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Sustainable solid-waste management in coastal and marine tourism cities in Vietnam: A hierarchical-level approach

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ABSTRACT

This study contributes to assess the sustainable solid-waste management of coastal and marine cities in Vietnam due to prior studies are lacking to develop a set of measures in hierarchical structure. Coastal and marine tourism cities are the largest and fastest growing segment of the tourism industry. City infrastructures are being developed in the absence of a solid-waste management capacity and create a gap in the measurement of sustainable solid-waste management. This study employs both qualitative techniques and quantitative measures to extend the literature. An exploratory factor analysis is applied to test the proposed hierarchical framework's validity and reliability. A fuzzy synthetic evaluation and a decision-making trial and evaluation laboratory are used to evaluate sustainable solid-waste management in the cities. A set of criteria that consider the economic benefit, environment assessment and social impact are constructed on six aspects: funding and expenditures, tourism activities, the policy and legal framework, environmental co-creation, stakeholder participation and community awareness. The result reveals the causal interrelationships among the aspects and that stakeholder participation, tourism activities, and the policy and legal framework are the causal attributes for achieving sustainability performance. Civil construction debris, the tourist flow, the support of political leadership, cost-sharing and mutual strategy adoption, and technical cooperation are also found to be success criteria that contribute as practical guidelines for practitioners and communities. More emphasis needs to be placed on coastal and marine environments, and doing so has the highest priority value and contributes to raising awareness of issues in the development process.

1. Introduction

Solid waste is an increasing problem in coastal and marine cities due to the connection between management networks (Granit et al., 2017; Pereira and Fernandino, 2019). In Vietnam, solid waste in inappropriate and poorly managed locations has caused an estimated 80% of the floating pollution among important natural tourist sites, causing significant economic losses to the industry (Worldbank, 2018). For example, most coastal and marine tourism (CMT) activities occur near cities, either on the shoreline side or in coastal and marine ecosystem zones, causing them to receive high environmental pressure (Adabre and Chan, 2019; Papageorgiou, 2016). Lu et al. (2019) argued that tourism city infrastructures are generally developed in the absence of a solid-waste management (SWM) capacity, leading to coastal zone contamination. These negative impacts have raised the need to implement sustainable solid-waste management (SSWM) systems to meet the requirements of economic activity while maintaining environmental and social synchronization for the carrying capacity of cities (Srivastava et al., 2005). However, CMT cities and their surrounding areas experience neglected shortages and mismanaged waste because they are non-sustainable SWM systems (Chen et al., 2019; Tseng et al., 2020). In addition, discharged waste may reach nearby beaches, resulting in the loss of recreational areas (Pham Phu et al., 2019; Hoang et al., 2019). The surface of waste has also been shown to be an aggressive microbe

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trajectory that causes diseases on coral reefs (Guerrero et al., 2013; Diaz-Farina et al., 2020; Lamb et al., 2018). Meanwhile, microplastics, formed in the marine environment or purposefully produced, have been found in the human food chain and are suspected to have a potential association with human health (Wright and Kelly, 2017; Tirkolaee et al., 2020). Regardless, little attention has been paid to analyzing the interrelationships between CMT growth and solid-waste generation. There is a gap in the measurement of SSWM in coastal and marine cities as tourism activities play an important role in accounting for the streams and amounts of solid waste generated.

In the literature, SWM is considered an important outlying service in cities (Paul et al., 2019). The interrelationships among coastal and marine environmental issues are vitally important for achieving successful SSWM (Pereira and Fernandino, 2019). SSWM requires the incorporation of the economic, environmental, and social perspectives (triple bottom line, TBL) of sustainability (Mohsenizadeh et al., 2020). El Zrelli et al. (2019) examined different solid wastes dumped in the coastal environment, described managerial barriers and evaluated long-term environmental influences. Diaz-Farina et al. (2020) estimated the involvement of tourism in miscellaneous types of SSWM at an island destination based on sociodemographic, economic and disposal-related attributes. Nevertheless, the SSWM approach for CMT cities has not yet been fully established. There is an inequity between the benefits generated by augmented tourism and its social and environmental impacts (Sanches et al., 2019). While the industry contributes greatly to the economic development of cities, its poor performance is a powerful driver of ecological degradation, community transformation and disruption (Lange, 2015). Shamshiry et al. (2011) and Greco et al. (2018) suggested that the waste generated by tourism potentially affects the overall TBL perspectives and that SWM practices are important. Paiano et al. (2020) proposed that CMT is an important economic driver but that it requires an adequate TBL implementation. Hence, an SSWM system must balance environmental impacts, social support, and economic conditions (Shekdar, 2009; Arbulú et al., 2016). A consolidated SSWM structure must be composed to improve the performance of cities.

Nevertheless, SSWM requests extend participation due to their complexity and magnitude (Pereira and Fernandino, 2019). Indeed, SSWM implementation often encounters difficulties since authorities cannot confront the uncertainty of multidimensional attributes (Bui et al., 2020a). The interrelationships among attributes are usually multifaceted, and the miscellaneous combinations require coastal marine monitoring. Fragmentation, misperception, and struggles arise as consequences of misunderstanding the complexity (Taljaard et al., 2019). Hence, this study adopts a fuzzy synthetic evaluation (FSE) method and the decision-making trial and evaluation laboratory (DEMATEL) to evaluate SSWM in CMT cities. Both qualitative techniques and quantitative measures are adopted. The subjective linguistic preferences of experts are used to assess the qualitative attributes, and the FSE converts qualitative perceptions into quantitative data so the attributes are prioritized (Tseng et al., 2019). The fuzziness of human insight is transformed into crisp values to construct a hierarchical framework under uncertainty (Islam et al., 2019). Accordingly, the DEMATEL is adopted to understand the causal interrelationships among attributes (Tsai et al., 2020). Additionally, an exploratory factor analysis (EFA) is used to test the construct reliability and validity of the proposed hierarchical framework (Tseng and Bui, 2017; Tsai et al., 2020). The objectives are as follows.

- To construct an SSWM hierarchical framework assessment through the valid and reliable proposed attributes.
- To address the causal interrelationships among the attributes to better understand the issue.
- To identify the SSWM attributes that are conducive to the performance of CMT cities.

This study provides both theoretical and practical contributions as follows. (1) A novel set of SSWM attributes is proposed, and a hierarchical framework is constructed, contributing to extending the SSWM model by serving as a reference for better decision-making processes. (2) By identifying the causal interrelationships among the attributes and indicating the critical attributes, practical guidelines are provided for practitioners, especially coastal and marine communities for local governance and tourism-service providers to improve the communities' sustainability performance.

The rest of this study is arranged in five sections. The literature on SSWM and CMT cities as well as the attribute categorization and the proposed method are discussed in Section 2. Section 3 details the methods used. The results are revealed in Section 4. Section 5 addresses the theoretical and practical implications. The conclusions, limitations of this study, and recommendations for future research are discussed in Section 6.

2. Literature review

This section addresses the details of SSWM and CMT cities. In addition, the proposed methods and measurements are discussed.

2.1. SSWM

SSWM is defined as an integrated management process that involves multiple TBL attributes (Soltani et al., 2015; Yadav and Karmakar, 2020). It is necessary for all phases of the city system—including planning, design, restructuring, organization and response—to preserve environmental quality for future development goals (Bui et al., 2020a). Morrissey and Browne (2004) suggested that an SSWM model needs to consider environmental effects, economic affordability, and social acceptance. Habibi et al. (2017) considered that the TBL optimizes the SSWM system with the aim of minimizing the total cost and visible effluent with regard to the level of contamination. Yadav and Karmakar (2020) proposed different technical practices for SSWM in urban centers to address the sustainability of economic features, ecological conservation, and social conventions. SSWM implementation is among the most critical processes for every city. Aid et al. (2017) argued that SSWM plays fundamental roles in utilizing resources while producing new commercial prospects by renovating new resource-management practices. Ikhlayel (2018) claimed that SSWM also encourages private-sector participation by generating more employment and business opportunities. Disregarding the provisions of SSWM can result in challenges for the city community and nearby areas (Adabre and Chan, 2019; Tirkolaee et al., 2020). It is essential to define the attributes that support an appropriate SSWM approach to handle the volume of generated waste, provide high economic benefits, and stabilize the local social situation.

However, the SSWM approach is not sustainable in practice. The environmental effects of solid-waste generation have placed pressure on municipal authorities to implement appropriate policies or other tools to deal with the situation (Arbulú et al., 2016; Aid et al., 2017). Ikhlayel (2018) stated that SSWM is hindered by insufficient infrastructure; weak strategic planning; the absences of a legislative framework, employee capabilities, and knowledge and information-sharing systems; and inadequate financing. Tsai et al. (2020) found that improper SWM may cause serious harm to municipal ecosystems by increasing soil, air, and water contamination, directly influencing human safety or public health. In particular, for a coastal municipality, Becherucci et al. (2017) claimed that poor SWM leads to a coastal zone dilemma, as waste is disposed directly into the environment and quickly overwhelms the marine area via the drainage system, contributing to an intensification of marine pollution issues. El Zrelli et al. (2019) presumed that solid wastes are understood well by municipalities because solid wastes contain various hazardous toxins, including radioelements and heavy metals, deteriorating the marine ecosystem and causing coastal destruction. Therefore, proper SSWM is more crucial due to its impacts on the TBL (Mohsenizadeh et al., 2020). A structural approach is necessary since the system reflects the attributes of human consumption and guarantees the sustainability of the biological environment through appropriate waste-management activities.

2.2. CMT

CMT is the largest and fastest-growing segment of the tourism industry and is one of the most important economic sectors in coastal and marine areas (Chen and Bau, 2016). On the one hand, coastal tourism is a type of tourism in which the water/sea component is the main and predominant asset and has the advantage of establishing leisure, water-based activities and recreation, such as undersea fishing, scuba diving, windsurfing, water skiing, going on maritime park tours, and wildlife watching (Diakomihalis, 2007). Marine tourism represents a form of tourism that is totally dependent on the marine environment and that involves various activities in deep-sea areas, such as cruising and sailing (Sanches et al., 2019). Needham and Szuster (2011) proposed that increasing CMT causes municipalities to increase fundamentally the provision of open space for recreational opportunities and tourism activities. Papageorgiou (2016) argued that the most vital and extensive category of CMT is related to accommodations, planned as part of the area's urban development, within tourism resorts along with hotel facilities, or even separately without the aforementioned planning. Tourism facilities vary between ports and marinas that serve yachts and cruise ships or one-person operations such as instructors, guides, small- and medium-sized private businesses, or even large corporations such as cruise ship organizations (Papageorgiou, 2016). It is necessary to involve the entire delivery system and all of the benefits of tourism to recognize the contributions of CMT to the economic and social development of destinations as tourist attractions as well as heritage and authenticity of cities (Paiano et al., 2020).

However, CMT growth has been categorized in the absence of sustainability (Anctil and Le Blanc, 2016). Although ecological quality and preserved coastal ecosystems are critical attributes for the success of the industry, cities have suffered from environmental deficiencies, influencing both their socioeconomic statuses and tourist intentions (Roca and Villares, 2008; Merli et al., 2019). Ross et al. (2015) indicated that socioeconomic development and climate change present major challenges for the management of coastal ecosystems. Lange (2015) stated that assessments of beaches and the sea carried out by localities are seriously limited, resulting in deficient livelihoods, while local communities barely receive the benefits of tourism. The environment is gravely damaged due to rapid population development, uncontrolled tourism growth, the disposal of untreated waste from urban areas and illegal coral exploitation (Lange, 2015). Hence, a balance is needed between socioeconomic benefits and sustainable environment to guarantee the long-term existence of CMT (Mustapha et al., 2018; Merli et al., 2019). For CMT cities, the most important challenge is designing an appropriate SSWM system, as tourism activities face increasing responsibility for the amounts and streams of waste generated at tourism destinations (Arbulú et al., 2015; Diaz-Farina et al., 2020). Specific implementation to deal with increasing tourism activities is essential for iconic marine habitats, and it must be planned and managed properly to be sensitive to coastal marine ecosystems.

2.3. Proposed method

Prior studies have employed various methods to highlight the role of SSWM in CMT. Shi et al. (2013) evaluated the potential of utilizing green waste from tourist destinations for renewable energy generation using a net energy–balance analysis. Greco et al. (2018) adopted an ordinary least squares regression to examine the impacts of tourism activities on the collection costs of different types of solid waste. Pereira and Fernandino (2019) applied a sustainability indicator matrix to evaluate the SWM of coastal cities and tested its applicability in practice. Ghayebzadeh et al. (2020) conducted a review of the relevant literature and government issues to analyze the solid waste generated, the management processes and the final disposal systems that reduce the volume of plastic waste entering the environment.

The complexity is underestimated between SSWM and CMT management. Misperception, conflicts, and fragmentation arise frequently because of the misunderstanding of this complexity, while a variety of specific issues combine in the CMT environment (Taljaard et al., 2019). The environment of CMT cities is a complex ecosystem formed by interactions between the ecological structure and the operation of physical processes and socioeconomic structures (Elliott et al., 2017). Their interrelationships are complicated and uncertain, with management processes continuously attempting to disentangle them. Tirkolaee et al. (2020) stated that SSWM must deal with various attributes, such as socioeconomic conditions, environmental impacts and social support. Bui et al. (2020a) claimed that it regularly faces obstacles since uncertainty exists among the attributes in multiple dimensions.

Hence, both qualitative techniques and quantitative measures are adopted. An FSE-DEMATEL method is proposed to evaluate SSWM in CMT cities. The FSE is used to convert experts' qualitative linguistic perceptions into quantitative data so the proposed attributes are prioritized to construct a hierarchical framework under conditions of uncertainty; at the same time, the DEMATEL is adopted to determine the causal interrelationships among attributes (Tseng et al., 2019; Tsai et al., 2020). Islam et al. (2019) applied the FSE-DEMATEL method using linguistic preferences to tackle the relative interdependence among attributes in a hierarchical structure and the performance of sustainable corporate culture. Wu et al. (2019) used this proposed method to assess the performance of sustainable resource management via a visual set of attributes and by mapping a causal model of them. Hence, it is appropriate for this study to adopt this method to construct a valid and reliable hierarchical framework of SSWM in CMT cities and to identify the critical attributes for successful performance.

However, the construct reliability and validity of the proposed hierarchical framework and the qualitative data have not yet been confirmed (Tseng and Bui, 2017; Bui et al., 2020b). An EFA is adopted to examine the constructing linear relations between the aspects and criteria (Tsai et al., 2020). The method groups the observed criteria into a multi-hierarchical framework by obtaining their important values that correlate implicitly with the proposed aspects. Thus, the hybrid EFA and FSE-DEMATEL method is suitable for determining the constructing correlations between the aspects and criteria of SSWM in CMT cities and the proposed hierarchical framework in this study.

2.4. Proposed measure

Tourism structures are often developed in the absence of waste treatment abilities, leading to contamination in coastal areas (Lu et al., 2019.). Hence, an SSWM design is needed that considers the interrelationships of various attributes (Mohsenizadeh et al., 2020). As SWM is an essential theme for sustainable development, it is necessary to consider the three TBL domains of sustainability (Bui et al., 2020a). This study proposes a set of attributes that includes these three perspectives and 21 criteria to assess the tourism economy, the coastal and marine environment, and the socio-culture (as shown in Table 1).

Economic sustainability is an important perspective for effective SWM systems. In particular, the tourism economy (P1) interconnects with a number of different economic activities, and the effects of its aspects on explicit areas are multilayered and multidimensional (Greco et al., 2018). When economic development and urbanization increase, a greater volume of solid waste is generated (Arikan et al., 2017). However, financial support has often been used to cover losses from inefficient SWM. Funding and expenditures (A1) are required to optimize the cost of the entire system, and the trade-off must be considered between overall expenditures, on the one hand, and environmental and social benefits, on the other hand (Ikhlayel, 2018). Deus et al. (2019) claimed that financial returns and financial income (C1) are quantified based on

Table 1
Proposed hierarchical framework.

Perspectives		Aspect		Criteria		References
P1	Tourism economy	A1	Funding and expenditures	C1	Financial return and income	Pereira & Fernandino (2019); Diaz-Farina et al. (2020); Greco et al. (2018); Yuan (2017)
				C2	Residents' consumption	
				C3	Civil construction debris	
		A2	Tourism activities	C4	Tourist flow	Deus et al. (2019); Diaz-Farina et al. (2020); Greco et al. (2018).
				C5	Accommodation	
P2	Coastal and marine environment	A3	Policy and legal framework	C6	Legislation cooperation and coordination	Paiano et al. (2020), Lu et al. (2019); Fernando (2019).
				C7	Marine environmental regulation	
				C8	Political leadership support	
				C9	Ecological security	
		A4	Environmental co-creation	C10	MSWM facilities and services	Chen & Bau (2016); Merli et al. (2019); Pereira & Fernandino (2019)
				C11	Technological implementations	
				C12	Green practices	
				C13	Coastal and marine ecosystems	
P3	Socio-culture	A6	Stakeholder participation	C14	Cost-sharing and mutual strategies adoptions	Srivastava et al. (2005); Pereira & Fernandino (2019); Merli et al. (2019); Fernando (2019).
				C15	Technical cooperation	
				C16	Guest environmental concern	
				C17	Citizen's participation	
		A5	Community awareness	C18	Cultural operant resources	Arnould et al. (2006); Chen & Bau (2016); Frempong et al. (2020)
				C19	Information provision	
				C20	Health and wellbeing	
				C21	Local community attitude	

investment activities. Diaz-Farina et al. (2020) studied residents' consumption (C2), assuming that healthcare, wholesale, and retail produce a certain volume of solid waste, cancelling out the supplementary profits from tourism activities and harming public health and the environment. Pereira and Fernandino (2019) presented that civil construction debris (C3) must be included in municipal recycling projects so local governments can obtain economic advantages such as a reduction in the cost of urban cleaning and the acquisition of recycled materials, which are cheaper options for public construction projects.

Tourism activities (A2) are an external attribute of the conflict and resolution between the supply of tourism products/services and tourism consumption, and such activities cannot be managed by waste management authorities (Deus et al., 2019). However, tourism intensity may be forecasted partially by historical information and market tendencies. Diaz-Farina et al. (2020) proposed accommodations (C4) to approximate the waste generated by establishing annual ratios between jobs and overnight stays and between jobs and beds in apartments and hotels. This method makes it possible to know the extent of the impacts of the tourism flow (C5) on waste management costs to limit cost increases under high tourist pressure to set suitable tax ratios, forcing the industry to contribute to SWM services without levying additional taxes on the local community (Greco et al., 2018).

The coastal marine environment (P2) is a highly important tourism sector, but it experiences tremendous pressure from the activities of humans fascinated by the waterfront and the sea, a pressure that is particularly intense in CMT (Papageorgiou, 2016). Most legislation related to environmental issues has been affected by the requirements imposed on other sectors (Taljaard et al., 2019). Policies and legal frameworks (A3) are essential for a feasible regulatory implementation of SSWM and for proper management strategies based on a straightforward outline, functional monitoring and application at both the local and national levels (Coffey and Coad, 2010). Indeed, yachts and cruises, which embody the largest sector of marine tourism, are accountable for high levels of marine environmental pollution (Copeland, 2008). The interrelationship between ports and destinations makes conceivable legislative cooperation and coordination (C6) for implementing cross-border waste policies and standardized information and performance on related environmental issues (Paiano et al., 2020). Marine environmental regulation (C7) is also proposed to improve marine ecological quality and to save coastal resources, limiting mass tourism and reducing pollution levels (Lu et al., 2019). Although broad policies that enable legislation at the central and regional levels is necessary, local municipalities are unvaryingly involved in management activities; thus, the support of political leadership (C8) is necessary for the successful implementation of SSWM strategies (Fernando, 2019). This support ensures ecological security (C9), a nonthreatening aptitude for adapting environmental deviations to cover the complex system of the economy, society and natural ecology (Lu et al., 2019).

An improper SWM has a negative impact on destination attractiveness since coastal and marine environmental resources contribute to the creation of the tourist experience (Arbulú et al., 2015). Therefore, environmental cocreation (A4) is included as an open, participatory and collaborative innovation that integrates resources from different players and in which stakeholders work together for mutual benefits (Frempong et al., 2020). Chen and Bau (2016) argued that SSWM facilities and services (C10) minister to social and ecological interests as long-term coastal and marine administration approaches controlled by the goals and priorities of policymakers. Pereira and Fernandino (2019) proposed technological implementation (C11) as a criterion of the adequacy and maintenance of the equipment used to help implement green practices (C12) to reduce environmental impacts (Merli et al., 2019). As a result, coastal and marine ecosystems (C13) that provide tourism and nature are preserved, and monitoring is conducted of the benefits from the carrying capacity of the environment.

Tourism consists of a set of social and economic activities that use very large amounts of resources and have substantial environmental impacts (Aljerf, 2015). The efficiency of SWM depends on the contribution of both municipal authorities and citizens; therefore, the socio-cultural perspective (P3) must be included in decision-making (Sharholy et al., 2008). Diaz-Barriga-Fernandez et al. (2017) proposed multi-stakeholder participation (A5), which involves various functions considered in SWM to maximize total benefits. In fact, different stakeholders have different tasks and interests associated with management that must be determined to induce them to cooperate for the common purpose of better operational performance (Tsai et al., 2020). Srivastava et al. (2005) suggested promoting cost-sharing and mutual strategy adoption (C14) so that communities and other stakeholders can support and strengthen SSWM successfully. Pereira and Fernandino (2019) claimed that technical cooperation (C15) among public and private sectors enhances studies and technologies related to waste treatment solutions to meet ecologically the final waste-disposal reduction target. In addition, guest environmental concerns (C16) and citizen participation (C17) are discussed to be the successful implementation of SWM. These attributes concern the attitudes of individuals toward the environment, and, without these criteria, SWM may fail (Merli et al., 2019; Fernando, 2019).

Community awareness (A6) also contributes to SSWM solutions. SSWM aims to improve public-awareness levels and to obtain the active participation of the community (Bui et al., 2020a). Arnould et al. (2014) claimed that cultural operant resources (C18) include specialized knowledge and skills, life expectancy and historical imagination to enable citizens to have a better position from which to engage in SSWM. Chen and Bau (2016) proposed information provision (C19) to promote the environmental awareness of coastal communities and provide them with relevant information. There is still a lack of awareness among citizens regarding waste management (Kala and Bolia, 2020). SWM has consequences for the health and wellbeing of citizens (C20), and changing the attitude of the local community (C21) is necessary to change behavior (Frempong et al., 2020).

3. Method

This section discusses the case background of SWM in Vietnamese CMT cities and provides details on the EFA and FSE-DEMATEL method as well as the proposed analytical steps.

3.1. Case background

Vietnam ranks fourth worldwide in terms of marine solid waste. On average, 0.5 million tons of solid waste are generated every year in coastal and marine areas, with an estimated 80% of marine debris being improperly treated waste and 92% being plastic (Worldbank, 2018; VASI, 2019). As a result, more than 3000 km of Vietnam's sea lanes and numerous resorts face serious pollution, causing the tourism attractiveness of these destinations to decrease gradually. The amount of untreated waste is large. The sources of solid waste discharged include land and sea sources. In tourism activities, waste from land sources is generated from tourists and tourism businesses such as accommodations, restaurants, food markets and souvenir shops. The main types of waste are plastic bags, plastic bottles, and fishing nets that accumulate in piles along the coast around which insects fly, creating a messy and polluted landscape. This situation affects the tourism industry directly, as all travel agencies rely on destinations. Massive tourism development without environmental management measures has greatly affected the quality of the landscape. CMT cities face pollution from solid waste, which affects the quality of not only the environment and ecosystems but also economic development and coastal communities as well as posing potential risks of food insecurity and public safety.

In Vietnam, Pham Phu et al. (2019) characterized waste and the SWM practice, and they analyzed the challenges in the solid waste management system in coastal tourism destinations. Hoang et al. (2019) developed a decision-support system for maximizing the social acceptance of sustainable municipal SWM in CMT cities. Although scholars and local authorities have formulated and implemented pilot models for management and mitigation that ban disposable waste products or nonbiodegradable plastic bags in some national tourist areas onshore, many businesses still aim to earn profits while ignoring their environmental responsibilities. There is no common framework, mechanism or plan for activities and actions to reduce waste in CMT cities. In this context, a wide and comprehensive set of attributes is used to measure and provide a solution for overcoming these practical challenges. This study aims to propose a consolidated SSWM structure to improve the performance of CMT cities.

3.2. EFA

EFA is a statistical reduction tool used to detect variables (such as the aspects in this study) and define a correlation tendency in an observed variable set (in this study, the criteria); then, it rearranges the variables into a more pertinent structure (Adabre and Chan, 2019). In particular, a factor loading is generated to guarantee that each observed variable achieves a practical significance standard. The Cronbach's alpha is used to test the internal consistency of the construct value; once the Cronbach's alpha exceeds 0.7, the variables group is confirmed to be reliable. Therefore, EFA precisely measure the reliability and validity of the proposed attributes in the analytical process (Bui et al., 2020b). This study used this method to confirm the hierarchical framework's validity and reliability.

3.3. FSE-DEMATEL

A multi-attribute evaluation model is applied to assess SSWM in CMT cities using the TBL approach. $a = \{a_1, a_2, a_3, \ldots, a_n\}$ and is a set of attributes with the evaluation matrix $(m_{ij})_{m*n}$, where m_{ij} determines the performance level of the attributes. $P1$, $P2$, and $P3$ are the three perspectives in the proposed measurement framework, where $P1$ is the tourism economy, P2 is the coastal and marine environment, and $P3$ is the socioculture. A five-point linguistic scale ranging from very low (VL) to low (L), medium (M), high (H), and very high (VH) is used to collect experts' perceptions (Tseng et al., 2019). m_{ij} is the degree of attribute i related to the perspectives (P) in the assessment matrix. The matrix is as follows:

$$\left(M_i^{Pk}\right)_{1*5} = \left(M_{i1}^{Pk}, M_{i2}^{Pk}, M_{i3}^{Pk}, M_{i4}^{Pk}, M_{i5}^{Pk}\right) \tag{1}$$

The performance of a perspective is calculated as follows:

$$Pk = \sum_{j=1}^{5}\left(r_j m_{r_j j}^{Pk}\right) \tag{2}$$

where r_j is the perception of criterion i and $r_j = 1, 2, 3, 4, 5$. Measurement criticality (MC) is used to determine the degree to which the attributes are aligned with the perspectives.

MC is computed based on the mathematical average by employing a matrix to preserve the consistency scale of all of the attributes and perspectives. MC is given as follows:

$$MC_i = \sqrt{P1 * P2 * P3} \tag{3}$$

Subsequently, the P_k values are used to generate the direct relation matrix (P_k). An $n * n$; RP_kmatrix is computed through pairwise comparison among the criteria using the FSE. $R_{ij}P_k$ is the degree of the effect of criterion i on criterion j. RP_k is calculated as follows:

$$RP_k = \left[R_{ij}P_k\right]_{n*n} \tag{4}$$

The normalization process of the direct relation matrix D is computed as follows:

$$D = \frac{RP_k}{\max_{1 \le i \le n} \sum_{j=1}^{n} R_{ij}} \tag{5}$$

Furthermore, the total relation matrix TR is generated as follows:

$$TR = D(I - D)^{-1} \tag{6}$$

where I is the identity matrix.

The cause-and-effect diagram is mapped. The columns (α) and rows (β) are aggregated from the total relation matrix TR; thus, $(\alpha + \beta,\ \alpha - \beta)$ is used to produce the cause-and-effect diagram. The horizontal axis is denoted by $(\alpha + \beta)$, and the vertical axis is denoted by $(\alpha - \beta)$. The horizontal axis in the diagram represents the importance of the attributes; the positive $(\alpha - \beta)$ values form the causal criteria, and the negative values form the effect criteria.

$$TR = \left[d_{ij}\right]\left[d_{ij}\right]_{n*n},\ ij = 1, 2, \ldots, n \tag{7}$$

$$\alpha = \left[\sum_{i=1}^{n} d_{ij}\right]_{n\times 1} = [dj]_{n\times 1} \tag{8}$$

$$\beta = \left[\sum_{j=1}^{n} d_{ij}\right]_{1\times n} = [dj]_{1\times n} \quad (9)$$

The weight $W = w_1, w_2, \ldots, w_k$ of each perspective is calculated from the criteria. Assuming that there are k criteria, the weight of perspective i is calculated as follows:

$$w_i^{p(i)} = \frac{P}{\sum_{i=1}^{k} P_i} \quad (10)$$

The assessment result of $R = WV * EM$ is obtained using the fuzzy weight vector WV and the evaluation matrix EM. The membership function groups (g) for perspectives $P1$, $P2$, and $P3$ are calculated as follows:

$$r_{gj}^{P1} = \sum_{i=1}^{k} wv_i^{P1} x em_{ij}^{P1}$$

$$\left(R_g^{P1}\right)_{1*5} = \left(WV_i^{P1}\right)_{1*k} * \left(EM_i^{P1}\right)_{k*5} = \left(r_{t1}^{P1}, r_{t2}^{P1}, r_{t3}^{P1}, r_{t4}^{P1}, r_{t5}^{P1}\right)$$

$$r_{gj}^{P2} = \sum_{i=1}^{k} wv_i^{P2} x em_{ij}^{P2}$$

$$\left(R_g^{P2}\right)_{1*5} = \left(WV_i^{P2}\right)_{1*k} * \left(EM_i^{P2}\right)_{k*5} = \left(r_{t1}^{P2}, r_{t2}^{P2}, r_{t3}^{P2}, r_{t4}^{P2}, r_{t5}^{P2}\right)$$

$$r_{gj}^{P3} = \sum_{i=1}^{k} wv_i^{P3} x em_{ij}^{P3}$$

$$\left(R_g^{P3}\right)_{1*5} = \left(WV_i^{P3}\right)_{1*k} * \left(EM_i^{P3}\right)_{k*5} = \left(r_{t1}^{P3}, r_{t2}^{P3}, r_{t3}^{P3}, r_{t4}^{P3}, r_{t5}^{P3}\right) \quad (11)$$

The membership functions of the criteria group (t) with the perspectives (P) are considered.

$$P_{gt} = \sum_{1}^{5} \left(r_j r_{tj}^{P_k}\right), \ k = 1,\ 2,\ 3 \quad (12)$$

$$MC_i = \sqrt{P1 * P2 * P3} \quad (13)$$

The total aspect weight for the perspectives is assessed as $W_{As} = \{W_{As1}, W_{As2}, \ldots, W_{Asm}\}$, where m is the number of aspects.

The weight of perspectives j is computed as follows:

$$w_{gj}^{P_k} = \frac{\left(\sum_{i=j}^{k} P_i\right)_j}{\sum_{j=1}^{x}\left(\sum_{i=1}^{k} P_k\right)_j} \quad (14)$$

where $\sum_{i=j}^{k} P_i$ is the sum of P from k criteria in group m.

Next, the membership functions for the overall weight of perspectives P are computed as follows:

$$mr_{Allj}^{P1} = \sum_{i=1}^{x} wv_{Asm}^{P1} x\ MR_{jj}^{P1}$$

$$\left(MR_{All}^{P1}\right)_{1*5} = \left(WV_{Asm}^{P1}\right)_{1*x} * \left(mr_{Asm}^{P1}\right)_{x*5} = \left(mr_{All1}^{P1}, mr_{All2}^{P1}, mr_{All3}^{P1}, mr_{All4}^{P1}, mr_{All5}^{P1}\right)$$

$$mr_{Allj}^{P2} = \sum_{i=1}^{x} wv_{Asm}^{P2} x\ MR_{jj}^{P2}$$

$$\left(MR_{All}^{P2}\right)_{1*5} = \left(WV_{Asm}^{P2}\right)_{1*x} * \left(mr_{Asm}^{P2}\right)_{x*5} = \left(mr_{All1}^{P2}, mr_{All2}^{P2}, mr_{All3}^{P2}, mr_{All4}^{P2}, mr_{All5}^{P2}\right)$$

$$mr_{Allj}^{P3} = \sum_{i=1}^{x} wv_{Asm}^{P3} x\ MR_{jj}^{P3}$$

$$\left(MR_{All}^{P3}\right)_{1*5} = \left(WV_{Asm}^{P3}\right)_{1*x} * \left(mr_{Asm}^{P3}\right)_{x*5} = \left(mr_{All1}^{P3}, mr_{All2}^{P3}, mr_{All3}^{P3}, mr_{All4}^{P3}, mr_{All5}^{P3}\right) \quad (15)$$

where $(mr_{Asm}^{Pi})_{x*5}$ denotes the $(x*5)$ matrix. The overall membership function for perspectives P_i and for MC is calculated as follows:

$$P_{i\,All} = \sum_{j=1}^{5}\left(r_j mr_{Allj}^{P_k}\right) \quad (16)$$

$$MC_{All} = \sqrt{P1_{All} * P2_{All} * P3_{All}} \quad (17)$$

where $r_j = 1, 2, 3, 4, 5$.

3.4. Proposed analytical steps

The proposed analytical steps are as follows.

1 A set of attributes including three perspectives and 21 criteria is proposed based on the literature review to develop a measurement structure. A committee of 32 experts was compiled, including 14 from academia, 10 practitioners in tourism and SWM firms, and eight experts from related government agencies; the experts had an average of eight years of experience working and researching in the field of waste management and tourism administration. Face-to-face interviews were conducted to improve the expert reliability and to confirm the validity of the attributes; then, the experts completed the evaluation questionnaires.
2 The EFA is used to rearrange the criteria into a hierarchical framework and to evaluate the construct reliability and validity of the proposed framework. The experts were asked to evaluate each criterion's importance level towards SSWM in CMT cities. The data are analyzed using SPSS 25.0 software.
3 The FSE transforms experts' linguistic perceptions into fuzzy numbers. Crisp values are then developed using Eqs. (1)–(3). A decision matrix is generated to address the interrelationships among the attributes using Eq. (4).
4 The total DEMATEL relation matrix is made coherent using the crisp values by applying Eqs. (5)–(9). The cause-and-effect diagram is mapped.
5 The crisp values of the perspectives and criteria as well as the criteria grouping weights are computed using Eqs. (10)–(13).
6 The crisp values of the perspectives and aspects are calculated, and the weights of the aspects are computed using Eq. (14)–(15). The overall weights of the perspectives are calculated by Eqs. (16)–(17).

4. Results

This section addresses the EFA and FSE-DEMATEL results.

4.1. EFA result

The result indicates that the study hierarchical framework is valid and reliable (Table 1). After removing the invalid attributes, 21 criteria remain with factor loadings higher than 0.5, indicating the significant validity of the criteria (Li et al., 2011). Next, the reliability of each aspect is confirmed with Cronbach's alpha values, which exceed 0.7. Three perspectives are divided into 6 aspects: (1) the tourism economy perspective includes funding and expenditures (A1) (Cronbach's alpha = 0.942) and tourism activities (A2) (Cronbach's alpha = 1.000), (2) the coastal and marine environment perspective includes the policy and legal framework (A3) (Cronbach's alpha = 0.990) and environmental cocreation (A4) (Cronbach's alpha = 0.967), and (3) the social-culture perspective includes stakeholder participation (A5) (Cronbach's alpha = 0.945) and community awareness (A6) (Cronbach's alpha = 0.947), as shown in Table 2.

Table 2
Exploratory factor analysis and reliability test.

Perspectives		Aspect		Criteria		Factor loadings	Cronbach's alpha
P1	Tourism economy	A1	Funding and expenditures	C1	Financial return and income	0.987	0.942
				C2	Residents' consumption	0.903	
				C3	Civil construction debris	0.948	
		A2	Tourism activities	C4	Tourist flow	0.995	1.000
				C5	Accommodation	0.995	
P2	Coastal and marine environment	A3	Policy and legal framework	C6	Legislation cooperation and coordination	0.954	0.990
				C7	Marine environmental regulation	0.991	
				C8	Political leadership support	0.955	
				C9	Ecological security	0.957	
		A4	Environmental co-creation	C10	MSWM facilities and services	0.939	0.967
				C11	Technological implementations	0.979	
				C12	Green practices	0.912	
				C13	Coastal and marine ecosystems	0.939	
P3	Socio-culture	A6	Stakeholder participation	C14	Cost-sharing and mutual strategies adoptions	0.991	0.945
				C15	Technical cooperation	0.949	
				C16	Guest environmental concern	0.878	
				C17	Citizen's participation	0.813	
		A5	Community awareness	C18	Cultural operant resources	0.945	0.947
				C19	Information provision	0.961	
				C20	Health and wellbeing	0.864	
				C21	Local community attitude	0.933	

4.2. FSE-DEMATEL result

The results of the FSE-DEMATEL method are presented in this section. The hierarchical framework of SSWM in CMT cities is formed along with the interrelationships among the attributes. Success indicators are also identified for further implementation.

The FSE calculates the membership functions and crisp values using Eqs. (1)–(3). Table 3 presents the membership functions and the crisp values of the criteria according to the perspectives. The three TBL aspects are P1, P2 and P3. The crisp values of C1 for P1, P2, and P3 are 3.000, 3.094 and 3.281, respectively, while the MC value is 3.123. Similarly, the crisp values, membership functions, and MC of all the other criteria are found in Table 3.

The crisp values of the FSE apply to the total relation matrix of the attributes. Then, Eq. (4) is used to calculate the matrix. Table 4 presents the total DEMATEL relation matrix of the aspects for the causal and effect groups. The DEMATEL method is applied using Eqs. (5)–(9) to inspect the interrelationships through a cause-and-effect diagram. As shown in Table 4, the interrelationship matrix has six aspects: funding and expenditures (A1), tourism activities (A2), the policy and legal framework (A3), environmental cocreation (A4), stakeholder participation (A5) and community awareness (A6).

The cause-and-effect diagram is mapped. Fig. 1 shows that tourism activities (A2), the policy and legal framework (A3), and stakeholder participation (A5), which belong to the causal group, are the main aspects that influence SSWM in CMT cities, whereas the effect group includes (A1), (A4), and (A6). In particular, stakeholder participation has strong effects on funding and expenditures and environmental cocreation, while tourism activities have a strong effect on funding and expenditures and moderate effects on stakeholder participation and environmental cocreation. Although the policy and legal framework has a moderate effect on funding and expenditures, this aspect still plays an important role in the system due to its significant interrelationship with other aspects (Table 5).

Similarly, the crisp values of the total relation matrix and the causal interrelationship matrix for the criteria are obtained in Tables 6 and 7. The cause-and-effect diagram is generated in Fig. 2. The results show that C3, C4, C5, C7, C8, C10, C14, and C15 are the causal criteria and that C1, C2, C6, C9, C11, C12, C13, C16, C17, C18, C19, C20, and C21 belong to the effect group. The top five criteria with the highest importance values $(\alpha + \beta)$ in the causal group are identified as civil construction debris (C3), the tourist flow (C4), the support of political leadership (C8), cost-sharing and mutual strategy adoption (C14), and technical cooperation (C15), about which further managerial implications are discussed below.

The membership functions of each aspect under each perspective are then calculated using Eqs. (10)–(12), followed by the calculation of group (P_i) using Eq. (13). MC is computed using Eq. (14). Table 8 reveals the aspect weights under the perspectives. The weights of the aspects based on the TBL are calculated using Eq. (15). Table 8 presents the overall crisp values, membership functions, and MC of the aspects under the TBL perspectives. All of the perspectives, P1, P2 and P3, are calculated using Eq. (16). Next, the total weights of the perspectives are calculated using Eq. (17) as $P_{1All} = 9.216$, $P_{1All} = 9.490$, $P_{1All} = 9.482$. Finally, the total MC is computed using Equation (18) as $MC_{All} = \sqrt[n]{P_{1All} * P_{2All} * P_{3All}} = \sqrt[3]{9.216 * 9.490 * 9.482} = 9.395$, where the average total performance is equal to $64.333\% \geq 60\%$, confirming the consistency of the proposed hierarchical framework (Islam et al., 2019). Furthermore, the MC value for the coastal and marine environment (P2) is 9.490, ranking first, while the MC values for the tourism economy (P1) and the socioculture (P3) are 9.428 and 9.216, respectively, ranking second and third in the structure, revealing gaps in the ranking of priorities among the perspective and indicating that, among the PBL perspectives, more emphasis needs to be placed on the coastal and marine environment, followed by the tourism economy and the socioculture, as shown in Table 9. Overall, the total performance of P1, P2, and P3 is 63.563%, 63.344%, and 66.094%, respectively (see Table 8); thus, there is still much room for improvement.

5. Discussions

The theoretical and managerial implications are presented in this section. The theoretical contributions are developed, and managerial action plans for practitioners are provided.

5.1. Theoretical implications

This study fills the gaps regarding SSWM in CMT cities that have not been addressed in the literature. A novel set of 21 SSWM criteria is proposed from the sustainable TBL perspectives of the tourism economy, the coastal and marine environment, and the socioculture. To extend the SSWM model, interrelationships among six aspects are identified: funding and expenditures (A1), tourism activities (A2), the policy and legal framework (A3), environmental cocreation (A4), stakeholder participation (A5) and community awareness. The results show that three aspects–i.e., stakeholder participation, tourism activities, and the

Table 3
Perspectives and attributes using FSE-DEMATEL.

Criteria	P1 Membership function					Value	P2 Membership function					Value	P3 Membership function					Value	MC
C1	0.125	0.313	0.156	0.250	0.156	3.000	0.188	0.250	0.125	0.156	0.281	3.094	0.188	0.156	0.156	0.188	0.313	3.281	3.123
C2	0.188	0.281	0.125	0.250	0.156	2.906	0.094	0.344	0.094	0.156	0.313	3.250	0.188	0.344	0.188	0.094	0.188	2.750	2.962
C3	0.125	0.125	0.344	0.250	0.156	3.188	0.250	0.156	0.219	0.219	0.156	2.875	0.125	0.250	0.250	0.094	0.281	3.156	3.070
C4	0.281	0.219	0.125	0.219	0.156	2.750	0.250	0.094	0.156	0.219	0.281	3.188	0.219	0.188	0.281	0.219	0.094	2.781	2.900
C5	0.281	0.125	0.219	0.156	0.219	2.906	0.250	0.188	0.125	0.188	0.250	3.000	0.250	0.063	0.156	0.375	0.156	3.125	3.009
C6	0.188	0.125	0.344	0.156	0.188	3.031	0.250	0.188	0.094	0.281	0.188	2.969	0.031	0.250	0.188	0.219	0.313	3.531	3.167
C7	0.156	0.219	0.188	0.125	0.313	3.219	0.250	0.156	0.125	0.219	0.250	3.063	0.094	0.125	0.219	0.344	0.219	3.469	3.246
C8	0.125	0.375	0.156	0.094	0.250	2.969	0.094	0.219	0.188	0.281	0.219	3.313	0.125	0.188	0.219	0.344	0.125	3.156	3.143
C9	0.219	0.156	0.125	0.156	0.344	3.250	0.281	0.094	0.313	0.188	0.125	2.781	0.094	0.188	0.250	0.219	0.250	3.344	3.115
C10	0.281	0.250	0.156	0.156	0.156	2.656	0.188	0.250	0.219	0.250	0.094	2.813	0.250	0.125	0.281	0.313	0.031	2.750	2.739
C11	0.219	0.313	0.188	0.125	0.156	2.688	0.313	0.125	0.156	0.094	0.313	2.969	0.250	0.188	0.219	0.125	0.219	2.875	2.841
C12	0.250	0.094	0.188	0.156	0.313	3.188	0.188	0.156	0.344	0.156	0.156	2.938	0.156	0.219	0.219	0.219	0.188	3.063	3.061
C13	0.156	0.094	0.250	0.156	0.344	3.438	0.250	0.125	0.125	0.219	0.281	3.156	0.219	0.094	0.281	0.281	0.125	3.000	3.193
C14	0.188	0.281	0.250	0.125	0.156	2.781	0.313	0.156	0.156	0.156	0.219	2.813	0.094	0.219	0.188	0.156	0.344	3.438	2.996
C15	0.219	0.219	0.156	0.188	0.219	2.969	0.156	0.281	0.094	0.250	0.219	3.094	0.156	0.313	0.094	0.250	0.188	3.000	3.020
C16	0.219	0.219	0.125	0.156	0.281	3.063	0.219	0.219	0.156	0.125	0.281	3.031	0.156	0.188	0.219	0.063	0.375	3.313	3.133
C17	0.156	0.219	0.219	0.219	0.188	3.063	0.219	0.219	0.250	0.125	0.188	2.844	0.125	0.219	0.125	0.281	0.250	3.313	3.067
C18	0.188	0.125	0.219	0.219	0.250	3.219	0.219	0.250	0.156	0.156	0.219	2.906	0.063	0.375	0.094	0.156	0.313	3.281	3.131
C19	0.125	0.281	0.219	0.125	0.250	3.094	0.125	0.125	0.219	0.250	0.281	3.438	0.250	0.188	0.281	0.188	0.094	2.688	3.057
C20	0.188	0.156	0.156	0.344	0.156	3.125	0.375	0.094	0.188	0.125	0.219	2.719	0.063	0.188	0.250	0.219	0.281	3.469	3.089
C21	0.219	0.125	0.219	0.250	0.188	3.063	0.250	0.156	0.094	0.250	0.250	3.094	0.125	0.094	0.344	0.219	0.219	3.313	3.154

Table 4
The total DEMATEL relation matrix of aspects.

	A1	A2	A3	A4	A5	A6
A1	2.948	2.969	2.938	2.844	3.188	2.760
A2	2.990	3.167	3.115	2.896	3.052	2.667
A3	2.938	2.948	2.927	3.156	2.760	2.990
A4	3.042	2.896	2.813	2.771	2.760	3.042
A5	3.156	2.948	2.792	3.115	3.083	2.927
A6	2.813	2.615	2.833	3.031	2.990	2.875

policy and legal framework—are the main aspects that influence SSWM in CMT cities by serving as a reference for better decision-making processes.

Stakeholder participation is proven to be the major causal aspect affecting multifaceted SSWM in CMT cities, and it is undertaken to recognize, observe and comprehend the interactions among the attributes in the framework (Diaz-Barriga-Fernandez et al., 2017; Tsai et al., 2020). The results show that stakeholder participation has strong effects on funding and expenditures and environmental cocreation. This study proposed that stakeholders have an essential role in developing sustainability, preserving tourism income, and producing natural capital to support tourism and SWM. Through financial mechanisms, manufacturing businesses can recover hazardous materials, change their business models, and innovate production technology to minimize waste. However, CMT cities frequently reach and surpass growth limitations with little notice, planning, or response from related stakeholders. If tourism is not properly planned and managed, it harms the destination environment, creates cultural and social conflict, and alienates the communities that host tourism. Stakeholders must be aware of their responsibility to join the management process, propagate change behaviors and deal with the wasted generated. CMT must share limited coastal resources with port logistics, port-vicinity industries, real-estate businesses and fisheries, and cruise ship tourism, heightening ecological system sensitivity (Lu et al., 2019). The provision to remove waste in an environmentally adequate and financially profitable way could be a sustainable solution. Thus, SWM cannot be dissociated from a sustainable CMT cities scenario because the appropriate tourism destination or even cruise ship–generated waste becomes a channel for social transformation with the different sectors involved. SSWM may benefit these sectors, in addition to reducing the environmental impacts and recycling used materials, as it reduces the deteriorating natural resources use (Sanches et al., 2019). It is also important to improve the capacity, cooperation and collaboration of local environmental governance, private tourism and related firms, and the community to increase the efficiency of the industry's waste-treatment enforcement-monitoring process. It is necessary to facilitate, encourage and support organizations and individuals to carry out activities related to collecting, classifying, transporting and treating solid waste in coastal ecosystems and mangrove areas, beaches, and waterfronts.

This study finds that tourism activities have a strong effect on funding and expenditures and moderate effects on stakeholder participation and environmental cocreation. This result highlights the importance of tourism in integrating the quality approach of tourists and community satisfaction based on socioeconomic development and ecological issues to induce SSWM (Arbulú et al., 2016; Deus et al., 2019). Since the industry invests in a destination, cooperation between its stakeholders and the local community is necessary to continue to maintain CMT SWM systems (Paiano et al., 2020). CMT makes it necessary to raise the issue of sustainable tourism development, emphasizing environmental protection at tourist destinations. By evaluating the capacity of a destination, it is possible to obtain the quantitative number of tourists who can be accommodated at any given time and in each season, as well as accompanying measures of the solid waste generated. Tourism facilities vary based on whether they are located at ports and marinas, beaches, heritage sites, or ecosystem areas

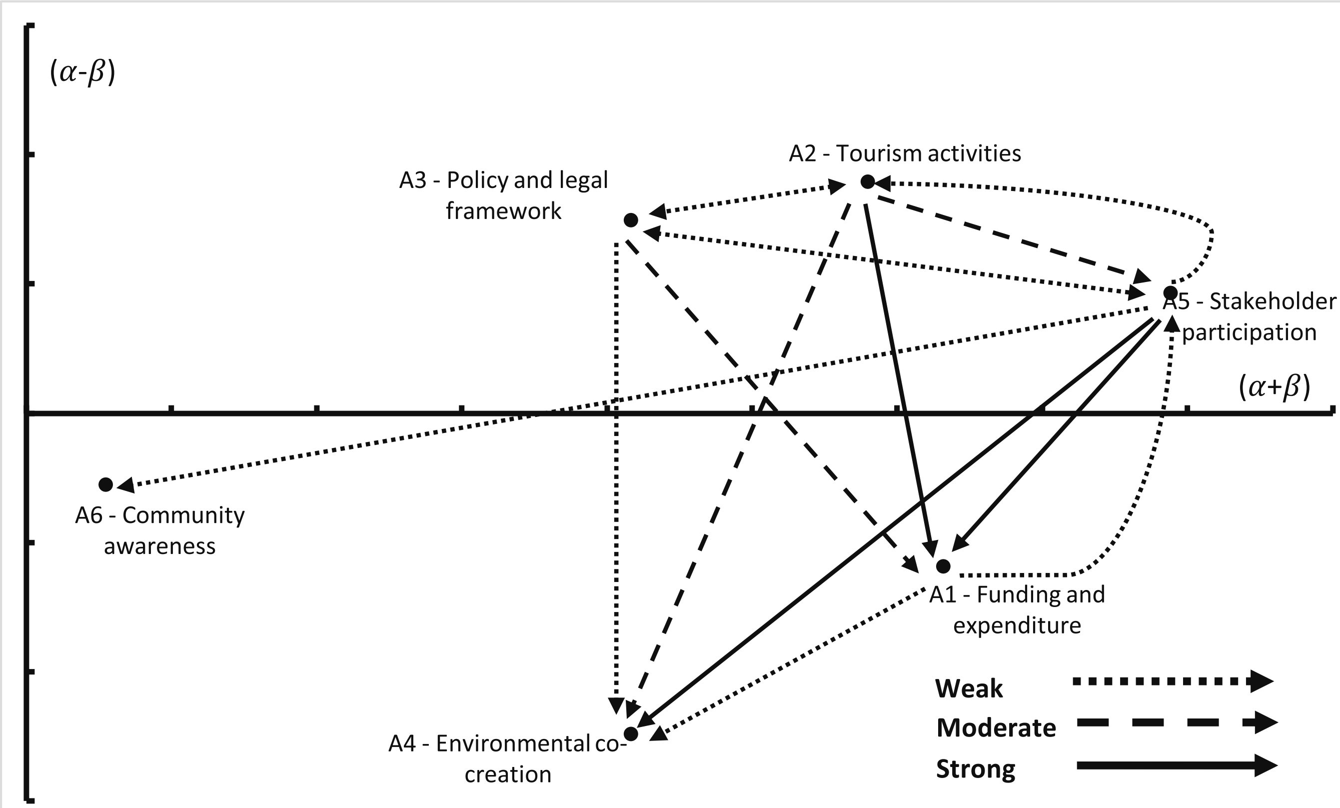

Fig. 1. The cause and effect diagram of aspects.

Table 5
The crisp values for the cause-and-effect of aspects.

	α	β	$\alpha+\beta$	$\alpha-\beta$
A1	44.783	45.375	90.158	(0.592)
A2	45.397	44.502	89.899	0.895
A3	44.914	44.167	89.081	0.747
A4	43.921	45.161	89.082	(1.240)
A5	45.704	45.238	90.942	0.466
A6	43.499	43.775	87.274	(0.276)

(Papageorgiou, 2016). However, the industry's rapid development only progresses short-term economic growth without focusing on the resource-consumption problem and environmental contamination. It is necessary to firmly establish SSWM policies. Tourism activities must comply with and actively respond to international and national regulations on environmental protection and waste treatment. The primary responsibility for performing tasks related to planning includes proactively organizing and allocating funds in the approved budget, and other funding sources must be mobilized according to the provisions of each player. A well-organized city structure can encourage tourism development and promote positive residential perceptions towards tourism to attract more tourists and gain a higher tourism income.

The policy and legal framework has a necessary role. The growth anticipated in tourism necessitates the expansion of more-specific legislation pertaining to this sector, especially to deal with the increasing, unplanned ecotourism activities that pose threats to iconic marine life and sensitive coastal marine habitats (Taljaard et al., 2019). The requirements for the regulatory implementation of proper SSWM strategies to inspect and to be applied in both local- and national-level systems have increased pressure on governance to deal with the impacts on ecosystem services (Coffey and Coad, 2010). Indeed, local governments can drive tourism development by employing policy instruments such as waste charging or improving the system's fairness in covering cleanliness, environmental quality preservation, public health standards, and the sustainability of financial provisions. Despite extensive acknowledgments, tourism that does not operate under a policy framework poses a serious threat because solid waste impacts the environment (Arbulú et al., 2016). The policy and legal framework of SSWM in CMT cities remains inadequate, is not specified or stipulated in legal documents and is not uniform, and interventions are lacking with regard to prohibitions and compulsory regulations. Therefore, it is impossible to guarantee the economic interests of CMT stakeholders and environmental benefits. Designing a policy and legal framework that can create an equilibrium among sustainable environment and socioeconomic benefits is needed to guarantee long-term CMT existence (Merli et al., 2019; Diaz-Farina et al., 2020). An appropriate SSWM system must be implemented as tourism activities face increasing responsibility for the amounts and streams of waste generated at tourism destinations. In addition, comprehensive regulations on managing ordinary solid waste and on conflict resolution in the field of ordinary SWM must be provided.

This study reveals that, with regard to the TBL, more emphasis must be placed on the coastal and marine environment. At many tourism destinations, environmental and natural resources are thought of as a comparative advantage (Arbulú et al., 2016). Environmental issues have had a great impact on the economic development of cities, including the development of the tourism industry, which is most affected by climate change and the ecological environment. Increasing CMT makes marine environments increasingly important in the provision of open space and opportunities for tourism and recreation activities (Chen and Bau, 2016; Papageorgiou, 2016). Plans for developing infrastructure for tourism lack a thorough consideration of the impact and risks to provide measures to protect these valuable resources, hence reducing revenue from tourism. The environment is critically damaged because of population growth, unplanned tourism expansion, untreated waste, and illegal coral

Table 6
The total DEMATEL relation matrix of criteria.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
C1	0.000	2.740	2.760	2.833	2.990	2.875	2.969	3.021	2.990	2.771	3.385	3.104	2.938	3.115	3.083	2.844	3.292	3.094	3.083	2.813	3.531
C2	2.875	0.000	3.063	2.958	2.917	2.427	2.792	2.906	3.417	3.490	2.594	2.667	3.167	2.990	2.688	3.281	3.073	3.250	2.927	2.854	3.021
C3	3.125	3.271	0.000	3.135	3.104	2.938	2.906	3.021	2.844	2.656	3.521	3.219	2.771	2.781	2.885	3.281	3.156	3.063	3.344	2.708	3.073
C4	3.125	3.302	2.802	0.000	2.906	2.854	3.208	3.104	3.344	2.833	3.094	2.635	2.958	2.875	3.219	3.229	2.875	2.813	3.042	3.156	3.344
C5	2.854	3.156	3.146	2.990	0.000	2.688	2.729	3.240	2.823	2.938	3.104	2.604	3.125	3.031	2.958	3.219	2.896	3.219	2.958	2.802	3.490
C6	3.073	2.875	3.125	3.115	2.917	0.000	3.188	2.792	2.927	2.802	3.094	2.854	3.313	3.604	2.865	2.833	3.198	3.146	3.146	3.333	3.167
C7	3.042	3.146	2.615	3.313	2.833	3.073	0.000	2.938	3.125	2.750	3.521	2.948	2.781	2.854	2.938	3.000	3.031	2.875	3.406	3.250	2.906
C8	2.865	2.948	3.385	2.667	2.854	2.854	3.115	0.000	3.146	2.792	3.031	3.135	2.854	3.385	3.125	3.125	3.083	3.229	3.240	3.104	2.740
C9	3.271	3.021	2.521	3.063	3.135	2.885	3.125	3.156	0.000	3.021	2.917	3.271	2.958	3.031	2.917	2.917	3.271	2.844	2.969	2.792	2.938
C10	3.188	3.031	2.750	3.292	2.865	2.948	3.135	3.125	2.896	0.000	3.427	3.302	2.917	3.188	3.094	3.000	3.177	3.229	2.917	3.094	2.688
C11	3.021	2.896	3.156	3.104	3.073	2.813	2.906	3.292	3.125	3.635	0.000	3.000	2.656	3.115	3.063	2.948	3.156	2.854	2.781	3.323	3.188
C12	2.813	3.115	2.792	2.948	2.719	2.781	2.750	2.656	2.844	2.792	2.917	0.000	2.844	2.792	2.792	3.365	2.979	2.802	3.010	3.000	3.083
C13	3.125	2.885	3.167	2.990	2.906	3.292	3.031	2.833	2.854	2.958	2.969	2.344	0.000	2.948	3.240	3.125	2.750	2.813	3.083	3.000	3.135
C14	3.177	3.156	3.135	3.000	2.865	2.802	2.875	2.865	3.125	2.813	2.938	3.146	3.156	0.000	3.385	3.010	3.375	2.906	3.167	2.938	2.969
C15	2.917	2.990	2.740	3.021	3.010	3.229	3.000	2.938	3.385	3.010	2.781	3.292	3.156	3.438	0.000	3.354	3.375	2.750	2.865	3.510	2.948
C16	2.875	3.240	3.313	3.125	3.177	2.865	2.854	3.208	3.146	2.865	2.885	3.125	2.969	2.844	2.865	0.000	2.844	2.625	2.698	2.969	2.729
C17	3.323	2.979	2.823	2.906	2.927	2.938	3.167	2.802	3.396	2.906	3.208	2.667	2.948	3.229	3.146	2.719	0.000	3.156	3.375	2.563	2.667
C18	3.198	2.948	2.677	2.813	3.281	3.000	2.854	2.792	2.594	2.729	2.542	3.031	2.563	2.948	2.771	3.250	2.469	0.000	2.938	2.854	2.823
C19	3.458	2.802	2.792	3.021	2.740	3.000	2.604	3.500	3.198	2.823	3.250	3.229	3.135	2.990	2.979	3.344	2.740	2.781	0.000	2.615	3.146
C20	3.073	2.688	3.417	2.813	3.010	2.635	2.885	3.271	2.875	3.010	2.979	3.052	3.240	2.917	2.885	2.781	3.031	2.781	3.375	0.000	2.656
C21	3.042	2.781	3.156	3.188	2.938	2.906	2.896	3.052	2.958	3.000	3.073	2.844	3.302	2.583	2.906	2.708	3.052	3.063	2.969	2.833	0.000

Table 7
The crisp values for the cause and effect of criteria.

	α	β	$\alpha+\beta$	$\alpha-\beta$
C1	35.735	36.428	72.163	(0.694)
C2	35.231	35.589	70.821	(0.358)
C3	36.055	35.234	71.289	0.821
C4	36.023	35.768	71.790	0.255
C5	35.587	35.141	70.728	0.446
C6	36.381	34.362	70.743	2.019
C7	35.809	35.033	70.843	0.776
C8	35.988	35.913	71.901	0.074
C9	35.618	36.199	71.818	(0.581)
C10	36.321	34.823	71.144	1.498
C11	36.247	36.301	72.549	(0.054)
C12	34.348	35.317	69.665	(0.969)
C13	35.321	35.465	70.786	(0.144)
C14	36.063	35.974	72.037	0.089
C15	36.573	35.507	72.080	1.066
C16	35.172	36.360	71.533	(1.188)
C17	35.534	36.078	71.612	(0.544)
C18	33.941	35.198	69.139	(1.258)
C19	35.695	36.332	72.027	(0.637)
C20	35.262	35.318	70.581	(0.056)
C21	35.188	35.749	70.937	(0.561)

exploitation (Lange, 2015). Pollution has caused a loss of local marine biodiversity and decreased the quality of seawater, impacting the attractiveness of local tourism (Lu et al., 2019). Tourism-based cities are also impacted since marine pollution causes esthetic problems and reduces the attractiveness of beaches, forcing municipal managers to choose rapid, nondefinitive solutions to this problem.

SSWM is an effective solution for tackling the environmental impacts of the ordinary resources used and cutting back on them (Lu et al., 2019; Sanches et al., 2019). However, based on the assessment that solid waste and marine debris are speedily accruing in the coastal and marine environment, it is critical to diminish solid-waste inputs into the oceans (Chen et al., 2019). The use of environmentally friendly resources and recyclable waste as material for landscaping is essential (Aid et al., 2017; Shi et al., 2013). It is necessary to change the direction of construction and to supply new tourism products, for example, by encouraging eco-friendly types of marine ecotourism and supporting projects effectively that protect the marine environment. Since tourism and the environment are inseparable, if the environment is good, then tourism will develop sustainably. The industry needs to be aware of environmental issues in the development process to build and design sites and tours to sustainably protect the environment, maintain it and be environmentally friendly.

5.2. Managerial implications

Many CMT cities in Vietnam are facing environmental pollution caused by solid waste. The main cause of marine pollution is widespread industrial and tourism development, along with unreasonable aquaculture activities, and the civilized habits of a large portion of the people living in these areas. The assessed situation of solid-waste generation, control and management in the CMT cities has not demonstrated concern about the marine sectors and localities; there are no specific regulations on marine- and coastal-waste management. Furthermore, the related stakeholders often do not engage in collaborations and focus on specific interests rather than on contributions to solve the solid-waste problems. This situation has resulted in a large amount of marine waste sourced inland. Marine environmental pollution caused by solid waste is an inclusive environmental problem, endorsed by governments, international organizations, non-governmental organizations, scientists and people. This study indicates that the crucial criteria of SSWM in CMT are civil construction debris (C3), the tourist flow (C4), the support of political leadership (C8), cost-sharing and mutual-strategy adoption (C14), and technical cooperation (C15). These criteria are considered success

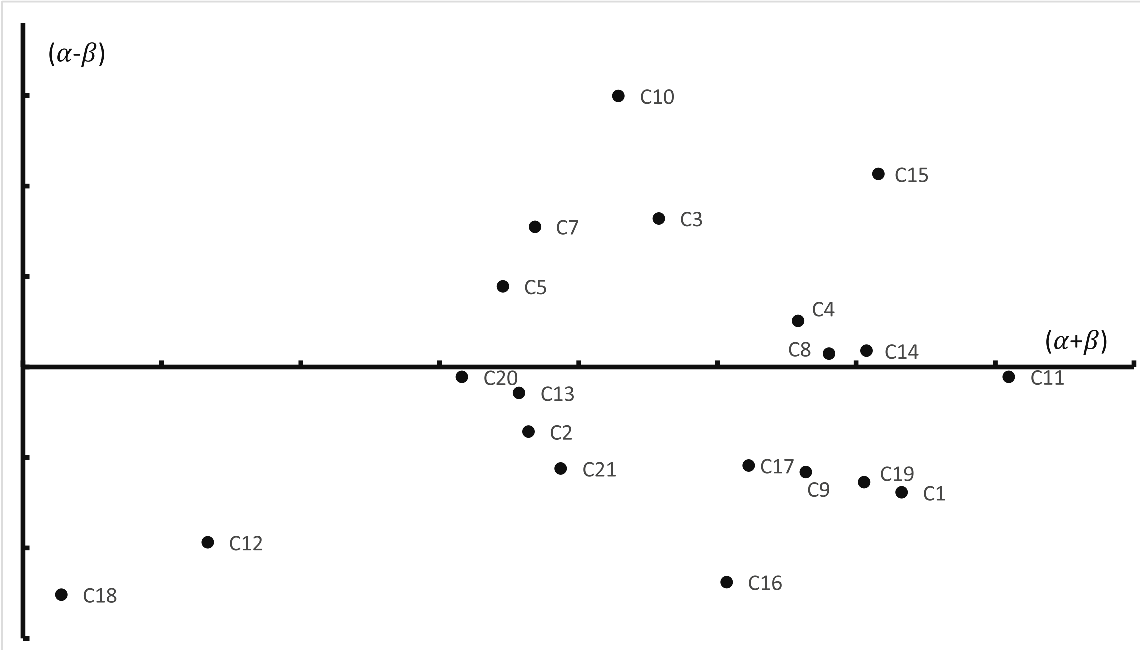

Fig. 2. The cause and effect diagram of criteria.

Table 8
The factor weights of the aspects under the perspectives.

Perspectives Aspects	Criteria	P1 Value	Group sum	Factor weight	P2 Value	Group sum	Factor weight	P3 Value	Group sum	Factor weight	Average totalperformance
A1	C1	3.000	9.094	0.330	3.094	9.219	0.340	3.281	9.188	0.361	
	C2	2.906		0.320	3.250		0.357	2.750		0.302	
	C3	3.188		0.351	2.875		0.316	3.156		0.347	
A2	C4	2.750	5.656	0.486	3.188	6.188	0.564	2.781	5.906	0.492	
	C5	2.906		0.514	3.000		0.530	3.125		0.552	
A3	C6	3.031	12.469	0.243	2.969	12.125	0.245	3.531	13.500	0.262	
	C7	3.219		0.258	3.063		0.246	3.469		0.278	
	C8	2.969		0.238	3.313		0.266	3.156		0.253	
	C9	3.250		0.261	2.781		0.223	3.344		0.268	
A4	C10	2.656	11.969	0.222	2.813	11.875	0.235	2.750	11.688	0.230	
	C11	2.688		0.225	2.969		0.248	2.875		0.240	
	C12	3.188		0.266	2.938		0.245	3.063		0.256	
	C13	3.438		0.287	3.156		0.264	3.000		0.251	
A5	C14	2.781	11.875	0.234	2.813	11.781	0.237	3.438	13.063	0.289	
	C15	2.969		0.250	3.094		0.261	3.000		0.253	
	C16	3.063		0.258	3.031		0.255	3.313		0.279	
	C17	3.063		0.258	2.844		0.239	3.313		0.279	
A6	C18	3.219	12.500	0.258	2.906	12.156	0.233	3.281	12.750	0.263	
	C19	3.094		0.248	3.438		0.275	2.688		0.215	
	C20	3.125		0.250	2.719		0.218	3.469		0.278	
	C21	3.063		0.245	3.094		0.248	3.313		0.265	
Total performance			63.563			63.344			66.094		64.333

attributes and need to receive more attention to provide more-practical guidelines for SWM practitioners, coastal and marine communities and local governance, and tourism service providers to improve their sustainability performance.

As industry develops, economic development is moving faster and stronger, and new construction works increases. This relationship is the main reason for the increasing amount, types and volume of civil construction debris that is continuously dumped into the environment, causing serious environmental pollution. Such debris is accompanied by many substances, such as heavy metals and toxic waste, from construction projects such as hotels, resorts, and civil works. Nonbiodegradable waste floating along the coast settles to the bottom of the sea, threatening the beach environment, eliciting different responses in terms of site deterrence and changing destination landscapes. However, this type of solid waste contains the most recyclable material and should be receiving recycling and reuse treatments. Such treatments are an economic advantage, allowing cities to reduce their cleaning expenses and to acquire recycled aggregates that are cheaper than new natural materials for public construction sites. The reality in Vietnam shows that the collection, classification and treatment of construction debris have not been highly effective, and the types of construction waste collected have not been properly processed. The method of crushing and screening needs to be enhanced with modern technologies and machines to handle various types of waste, such as bricks, mortar and concrete. An optimal solution to the problem of treatment and collection is necessary and is a problem not only for authorities but also for all communities and

Table 9
The crisp values of the aspects under the perspectives with the MC and final rankings.

	P1						P2						P3						MC
	Value	Membership Function					Value	Membership Function					Value	Membership Function					
A1	3.036	0.145	0.237	0.212	0.250	0.156	3.081	0.174	0.254	0.143	0.176	0.253	3.079	0.166	0.245	0.198	0.127	0.264	3.093
A2	2.830	0.281	0.171	0.173	0.187	0.188	3.097	0.250	0.139	0.141	0.204	0.266	2.963	0.235	0.121	0.215	0.301	0.127	3.161
A3	3.122	0.173	0.217	0.202	0.133	0.275	3.043	0.214	0.167	0.177	0.244	0.197	3.381	0.085	0.188	0.218	0.280	0.229	2.932
A4	3.029	0.223	0.178	0.199	0.149	0.252	2.974	0.235	0.162	0.209	0.179	0.214	2.927	0.217	0.157	0.249	0.234	0.142	3.064
A5	2.973	0.195	0.233	0.186	0.173	0.212	2.950	0.225	0.220	0.162	0.165	0.227	3.274	0.132	0.232	0.158	0.186	0.292	2.916
A6	3.126	0.180	0.171	0.203	0.234	0.211	3.062	0.235	0.156	0.165	0.200	0.244	3.215	0.118	0.211	0.241	0.196	0.234	3.061
P_{iAll}	9.216						9.490						9.482						
Rank	2						1						3						

their stakeholders.

The number of tourists is rapidly increasing; thus, the demand for consumption is increasing, putting pressure on the environments and landscapes of CMT cities. In Vietnam, tourism still focuses mainly on the quantity instead of the quality of visitors' service experience. Due to the high number of tourists, this issue requires management agencies to have solutions to control and manage the tourist flow to bring the greatest efficiency and highest revenue to the tourism industry. Many coastal and marine destinations face environmental pollution caused by solid waste generated under the widespread development of tourism, along with the irrational aquaculture activities and exploitative habits of many local communities and visitors. Therefore, practitioners should be acutely aware of the importance of the tourism business community for environmental protection and should clearly define its responsibilities. This paper proposes evaluating the capacity of SSWM facilities through measures of the quantitative number of tourists that the destination can accommodate at any given time and each season. The industry also raises the issue of sustainable tourism development and environmental protection at tourist destinations to provide specific programs and actions to improve the efficiency of tourism and to enhance the attitudes of tourists, resulting in the use of natural resources and a gradual improvement in the index of environmental competitiveness. Focusing on high-quality tourism products for tourists willing to pay more is recommended; thus, revenue is still guaranteed and, compared to mass tourism, negative impacts are minimized.

The support of political leadership is needed to ensure SSWM in CMT cities. Although policies and the legislative system regarding SWM have been relatively complete, creating a legal corridor for implementation in the period of accelerating development is necessary. In addition, by issuing priority and preferential mechanisms and policies to attract investment resources for CMT development projects, localities should apply environmental standards and waste management technologies and implement them. Relevant agencies should study and develop a method for determining solid waste in the marine environment, apply economic tools to prevent and reduce the waste generated, and encourage organizations and individuals to research and produce alternative environmentally friendly materials. Modernizing and promoting the international integration of regulatory supports is suggested to improve the effectiveness of waste management nationwide. Furthermore, city governance needs to direct tourist areas, destinations, restaurants, and hotels to modify their business models and support investment in a system of waste collection and treatment. For example, providing free bins for community-based tourism and construction, upgrading public lavatories to serve tourists, erecting signs, distributing leaflets, and creating brochures on environmental protection are essential activities for raising the awareness of tourists and the local community. At the same time, in the process of building infrastructure, the material-technical assessment of SWM sites is important to avoid affecting or damaging marine resources or polluting the water environment.

SSWM implementation still receives little attention. The sector lacks investment funds and currently does not pay operational costs. In this regard, there is a need for cost-sharing and mutual-strategy adoption to strengthen the effective linkage between tourism stakeholders and waste-management authorities in the implementation of environmental management policies in tourism development. It is necessary to harmonize development with SSWM activities to create trust, attract tourists and improve tourism competitiveness. It is necessary to strengthen government administration, focus on training and improving the quality and quantity of human resources, and encourage regional linkages to promote the advantages of coastal areas and cities. Additionally, it is necessary to encourage communication and education about marine environmental protection for tourists and to raise the awareness and responsibility of tour operators, tourist-accommodation establishments and staff in regard to the environment in coastal areas. Handling organizations and individuals who violate SWM regulations strictly, such that the polluter pays for pollution, is recommended. Hotels, restaurants and homestays should increase the use of eco-friendly, organic or reusable products to reduce the solid waste generated; increasing the use of such products will also create business opportunities for the development, creation, and sale of environmentally friendly products to develop an environmentally friendly tourism-supply chain. This paper also proposes elaborating and publicly listing environmental protection regulations at observable locations and disseminating them to all officials and employees of tourism enterprises and in local communities so they can also limit waste.

Although municipalities have experience establishing collaborative projects, the private sector has very limited capacity and experience in providing and improving waste-management services. Solid-waste collection and treatment have not received adequate investments, the resources are low, and appropriate technical solutions are lacking; meanwhile, the demand for SWM is increasingly urgent. The disconnected and small-scale activities in Vietnam do not create many benefits in terms of waste-management tasks. Furthermore, most waste-treatment technology is implemented by domestic providers, who have implemented only the technological line; thus, such technology is not synchronized, and many specifications are not accurate. The local government and its private partners alone do not have sufficient skills and capacity. It is necessary to pay attention to the needs of technical cooperation, for example, by promoting joint ventures, partnerships and investment cooperation, and cooperation will capture tourism demand. Technical cooperation for local waste management creates mutual benefits for the whole community by sharing the responsibility for waste management and a clean environment, and it creates more advantages in developing local livelihoods. The criteria for waste management should be fostered by strengthening international cooperation and increasing socialization, perfecting legislation to ensure consistency, reducing administrative costs, and promoting work. Promoting collaboration in scientific research and technological application as well as developing and exchanging information and data result in the technical skills and knowledge of waste-management processes that are suggested to achieve a highly efficient SSWM.

In CMT cities in Vietnam, the facilitators are cities and regions dependent on tourism. Supporting links between thriving tourist cities and impoverished coastal and marine communities can help the government respond with more-cooperative and -forceful efforts. Similarly, there is a need to promote linkages between the formal recycling sector, informal recycling facilities and the municipal government located where these activities take place. To contribute to the development of sustainable marine tourism, especially to gradually reduce the environmental pollution caused by solid waste, experts in the environmental field suggest that local governments focus on implementation. Synchronous waste-management solutions allow for the application of strict, compulsory sanctions against violating agencies and businesses. Thus, efforts should focus on improvement in hotspot areas (riversides, beaches with resorts and the hotel industry, fishing ports, communes and urban areas). Focus is also needed on the hotel and food-packaging industry in their transition from plastic to other types of waste. An appropriate sorting and collecting recyclable solid-waste process as well as a waste-material labeling system should be implemented to determine the recycling capacity. Urgently needed are the establishment of communication, training and education systems to protect the marine environment for tourism agencies and tourists; in addition the awareness and responsibility need to be raised of travel businesses, tourist-accommodation establishments and staff in regard to the environmental protection of coastal localities. Organizations and individuals violating regulations on marine environmental protection must be strictly and compulsorily managed.

6. Conclusion

Tourism structures are often developed in the absence of a lack of solid-waste treatment ability, leading to contamination in coastal areas and creating a gap in the measurement of SSWM in coastal and marine cities. An SSWM design that considers the interrelationships of various attributes is needed, as tourism activities play an important role in accounting for the streams and amounts of solid waste generated. This study proposes 21 criteria based on the theme of sustainable development considering the TBL perspectives to assess the tourism economy, the coastal and marine environment, and the socioculture. Both qualitative and quantitative techniques are adopted for the measurement. The FSE-DEMATEL method is adopted to evaluate SSWM in CMT cities to construct a hierarchical framework and to indicate the critical attributes for successful performance under conditions of uncertainty. The FSE is used to convert subjective fuzzy linguistic preferences from experts into script values so the constructs are determined on a priority basis. The DEMATEL is then adopted to understand the causal interrelationships among attributes and to identify the critical attributes for improvement. Furthermore, an EFA is used to test the construct reliability and validity of the proposed hierarchical framework.

From the results, the 21 criteria are categorized into six aspects—i.e., funding and expenditures, tourism activities, the policy and legal framework, environmental cocreation, stakeholder participation, and community awareness—and their interrelationships are identified. Three aspects—i.e., stakeholder participation, tourism activities, and the policy and legal framework—are the main aspects and are considered causal attributes for achieving SSWM in CMT cities. In particular, (1) stakeholder participation has strong effects on funding and expenditures as well as on environmental cocreation, (2) tourism activities have a strong effect on funding and expenditures as well as moderate effects on stakeholder participation and environmental cocreation, and (3) the policy and legal framework has a moderate effect on funding and expenditures. The crucial criteria are also found to be civil construction debris, the tourist flow, the support of political leadership, cost-sharing and mutual strategy adoption, and technical cooperation, and these criteria should receive more specific attention. Furthermore, in regard to the TBL, more emphasis should be placed on the coastal and marine environment, followed by the tourism economy and the socioculture, as these perspectives have the highest priority values.

This study has both theoretical and practical implications. An extended novel set of SSWM attributes is proposed, and a hierarchical framework is constructed to serve as a reference for better decision-making processes. By identifying the causal interrelationships among attributes, three aspects—i.e., stakeholder participation, tourism activities, and the policy and legal framework—are suggested to serve as a reference for better decision-making processes in SSWM. In practice, civil construction debris, the tourist flow, the support of political leadership, cost-sharing and mutual strategy adoption, and technical cooperation are indicated to provide action-plan guidelines for practitioners, especially CMT communities, local governance, and policymakers, as well as SWM firms and tourism service providers to improve their sustainability performance. Since tourism and the environment are inseparable, more emphasis needs to be placed on the coastal and marine environment. Doing so will contribute to raising awareness about environmental issues in the development process, such as integrating SSWM into building and design strategies at tourism destinations to protect the environment sustainably, ensure economic benefits, and be environmentally friendly for both the local community and visitors.

Some limitations remain. First, the attributes proposed are based on the literature; therefore, the hierarchical framework of this study may not be comprehensive. Future studies should include more attributes for further evaluation. Second, the context is dependent on experts' knowledge, which may cause biases due to their familiarity with the field. Future studies should extend the sample size to overcome this problem. Third, CMT cities are adopted to evaluate SSWM, which limits the contribution of this study. Future research is suggested to increase the generalizability of the results by applying the proposed framework to other subjects, such as rural cities or other types of tourism, and comparisons among cities and countries are recommended. Since the CMT cities are affected by other entities such as port operations, cruise tourism, and cargo transportation, future studies can also investigate the ecosystems impact of these entities on SSWM.

CRediT authorship contribution statement

Feng Ming Tsai: Writing - original draft. **Tat-Dat Bui:** Writing - original draft, Writing - review & editing. **Ming-Lang Tseng:** Writing - original draft, Writing - review & editing. **Ming K. Lim:** Writing - review & editing. **Raymond R. Tan:** Writing - review & editing.

Declaration of Competing Interest

This study is free of Conflict of interests

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