector *u* refers to the **net influence degree** (difference between influencing and influenced values), positive values of which denote causes while negative values denote effects

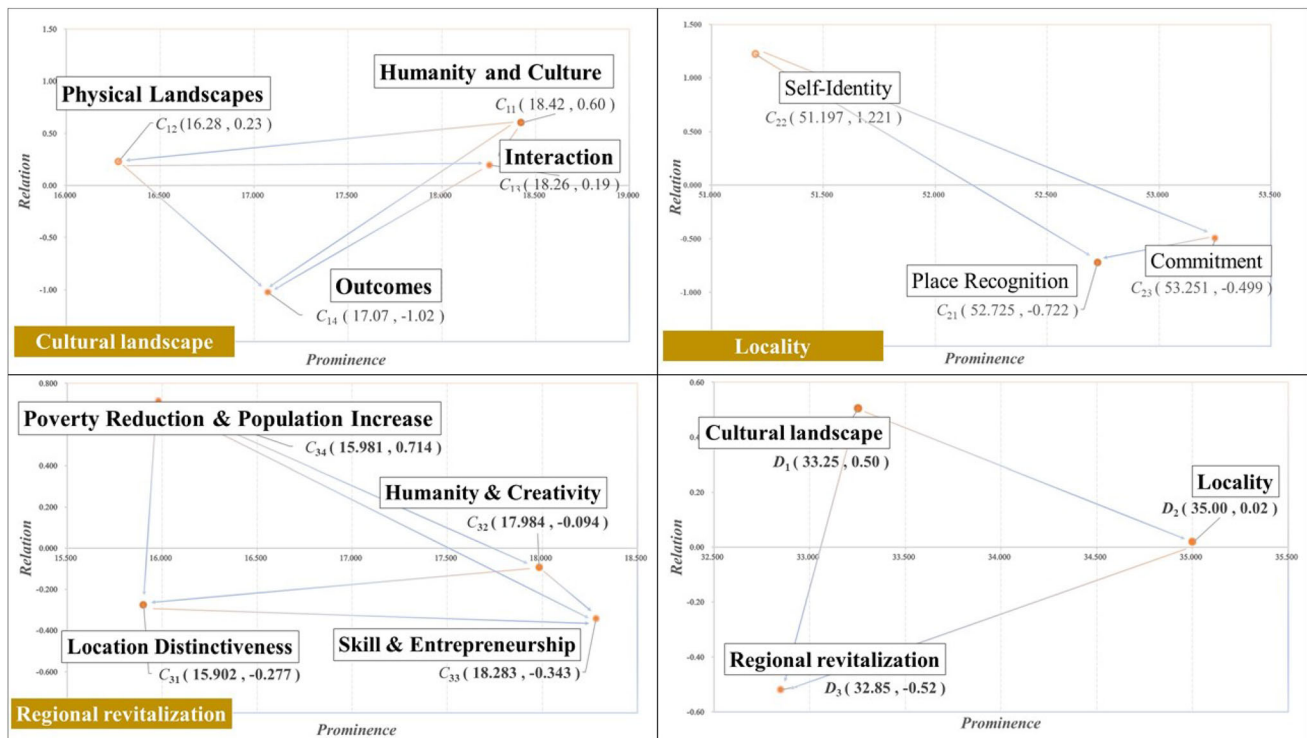


Fig. 4 Inter-network relations map (INRM) of the dimensions and criteria

$C_{11} \succ C_{13} \succ C_{14} \succ C_{12}$. This result reveals that all the efforts of humanity/culture, physical landscapes, and human-landscape contribute to outcomes shared by the locals [44, 50]. Therefore, these criteria are the starters generate cause-effect chain.

In the dimension of D_2 (Locality), the order of influence of criteria by their *g* values was $C_{23} \succ C_{21} \succ C_{22}$, indicating that C_{23} (Commitment) has the largest influence and is a nexus in this dimension. This result suggests that the local commitment enforces the self-identity of inhabitants and

Table 9 Improvement plans for B&B tourism and poverty alleviation using inter-network relations

Plans	Perspectives	Interrelations	Cause-effect relationships
P1	All dimensions	$D_2 \succ D_1 \succ D_3$	D_1
P2	Criteria in D_1 cultural landscape	$C_{11} \succ C_{13} \succ C_{14} \succ C_{12}$	C_{11}, C_{12}, C_{13}
P3	Criteria in D_2 locality	$C_{23} \succ C_{21} \succ C_{22}$	C_{22}
P4	Criteria in D_3 regional revitalization	$C_{33} \succ C_{32} \succ C_{34} \succ C_{31}$	C_{34}

Perspectives refers to Inter-network relations of dimensions/criteria; Interrelations refers to influencing-influenced nexus; Cause-effect relationships refers to cause-effect chain starters

subsequently produces place recognition. Moreover, the u value of C_{22} (Self-identity) was positive and functioned as the cause to the other two criteria, C_{21} (Place recognition) and C_{23} (Commitment). The cause-effect sequence was $C_{22} \succ C_{21} \succ C_{23}$, which indicates that self-identity ushers place recognition and enhances the local commitment. This matches the discussion above that locality is self-identity to land beyond emotional baggage [51].

In the dimension of D_3 (Regional revitalization), the order of influence according to g values was $C_{33} \succ C_{32} \succ C_{34} \succ C_{31}$, indicating that C_{33} (Skill & entrepreneurship) has the largest influence and is a nexus of interrelations. Therefore, the skill and entrepreneurship value adds humanity/creativity and location distinctiveness, and can thereby alleviate poverty and population loss. This is consistent with previous findings of using the tool of upgrading skill and entrepreneurship to revitalize rural tourism [6]. Furthermore, the u value of C_{34} (Poverty reduction & population return) is positive, which indicates that it is the cause to the three other criteria, which have negative values. Because tourism can play a vital role in poverty reduction and population return as stated by UNWTO [1], this universal value may prompt all forms of revitalization efforts, such as C_{31} (Location distinctiveness), C_{32} (Humanity & creativity), and C_{33} (Skill & entrepreneurship). This supports the UNWTO's initiative of SDGs, in which Goal 1 is poverty reduction and job creation for the socio-economic sustainability of global destinations [6, 14].

4.2 Implications

Some implications for efficient improvement strategies can be inferred from the interrelations and cause-effect relationships between the Dimensions/Criteria (Table 9). Holistically, P1 suggests that the influencing power of D_2 (Locality) functions as a continuous nexus prompt for D_1 (Cultural landscape) and D_3 (Regional revitalization). The chain of effect may begin from the cause (D_1) and subsequently approach D_3 and fulfill D_2 , in that order.

The same rule can be applied to each dimension. For example, P2 C_{11} (Humanity & culture) as a nexus can simultaneously influence C_{13} (Interaction), C_{12} (Physical

landscapes) and C_{14} (Outcomes) through the influencing network. Via the cause-effect relationship, C_{14} (Outcomes) as the starter can create a chain effect for C_{13} (Interaction), C_{12} (Physical landscapes), and C_{11} (Humanity & culture). Such nexuses (e.g., D_2 , C_{11} , C_{23} , and C_{33}) and starters (e.g., D_1 , C_{11} , C_{23} , and C_{33}) can be traced from the perspective of dimensions or criteria by the INRM (Fig. 4), in terms of both interrelations and cause-effect chains. This synthesized index (Table 9) can yield two times the result with half the effort for policy makers, thereby improving the poverty-alleviating effect of B&B tourism.

5 Conclusion

This study investigated the novel Z-numbers model to examine the empirical case of the Taitung region for evaluating the role of B&B tourism in poverty alleviation. The results revealed that the model is appropriate and efficient (Table 9) and satisfies research requirements. Consequently, this model contributes to: (1) composing improvement strategies to alleviate the lingering poverty and population loss in the B&B tourism destinations using Z-DEMATEL; (2) managing the uncertainty of expert expression using the unique technique of information integration (e.g., exclusive somatic scale, confidence scale, and Z-numbers) and superior to the current fuzzy methods (ex. TFN, Fuzzy sets, Neutrosophic sets, AHP, BWM, and, etc.); (3) filling the gap in the literature by demonstrating the appropriateness between B&B tourism and poverty alleviation using Z-DEMATEL; (4) and providing an INRM of Z-DEMATEL model, which reveals the interrelation improvement compared to linear cause-effect findings (such as Structural Equation Modeling, SEM or Linear Structural Relations, LISERAL).

However, this study has some limitations. Firstly, the measurement scale developed in this study may not be generalizable for cross-industry application because it is tailored to the B&B tourism domain. Secondly, a comparison between the opinions of owners, officials, and locals would have deepened the discussion. Finally, further research is required to compare the performance of various fuzzy models (e.g., fuzzy DEMATEL, gray DEMATEL, and rough-DEMATEL) for methodological renovation.

Appendix

See Table 10.

Table 10 List of symbols

Term	Definition	Term	Definition	Term	Definition
C	Criteria	i, j	Algebra of criteria	n	Number of criteria
Z	Z-numbers	F	Sematic measure	ℓ	Reliability
A	Direct influential matrix	T	Total influential matrix	m	Benchmark value
V	Normalizing the direct influential matrix	I	Identity matrix	g	Total influence degree
r	Influence degree	d	Influenced degree	u	Net influence degree
L	Lower bound	M	Middle bound	U	Upper bound
EXP	Number of expert	NI	No influence	LI	Low influence
MI	Moderate Influence	HI	High influence	VHI	Very high influence

Funding Research supported by MOST 110-2635-H-424-002, NSTC 111-2811-M-027-002 and NSTC 111-2410-H-305-020.

References

- UNESCO: Convention concerning the protection of the World Cultural and Natural Heritage. World Heritage Convention. <https://whc.unesco.org/en/conventiontext/4> (1972). Accessed 12 Dec 2020
- Harrison, D.: Pro-poor tourism: a critique. *Third World Q.* **29**, 851–868 (2008)
- Medina-Muñoz, D.R., Medina-Muñoz, R.D., Gutiérrez-Pérez, F.J.: A sustainable development approach to assessing the engagement of tourism enterprises in poverty alleviation. *Sustain. Dev.* **24**, 1–18 (2016)
- UNESCO: Tourism and the sustainable development goals—journey to 2030. <https://www.unwto.org/global/publication/tourism-and-sustainable-development-goals-journey-2030> (2022). Accessed 10 Apr 2022
- Samsudin, Y.P., Maliki, Z.N.: Preserving cultural landscape in Homestay programme towards sustainable tourism: brief critical review concept. *Proc Soc Behav Sci.* **2014**, 433–441 (2014)
- Li, H., Guo, T., Nijkamp, P., Xie, X., Liu, J.: Farmers' livelihood adaptability in rural tourism destinations: an evaluation study of rural revitalization in China. *Sustainability.* **12**, 9544 (2020)
- Taitung Tourism Bureau: <https://tour.taitung.gov.tw/en/discover/intro> (2022). Accessed 1 Oct 2022
- Department of Household Registration: <https://www.ris.gov.tw/app/en/3912> (2020). Accessed 1 Oct 2022
- Blake, A., Arbache, J.S., Sinclair, M.T., Teles, V.: Tourism and poverty relief. *Ann. Touris. Res.* **35**, 107–126 (2008)
- Zhao, W., Ritchie, J.R.B.: Tourism and poverty alleviation: an integrative research framework. *Curr. Issues Tour.* **10**, 119–143 (2007)
- Meerow, S., Newell, J.P., Stults, M.: Defining urban resilience: a review. *Landsc. Urban Plan.* **147**, 38–49 (2016)
- Chelleri, L., Waters, J.J., Olazabal, M., Minucci, G.: Resilience trade-offs: addressing multiple scales and temporal aspects of urban resilience. *Environ. Urban.* **27**, 1–18 (2015)
- Wilson, G., Schermer, M., Stotten, R.: The resilience and vulnerability of remote mountain communities: the case of Vent, Austrian Alps. *Land Use Pol.* **71**, 372–383 (2018)
- Romão, J., Nijkamp, P.: Impacts of innovation, productivity and specialization on tourism competitiveness—a spatial econometric analysis on European regions. *Curr. Issues Tour.* **22**, 1150–1169 (2019)
- Si, S.L., You, X.Y., Liu, H.C., Zhang, P.: DEMATEL technique: a systematic review of the state-of-the-art literature on methodologies and applications. *Math. Probl. Eng.* (2018). <https://doi.org/10.1155/2018/3696457>
- Braga, I.F., Ferreira, F.A., Ferreira, J.J., Correia, R.J., Pereira, L.F., Falcão, P.F.: A DEMATEL analysis of smart city determinants. *Technol. Soc.* **66**, 101687 (2021)
- Singh, C., Singh, D., Khamba, J.S.: Analyzing barriers of green lean practices in manufacturing industries by DEMATEL approach. *J. Manuf. Technol. Manag.* **32**, 176–198 (2021)
- Khan, S., Haleem, A., Khan, M.I.: Enablers to implement circular initiatives in the supply chain: a grey DEMATEL method. *Glob. Bus. Rev.* (2020). <https://doi.org/10.1177/0972150920929484>
- Liu, C.H., Liu, B.: Using DANP-mV model to improve the paid training measures for travel agents amid the COVID-19 pandemic. *Mathematics.* **9**, 1924 (2021)
- Liu, C.H., Liu, B.: Exploring hotel appraisal determinants amid sales trend during pandemic COVID-19: using a DANP-mV Model. *Int. J. Strateg. Prop. Manag.* **26**, 258–271 (2022)
- Liu, C.H., Tzeng, G.H., Lee, P.Y.: Combined CFPR and VIKOR model for enhancing the competences of domestic chain hotel groups. *Int. J. Inf. Technol. Decis. Mak.* **18**, 901–927 (2019)
- Liu, C.H.: Schemes for enhancing Taiwanese cruise PAK relationships using the hybrid MADM model. *Tourism Manage.* **69**, 510–522 (2018)
- Huang, S.W., Liou, J.J., Chuang, H.H., Ma, J.C., Lin, C.S., Tzeng, G.H.: Exploring the key factors for preventing public health crises under incomplete information. *Int. J. Fuzzy Syst.* **23**, 2467–2488 (2021)
- Hosseini, S.M., Paydar, M.M., Hajiaghahi-Keshтели, M.: Recovery solutions for ecotourism centers during the Covid-19 pandemic: utilizing Fuzzy DEMATEL and Fuzzy VIKOR methods. *Expert Syst. Appl.* **185**, 115594 (2021)
- Farooque, M., Jain, V., Zhang, A., Li, Z.: Fuzzy DEMATEL analysis of barriers to blockchain-based life cycle assessment in China. *Comput. Ind. Eng.* **147**, 106684 (2020)
- Xu, C., Wu, Y., Dai, S.: What are the critical barriers to the development of hydrogen refueling stations in China? A modified fuzzy DEMATEL approach. *Energy Policy* **142**, 111495 (2020)
- Zadeh, L.A.: A note on Z-numbers. *Inf. Sci.* **181**, 2923–2932 (2011)
- Duan, C.Y., Liu, H.C., Zhang, L.J., Shi, H.: An extended alternative queuing method with linguistic Z-numbers and its application for green supplier selection and order allocation. *Int. J. Fuzzy Syst.* **21**, 2510–2523 (2019)
- Huang, J., Xu, D.H., Liu, H.C., Song, M.S.: A new model for failure mode and effect analysis integrating linguistic Z-numbers

- and projection method. *IEEE Trans. Fuzzy Syst.* **29**, 530–538 (2019)
30. Qiao, D., Shen, K.W., Wang, J.Q., Wang, T.L.: Multi-criteria PROMETHEE method based on possibility degree with Z-numbers under uncertain linguistic environment. *J. Ambient Intell. Humaniz. Comput.* **11**, 2187–2201 (2020)
 31. Peng, H.G., Wang, X.K., Wang, J.Q.: New MULTIMOORA and pairwise evaluation-based MCDM methods for hotel selection based on the projection measure of Z-numbers. *Int. J. Fuzzy Syst.* **24**, 371–390 (2022)
 32. Christina M.: Restrictions. China says it's an overreaction. *CNN Travel*. <https://edition.cnn.com/travel/article/coronavirus-us-travel-restrictions-monday/index.html> (2020) Accessed 3 Apr 2021
 33. Taitung County Government: Lonely planet promotes Taitung as one of top ten tourist destinations in Asia. Taitung travel network website. <https://tour.taitung.gov.tw/en/news/details/1839> (2017) Accessed 1 Oct 2007
 34. Booking.com: Traveler review awards: Taitung stands 2nd place of the world's most friendly B&B destination. <https://news.booking.com/zh-tw/traveller-review-awards-2022-taitung/> (2022) Accessed 28 Feb 2022
 35. Ministry of the Interior: County population index by gender and five age groups. Dept. of Household Registration, M.O.I. <https://www.ris.gov.tw/app/portal/346> (2020) Accessed 10 Feb 2020
 36. Executive Yuan: Report on the survey of family income and expenditure. <https://win.dgbas.gov.tw/fies/doc/result/109.pdf> (2021) Accessed 10 Feb 2020
 37. Lin, C.Y., Chung, C. C., Pan, C. C., and Hsieh, C. Y.: Ministry of Health and welfare announced the latest poverty line Taitung, Pingtung, Changhua, the top 3 poor households. *China Times*. <https://www.chinatimes.com/newspapers/20191027000431-260114?chdtv> (2019) Accessed 1 Oct 2022
 38. Heilbrun, J., Gray, C.M.: *The economics of art and culture*. Cambridge University Press, Cambridge (2001)
 39. Shen, F., Hughey, K.F.D., Simmons, D.: Connecting the sustainable livelihoods approach and tourism: a review of the literature. *J. Hosp. Tour. Manag.* **15**, 19–31 (2008)
 40. Naveh, Z.: Interactions of landscapes and cultures. *Landsc. Urban Plan.* **32**, 4354 (1995)
 41. Sauer, C.O.: The morphology of landscape. In: Wiens, J.A., Moss, M., Mladenoff, D., Turner, M. (eds.) *Foundation papers in landscape ecology*, pp. 19–54. Columbia University Press, Geography New York (1925)
 42. Jones, M.: The concept of cultural landscape: discourse and narratives. In: Hannes, P., Gary, F. (eds.) *Landscape interfaces*, pp. 21–51. Heidelberg, Springer (2003)
 43. Taylor, S.A., Ishida, C., Wallace, D.W.: Intention to engage in digital piracy: a conceptual model and empirical test. *J. Serv. Res.* **11**, 246–262 (2009)
 44. Bureau of Cultural Heritage: Cultural landscapes. https://twh.boch.gov.tw/taiwan/qa_detail.aspx?id=9 (2020) Accessed 20 Nov 2020
 45. Buckley, R.C.: Adventure tourism products: price, duration, size, skill, remoteness. *Tourism Manage.* **28**, 1428–1433 (2007)
 46. Buckley, R.C.: *Environmental impacts of ecotourism*. CAB International, Wallingford (2004)
 47. Jackson, J.B.: *Discovering the Vernacular Landscape*. Yale University Press, USA (1984)
 48. Walker, R.: *Struggle without end*. Penguin, New York (2004)
 49. Yen, L. Y.: Exploring the concept of cultural landscape. Blogger. http://spaces-hope.blogspot.com/2009/04/blog-post_535.html (2009). Accessed 2 Oct 2022
 50. Zube, E.H., Sell, J.L., Taylor, L.G.: Landscape perception: research, application and theory. *Landsc. Urban Plan.* **9**, 1–33 (1982)
 51. Twigger-Ross, L.C., Uzzell, L.D.: Place and identity processes. *J. Environ. Psychol.* **16**, 205–220 (1996)
 52. Proshansky, H.M., Fabian, A.K., Kaminoff, R.: Place-identity: physical world socialization of the self. *J. Environ. Psychol.* **3**, 57–83 (1983)
 53. Proshansky, H.M.: The city and self-identity. *Environ. Behav.* **10**, 147–169 (1978)
 54. Breakwell, G. M.: Processes of self-evaluation: efficacy and estrangement. <https://researchportal.bath.ac.uk/en/publications/processes-of-self-evaluation-efficacy-and-estrangement> (1992). Accessed 10 Feb 2020
 55. Lalli, M.: Urban-related Identity: theory, measurement, and empirical findings. *J. Environ. Psychol.* **12**, 285–303 (1992). [https://doi.org/10.1016/S0272-4944\(05\)80078-7](https://doi.org/10.1016/S0272-4944(05)80078-7)
 56. Knez, I.: Attachment and identity as related to a place and its perceived climate. *J. Environ. Psychol.* **25**, 207–218 (2005). <https://doi.org/10.1016/j.jenvp.2005.03.003>
 57. Droseltis, O., Vignoles, V.L.: Towards an integrative model of place identification: dimensionality and predictors of intrapersonal level place preferences. *J. Environ. Psychol.* **30**, 23–34 (2010). <https://doi.org/10.1016/j.jenvp.2009.05.006>
 58. Zhuang, C.P., Zhang, J.X.: Place identity: analysis from environmental psychology perspective. *Adv Psychol Sci* **19**, 1387–1396 (2011)
 59. Wang, J.Y., Zhao, H.J., Zou, L.L., Gao, Y., Li, M.G.: A study on the antecedent relationship of recreation spatial loyalty of tourism city residents based on the spatial perception. *Tourism Tribune.* **34**, 108–117 (2019)
 60. Kao, C.P.: What is 'placemaking'? This antidote can prevent Baodao from becoming a poor and old ghost island. <https://opinion.cw.com.tw/blog/profile/52/article/6556> (2018) Accessed 1 Oct 2022
 61. Adamov, T., Ciolac, R., Iancu, T., Brad, I., Pet, E., Popescu, G., Smuleac, L.: (2020) Sustainability of agritourism activity Initiatives and challenges in Romanian mountain rural regions. *Sustainability.* **12**, 2502 (2020)
 62. Chuang, M.T., Chou, W.H., Chang, C.H., Chou, W.L.: Examining the key drivers for regional revitalization based upon social network analysis: a case study of Badouzi in Taiwan. *Mar. Pol.* **133**, 104754 (2021)
 63. Tsai, S. F.: Using Japan experience to Sustain Taiwan—local REVITALIZATION 2.0. Chiayim, Taiwan. https://person.ccu.edu.tw/kno_elearning/book/109/10902.pdf (2019) Accessed 2 Oct 2022
 64. Pandey, V.P., Babel, M.S., Shrestha, S., Kazama, F.: A framework to assess adaptive capacity of the water resources system in Nepalese river basins. *Ecol. Indic.* **11**, 480–488 (2011). <https://doi.org/10.1016/j.ecolind.2010.07.003>
 65. Li, H., Nijkamp, P., Xie, X., Liu, J.: A new livelihood sustainability index for rural revitalization assessment—a modelling study on smart city sustainable development in China. *Sustainability* **12**, 3148 (2020)
 66. Huang, S.W., Liou, J.J., Cheng, S.H., Tang, W., Ma, J.C., Tzeng, G.H.: The key success factors for attracting foreign investment in the post-epidemic era. *Axioms.* **10**, 140 (2021)
 67. Shao, Q.G., Jiang, C.C., Lo, H.W., Liou, J.J.: An assessment model of smart city sustainable development: integrating approach with Z-DEMATEL And Z-TOPSIS-AL. *Res Sq.* (2022). <https://doi.org/10.21203/rs.3.rs-1210313/v1>
 68. Haleem, A., Khan, S., Khan, M.I.: Traceability implementation in food supply chain: a grey-DEMATEL approach. *Info Process Agric.* **6**, 335–348 (2019)
 69. Tseng, M.L.: Using the extension of DEMATEL to integrate hotel service quality perceptions into a cause-effect model in uncertainty. *Expert Syst. Appl.* **36**, 9015–9023 (2009)

70. Nisa, E., Zeynep, Ü., Emre Ipekçi, Ç.: Bes yıldızlı otel işletmelerinde kriz dönemlerinde uygulanan tasarruf stratejilerinin bulanık DEMATEL Yöntemiyle İncelenmesi/Analyzing retrenchment strategies of five-star hotels during the crisis periods using fuzzy dematel method. *Bus. Econ Res J.* **8**, 259–273 (2017)
71. Ocampo, L., Tan, T.: Using fuzzy DEMATEL in modeling the causal relationships of the antecedents of organizational citizenship behavior (OCB) in the hospitality industry: a case study in the Philippines. *J. Hosp. Tour. Manag.* **34**, 11–29 (2017)
72. Mehrdad, K.: Ranking of performance assessment measures at Tehran hotel by combining DEMATEL, ANP, and SERVQUAL models under Fuzzy condition. *Math. Probl. Eng.* **3**, 1–11 (2018)
73. Erkal, G., Kilic, H.S., Kalender, Z.T., Yalcin, A.S., Tuzkaya, G.: An integrated IVIF-DEMATEL and IVIF-TOPSIS methodology for hotel information system selection. *Intell Syst Comput.* (2021). https://doi.org/10.1007/978-3-030-51156-2_45

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.



Liu Chui-Hua is currently a full-time professor in the Department of Tourism and Hospitality of Kainan University. Her current research focuses on solving the problems of the tourism issues with the multiple-criteria decision-making (MCDM) methods, extending to fuzzy applications.



Huang Sun-Weng is a post-doctoral researcher, supervised by professor Gwo-Hsiung Tzeng and professor James Jiann-Haw Liou. He is a part-time assistant professor at China University of Technology. Also, he is doing his second Ph.D. at National Taipei University, with a specialty in industrial engineering & management and urban planning. The multiple-criteria decision-making (MCDM) methods are applied in recent research.



Hsieh Mei-Ting is currently a full-time Associate Professor at the Department of Tourism and Leisure, Lunghwa University of Science and Technology Taiwan. Her research interests include hospitality management and wellness travel behaviour. Her current research focuses on hospitality management with information technology issues.



Lin Chiao-Bing is a practitioner and researcher in the hotel industry. So far, He have developed and operated many hotels in Taiwan, and completed the stock listing of a hotel management company. His expertise is involved holistic aspects of hotel management, such as construction, decoration, human resources, marketing, guest rooms and catering services ect. For the present time, He is able to apply his experiences on the academic fields as doing PhD program at Chinese Culture University.



Tzeng Gwo-Hsiung Distinguished Chair Professor of National Taipei University. Chair Professor of National Chiao Tung University. Institute of Management of Technology, College of Management, National Chiao Tung University. National Distinguished Chair Professor (Highest Honor offered by the Ministry of Education Affairs, Taiwan) and Distinguished Research Fellow (Highest Honor Offered by NSC, Taiwan). PhD, Faculty of Economics, Osaka University, Japan.