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EXAMINING THE INTERRELATIONSHIP BETWEEN ECOTOURISM PROGRAM ATTRIBUTES FOR HORSESHOE CRAB CONSERVATION IN TERENGGANU: FUZZY DEMATEL APPROACH

Kalsitinoor Set[1], Faridah Mohamad[2], Nurul Najwa Napatah[3*], Aslina Nasir[4]

[1] Faculty of Business, Economics and Social Development, Universiti Malaysia Terengganu, 21030 Terengganu, Malaysia
Email: kalsitinoor@umt.edu.my
[2] Faculty of Science and Marine Biology, Universiti Malaysia Terengganu, 21030 Terengganu, Malaysia
Email: mfaridah@umt.edu.my
[3] Faculty of Business, Economics and Social Development, Universiti Malaysia Terengganu, 21030 Terengganu, Malaysia
Email: najwanapatah@umt.edu.my
[4] Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, 21300 Terengganu
Email: inaslina@umt.edu.my
[*] Corresponding Author

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Abstract:

The horseshoe crab (Tachypleus gigas) is an endangered species in Malaysia, and its conservation is the primary concern. Ecotourism has been identified as a viable strategy for conservation. However, determining the most significant characteristics for an effective ecotourism program is essential. This study utilized the Fuzzy Decision-Making Trial and Evaluation Laboratory (Fuzzy DEMATEL) to identify the potential ecotourism program features for horseshoe crab conservation in Terengganu, Malaysia. The fuzzy causal map was employed to identify the relationships between five attributes, including community participation, value of attractions, ecotourism activities, environmental concerns, and facility management. The results indicated that environmental concerns and facility management were the primary fuzzy causal attributes affecting the effectiveness of the ecotourism program, while community participation, value of attractions, and ecotourism activities were influenced by these two dominant factors. This study demonstrates the efficacy of Fuzzy DEMATEL in identifying the critical factors for designing a successful community-based ecotourism program that prioritizes horseshoe crab conservation in Terengganu, Malaysia by emphasizing the environmental concerns and facility management. The findings offer valuable insights for

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policymakers and stakeholders to develop effective ecotourism programs that prioritize the conservation of horseshoe crabs in Terengganu.

Keywords:

Fuzzy DEMATEL; Horseshoe Crab; Attribute; Potential; CBET Program

Introduction

The horseshoe crab is a unique aquatic arthropod recognized as a fossil animal due to its morphological similarities for millions of years. There are just four species left in the world, three of which may be found in Malaysia (Manca et al., 2017; Akbar et al., 2018). Tachypleus gigas, often known as coastal horseshoe crabs, were once common on the beaches of Peninsular Malaysia. On the other hand, anthropogenic activities can only be found in a few areas nowadays. Because of its rarity and ecological significance, this animal has the potential to become a tourist attraction in Malaysia, including Kuala Kemaman, Terengganu on the East Coast of Peninsular Malaysia. Horseshoe crabs are readily available throughout the year, with an estimated population size between 7140-9900 in the two nearest localities (Mohamad et al., 2015; Sarmiento et al., 2021).

Unlike American horseshoe crabs, Limulus polyphemus, Asian horseshoe crab species, such as T. gigas, do not currently have a conservation plan. Malaysia still implements the legal horseshoe crab trade. However, in ASEAN countries, it is still legally or illegally traded (Akbar et al., 2021), and consequently, it leads to an overharvested wild population. The cultured juveniles can be released into the waters to replenish the waters with a new generation of horseshoe crabs to ensure the species is preserved. It is one option for ensuring stock preservation and resource sustainability (Xu et al., 2021).

The horseshoe crab conservation effort has positively been impacted by public perspective change through citizen science programs (Akbar et al., 2021). The conservation of this species heavily relies on the participation of local communities and the public. Encouraging substantial community engagement, which contributes to environmental and natural resources management, is critical for sustainable ecotourism (Masud et al., 2017; Chan et al., 2021; Marzo et al., 2023). Community-Based Ecotourism (CBET) is natural resource management implemented by a community based on conservation philosophy and practices. Sustainable CBET development necessitates the involvement of local communities and institutions, which can be accomplished in various techniques.

Ecotourism could be described as tourism based on natural resources promoting environmental sustainability and improving people's well-being. Ecotourism is defined in Malaysia as "travel and visits without neglecting the responsibility towards nature so as not to impede the enjoyment and appreciation of nature and the promotion of environmental protection (Ministry of Tourism, Arts and Culture Malaysia, 2023). The tourism industry all over the world is experiencing an overabundance of ecotourism. It can inspire sustainable behavior, environmental preservation, and community economic contributions.

Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

Even though theoretical studies attempted to establish a theoretical framework for ecotourism, only a few assessments of ecotourism potential in a wide range of characteristics. A potential assessment is a move that can be made to help encourage communities to engage in ecotourism (Reitsamer et al., 2016; Nguyen et al., 2022; Hafezi et al., 2023). It entails learning about the various resources and sites that could be utilized to enhance the attraction of a destination. Once completed, this can assist in making smart decisions on how to promote a certain area.

Some studies focused on ecotourism development, including a study by Canteiro et al. (2018) determining tourism's impact on the environment in four protected areas. However, only a few studies identify the interrelationship between ecotourism attributes. Furthermore, they overlooked the underlying complexity issues and the interconnections between attributes regarding the horseshoe crab's ecotourism. Therefore, to bridge this gap, this study is conducted to identify the potential of the ecotourism program for horseshoe crab conservation in Terengganu and as an ecotourism destination in Malaysia based on attributes: facility management, ecotourism activities, environmental concerns, value of attraction and community participation.

Despite the shortage of resources, the value of tourist attractions still plays an important role. Providing learning centers and other attractions that provide unique experiences would draw tourists to tourist destinations (Reitsamer et al., 2016; Li and Yu, 2023; Xue et al., 2022). The numerous characteristics regarded as the attraction's value include beauty and uniqueness, an attachment between the place and tourists, and clear and abundant resources (Qu, Kim & Im, 2011; Yan et al., 2017.; Pessoa, Oliveira & Souza, 2022).

Facilities management is an important aspect of tourism destination operations because it assures that the facilities provided are compatible with guests' demands and expectations. The facilities management provided in remote areas should attract visitors (Hsu, 2019; Zhou et al., 2015; Ali et al., 2022; Achmad et al., 2023; Quynh, Hoai, & Van Loi, 2021). Consequently, the horseshoe crab hatchery serves as a learning center for visitors to better comprehend ecological systems and biodiversity. To attract travelers, the best services and high-quality facility is required. It also assists in minimizing tourism's negative effects on local populations and the environment.

An ecotourism destination is where visitors may relax and enjoy the natural surroundings (Canteiro et al., 2018; Ajuhari, Aziz & Bidin, 2023). It attracts visitors due to its quality of life and the environment. Thus, the environmental concern was crucial in ecotourism development, which could give an advantage to the environment besides providing jobs and stimulating local economies (Lee & Son, 2016; Baloch et al., 2023). Its physical characteristics and climate determine the quality of the horseshoe crab's environment.

Ecotourism activities need to address the requirements of both tourists and local communities Luo et al. (2016) to increase environmental awareness and conservation among them (Pineda et al., 2023). Community involvement in ecotourism aims to the shelter environment (Osman et al., 2018). This can be accomplished by working with different stakeholder groups, including the government, the private sector, and tourists. Individuals must feel motivated to participate in the development of the program if there is a high level of community involvement.

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EISSN: 0128-178X JTHEM
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Methodology

Fuzzy DEMATEL evolved from the multiple criteria decision-making method (DEMATEL) to analyze the interrelationship between attributes (Çelikbile and Tüylü, 2022). Next, the experts' evaluations of the causal relationship between these attributes are measured using Fuzzy DEMATEL. According to Akyuz and Celik (2015), fuzzy DEMATEL approach that a decision-maker could use to obtain scientific, simple, easy and effective decision-making. The findings are determined through 5 steps of Fuzzy DEMATEL: (1) constructing fuzzy initial direct-relation matrix, (2) generating normalised initial direct-relation matrix, (3) attaining total relation matrix, (4) determining driving and dependence power of attributes and (5) mapping the causal relationship. The fuzzy initial direct-relation matrix is constructed based on experts' evaluation using the fuzzy linguistic scale to obtain the interrelationship between attributes and then is normalised as a normalised initial direct-relation matrix (Seifi and Ghobadi, 2017). Next, the total relationship between attributes is evaluated as the total relation matrix. The driving attributes and dependence attributes are determined by the sum of row (R) and column (C) of the matrix, respectively. Finally, the causal diagram is drawn to map the cause or effect attribute. After conducting all steps of Fuzzy DEMATEL, the result indicates that the causal attributes comprise environmental concerns and facility management. In contrast, the effect attributes consist of the value of attractions, ecotourism activities, and community participation.

The DEMATEL method is explained in the following stages (Gao et al., 2018).

Stage 1: Constructing Initial Direction Relationship

To determine the interrelationship between each pairwise comparison of attributes by experts, an initial direct relation matrix B=[b_{ij}], n×n non-negative matrix, was generated, where b_{ij} signified the causal relationship of attributes i on attributes j as well as b_{ij} =0 was the diagonal elements for i=j. Matrix b_{ij} could be obtained from Eq (1) by calculating the average of each expert's preferences (Gao, Chen & Chen, 2018).

$$b_{ij} = \frac{1}{k}\sum_{k=1}^{k} x_{ij} \quad (1)$$

Where $b_{ij} = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{bmatrix}$ and $b_{ij} = (q_{ij}, s_{ij}, v_{ij})$ were dimensions of triangular fuzzy number (TFN). $T = N(I - N)^{-1}$

Stage 2: Generating Normalized Initial Direct Relation Matrix

The initial direct-relation matrix was normalized and represented by IR as in Eq. (2). Next, it was multiplied to acquire matrix N (see Eq. 3), where all elements in N conformed to $0 \le i \le 1$ except the elements of diagonal that were equivalent to 0 (Abbasi et al., 2013; Lin, 2013).

$$I_R = \left[d_{ij} \right] = \frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} b_{ij}}$$

(2) $N = I_R \times B$

(3)

Journal of Tourism, Hospitality and Environment Management
EISSN: 0128-178X
JTHEM
Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

$$N = \left[n_{ij}\right] = \begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1n} \\ n_{21} & n_{22} & \cdots & n_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ n_{n1} & n_{n2} & \cdots & n_{nn} \end{bmatrix}$$

$$N_{ij} = \left(xq_{ij}^{k} = \frac{\left(xq_{ij}^{k} - min\, xq_{ij}^{k}\right)}{max\, r_{ij}^{n} - min\, l_{ij}^{n}}, xs_{ij}^{k} = \frac{\left(xs_{ij}^{k} - min\, xs_{ij}^{k}\right)}{max\, r_{ij}^{n} - min\, l_{ij}^{n}}, xt_{ij}^{k} = \frac{\left(xv_{ij}^{k} - min\, xv_{ij}^{k}\right)}{max\, r_{ij}^{n} - min\, l_{ij}^{n}} \right) \tag{4}$$

for i=1,..,n and j=1,…,n.

Then, normalized values of right (r) and left (l) could be calculated as follows:

$$xl_{s_{ij}}^{k} = \frac{xs_{ij}^{k}}{\left(1 + xs_{ij}^{k} - xq_{ij}^{k}\right)} \tag{5.1}$$

$$xr_{s_{ij}}^{k} = \frac{xv_{ij}^{k}}{\left(1 + xv_{ij}^{k} - xs_{ij}^{k}\right)} \tag{5.2}$$

$$x_{ij}^{k} = \frac{xl_{s_{ij}}^{k}\left(1 - xl_{s_{ij}}^{k}\right) + \left(xr_{s_{ij}}^{k}\right)^{2}}{1 - xl_{s_{ij}}^{k} + xr_{s_{ij}}^{k}} \tag{6}$$

$$\widetilde{w}_{ij}^{k} = min\, b_{ij}^{n} + x_{ij}^{n}\left(max\, r_{ij}^{n} - min\, l_{ij}^{n}\right) \tag{7}$$

$$d_{ij}^{k} = \sum_{k=1}^{n} \widetilde{w}_{ij}^{k} = \frac{x_{ij}^{1} + x_{ij}^{2} + x_{ij}^{3} + \ldots + x_{ij}^{k}}{k} \tag{8}$$

Stage 3: Attaining Total Relationship Matrix

Next, the total-relation matrix (T) was calculated to identify the total relationship between each pair of attributes. Matrix T is expressed as in Eq (9).

$$T = N(I - N)^{-1} \tag{9}$$

where I was the identity matrix $(n \times n)$

Stage 4: Determining the Driving Power and Dependence Power

The sum of value in the column cells (C) and row cells (R) from total relation matrix T could be acquired as in Eq. (10) and (11), respectively. C and R are obtained to measure the driving power and dependence power, respectively

$$R = \left[\sum_{i=1}^{n} t_{ij}\right]_{n\times 1} = (r_i)_{n\times 1} \tag{10}$$

$$C = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = (c_i)_{1\times n} \tag{11}$$

where t_{ij} denoted the indirect effects of criterion i on criterion.

Stage 5: Plotting the Causal Diagram

The causal diagram, with R+C (horizontal axis) and R-C (vertical axis), was drawn to map the causal relationship between attributes. The R+C value can be calculated to determine the attributes' importance in evaluating eco-tourism potential, where R-C, on the other hand,

Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

determines the causal or effect groups. The positive value of R-C signified the attributes of the cause group, while the negative value of R-C indicated the attributes of the effect group (Muhammad and Cavus, 2017; Priyanka, 2023).

Results and Discussion

The findings of this study are reported under the stages outlined in the method section. The initial direct relation matrix is generated through a five-point fuzzy linguistic scale most frequently applied in the previous study, as shown in Table 1, based on the expert's rating average.

Table 1: Five-point Fuzzy Linguistic Scale

Influence Score	Triangular Fuzzy Number	Linguistic Preferences
0	(0.0, 0.1, 0.3)	No influence
1	(0.1, 0.3, 0.5)	Very low influence
2	(0.3, 0.5, 0.7)	Low influence
3	(0.5, 0.7, 0.9)	High influence
4	(0.7, 0.9, 1.0)	Very high influence

Stage 1: Constructing the Initial Direct-Relationship

Table 2 presents the triangular fuzzy number converted from the fuzzy initial direct-relation matrix (D).

Table 2: Initial Direct Relation Matrix

	Facility management (A1)	Ecotourism activities (A2)	Environmental concerns (A3)	Value of attractions (A4)	Community participation (A5)
A1	(1.0, 1.0, 1.0)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
A2	(0.5, 0.7, 0.9)	(1.0, 1.0, 1.0)	(0.7, 0.9, 1.0)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)
A3	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(1.0, 1.0, 1.0)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
A4	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)	(1.0, 1.0, 1.0)	(0.7, 0.9, 1.0)
A5	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)	(1.0, 1.0, 1.0)

Stage 2: Generating the Normalised Initial Direct Relation Matrix

The crisp values (d_{ij}^{k}) of the normalised initial direct-relation matrix are calculated based on Eq. (2) to (7). These crisp values must be aggregated into matrix A through Eq. (8) once the transformation stages have been completed.

Table 3: Normalised Initial Direct-Relation Matrix (Defuzzification) Procedure From Experts

	A1	A2	A3	A4	A5
A1	[1.000 1.000 1.000]	[0.500 0.700 0.900]	[0.500 0.700 0.900]	[0.000 0.100 0.300]	[0.300 0.500 0.700]
A2	[0.500 0.700 0.900]	[1.000 1.000 1.000]	[0.700 0.900 1.000]	[0.500 0.700 0.900]	[0.300 0.500 0.700]

Journal of Tourism, Hospitality and Environment Management
EISSN: 0128-178X JTHEM
Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

A3	[0.500 0.700 0.900]	[0.700 0.900 1.000]	[1.000 1.000 1.000]	[0.300 0.500 0.700]	[0.300 0.500 0.700]
A4	[0.500 0.700 0.900]	[0.500 0.700 0.900]	[0.300 0.500 0.700]	[1.000 1.000 1.000]	[0.700 0.900 1.000]
A5	[0.300 0.500 0.700]	[0.300 0.500 0.700]	[0.500 0.700 0.900]	[0.300 0.500 0.700]	[1.000 1.000 1.000]

	xq_{11}^k xs_{12}^k xv_{13}^k	xq_{21}^k xs_{22}^k xv_{23}^k	xq_{31}^k xs_{32}^k xv_{33}^k	xq_{41}^k xs_{42}^k xv_{43}^k	xq_{51}^k xs_{52}^k xv_{53}^k
A1	[1.000 0.714 0.429]	[0.286 0.286 0.286]	[0.286 0.286 0.857]	[0.000 0.000 0.000]	[0.000 0.000 0.000]
A2	[0.286 0.286 0.286]	[1.000 0.714 0.429]	[0.571 0.571 1.000]	[0.500 0.600 0.600]	[0.000 0.000 0.000]
A3	[0.286 0.286 0.286]	[0.571 0.571 0.429]	[1.000 0.714 1.000]	[0.300 0.400 0.400]	[0.000 0.000 0.000]
A4	[0.286 0.286 0.286]	[0.286 0.286 0.286]	[0.000 0.000 0.571]	[1.000 0.900 0.700]	[0.571 0.571 0.429]
A5	[0.000 0.000 0.000]	[0.000 0.000 0.000]	[0.286 0.286 0.857]	[0.300 0.400 0.400]	[1.000 0.714 0.429]

	$xl_{s_{ij}}^k$	$xr_{s_{ij}}^k$	$xl_{s_{ij}}^k$	$xr_{s_{ij}}^k$	$xl_{s_{ij}}^k$	$xr_{s_{ij}}^k$	$xl_{s_{ij}}^k$	$xr_{s_{ij}}^k$	$xl_{s_{ij}}^k$	$xr_{s_{ij}}^k$
A1	1.000	0.600	0.286	0.286	0.286	0.545	0.000	0.000	0.000	0.000
A2	0.286	0.286	1.000	0.600	0.571	0.700	0.545	0.600	0.000	0.000
A3	0.286	0.286	0.571	0.500	1.000	0.778	0.364	0.400	0.000	0.000
A4	0.286	0.286	0.286	0.286	0.000	0.364	1.000	0.875	0.571	0.500
A5	0.000	0.000	0.000	0.000	0.286	0.545	0.364	0.400	1.000	0.600

	x_{ij}^k				
A1	0.600	0.286	0.398	0.000	0.000
A2	0.286	0.600	0.651	0.576	0.000
A3	0.286	0.533	0.778	0.378	0.000
A4	0.286	0.286	0.097	0.875	0.533
A5	0.000	0.000	0.398	0.378	0.600

w_{ij}^k

Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

A1	0.720	0.500	0.579	0.000	0.300
A2	0.500	0.720	0.756	0.576	0.300
A3	0.500	0.673	0.844	0.378	0.300
A4	0.500	0.500	0.368	0.875	0.673
A5	0.300	0.300	0.579	0.378	0.72

Stage 3: Attaining Total Relationship Matrix
The total relation matrix (T) in Table 4 is obtained using Eq. (9) to (11).

Table 4: Total-Relation Matrix (T)

	A1	**A2**	**A3**	**A4**	**A5**	**R**
A1	1.299	1.316	1.539	0.834	0.960	**5.947**
A2	1.679	1.900	2.173	1.476	1.375	**8.604**
A3	1.586	1.785	2.095	1.315	1.286	**8.068**
A4	1.672	1.802	2.018	1.597	1.546	**8.636**
A5	1.249	1.356	1.670	1.109	1.252	**6.636**
C	**7.486**	**8.160**	**9.495**	**6.331**	**6.419**	

Stage 4: Determining the Driving Power and Dependence Power
In Table 4, C and R are the totals of columns and total of rows, respectively, acquired from Table 3. C is represented as driving power, while R is dependence power. The results show A3 and A4 have a high value of C+R, consequently implying that both are important to be included in ecotourism potential evaluation. Besides, the value C-R for A2 and A3 is positive, indicating them as the causal attributes. Whereas the value C-R for A1, A4, and A5 are negative, indicating them as the effect attributes.

The most significant causal attribute that leads to the ecotourism potential is "facility management (A2)", which records the highest value of C+R with 1.538. It means A2 should be given more consideration in enhancing the ecotourism potential. Besides, the influential impact degree of facility management is ranked the lowest degree among all causal with C+R= 13.433. Meanwhile, "environmental concern" (A3) indicates the second-highest significant causal attribute for the ecotourism potential with C+R with 1.427. The influential impact degree of environmental concern is ranked the highest degree among all causal with C+R= 17.563.

The effect attribute represents the attribute influenced by others. From the findings, "value of attraction" (A1)" has the highest value among the whole process with C-R= 2.306. Whereas the "ecotourism activities" (A4)" and "community participation" (A5) show a low value of C-R= 0.444 and 0.217, respectively. These values are comparatively low, which point to a strongly influenced degree and are easily affected by other factors.

Journal of Tourism, Hospitality and Environment Management
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DOI 10/35631/JTHEM.1041029

Table 5: Driving And Dependence Power Of Attributes

	C	*R*	*C+R*	*C-R*
A1	7.486	5.947	13.433	1.538
A2	8.160	8.604	**16.763**	(0.444)
A3	9.495	8.068	**17.563**	**1.427**
A4	6.331	8.636	14.967	(2.305)
A5	6.419	6.636	13.055	(0.217)

Step 5: Plotting The Causal Diagram

Figure 1 is drawn based on Table 5. From the plot, the group of causal relationships consists of Facility management (A1) and environmental concerns (A3), while the values of attractions (A4), ecotourism activities (A2) and community participation (A5) are in the effect group. This explains the operation of the facility management of either public facilities or the organisation must be able to provide security, maintenance and facilitate tourist needs (Temeljotov Salaj & Lindkvist, 2021) While the suggested tourism activity related to horseshoe crab must reflect on the aim for environmental protection and preservation that will cause a tourist to visit the destinations. Thus, based on the effectiveness of the facilities management's services and ecosystem integrity practices, it will affect the tourism product's uniqueness through its activity, educating both tourists and stakeholders, and directly affecting the community through economic activity from tourist arrival.

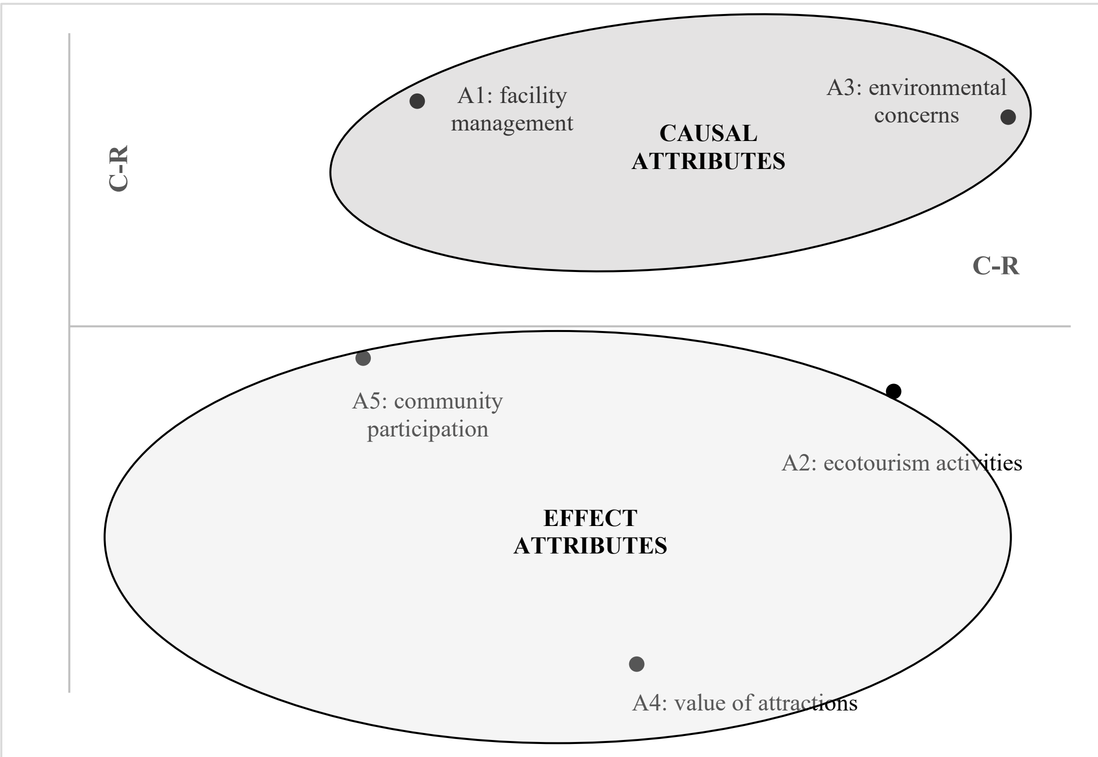

Figure 1: Causal Diagram

Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

Table 6 explains the importance and relation of the attribute value. Overall, environmental concerns are the most essential attributes, followed by ecotourism activities, the value of attractions, facility management and community participation. Furthermore, the facility management is recorded as having higher cause attributes than environmental concerns. Besides, community participation shows the highest effect attributes, followed by ecotourism activities and attractions value.

Table 6: The Importance and Relation of Attributes Value

	C+R	Rank of attributes	*C-R*	Causal/Effect group	Rank based on group
Facility management (A1)	13.433	4	1.538	Causal	1
Ecotourism activities (A2)	16.763	2	(0.444)	Effect	(2)
Environmental concerns (A3)	17.563	1	1.427	Causal	2
Value of attractions (A4)	14.967	3	(2.305)	Effect	(3)
Community participation (A5)	13.055	5	(0.217)	Effect	(1)

Conclusion

The scarcity of horseshoe crabs has sparked a global concern, with the species having drastically declined in Terengganu's beaches. The reproduction capacity is a critical factor in the horseshoe crab's persistence and growth. In regions of Terengganu where the species persists, conservation efforts are underway to boost spawning and hatching rates. A study by Salman et al. (2021) highlights environmental protection as the primary focus of all stakeholders, with any activities detrimental to the environment being strictly prohibited. Therefore, it is essential to identify the role of environmental concern in enhancing the potential of community-based ecotourism (CBET) on horseshoe crab conservation and sustainability. A Fuzzy DEMATEL analysis is employed to determine the interrelationship between five key attributes affecting ecotourism potential: facility management, ecotourism activities, environmental concerns, value of attraction, and community participation. This study aims to identify causal and effect relationships between these attributes to overcome theoretical limitations.

Based on statistical analysis, the coefficient of determination of ecotourism potential is strongly correlated with facility management, indicating that it is a significant influencing variable. The provision of amenities should not only be optimized for tourist convenience but also satisfy the community's needs. According to recent studies, inadequate infrastructure and lack of planning were identified as primary contributors to underdeveloped ecotourism potential (Seifi and Ghobadi, 2017). Furthermore, stakeholders suggest that promoting ecotourism through mathematical modelling of nature walks, trash removal optimization, and photography opportunities can enhance its effectiveness (Salman et al., 2021).

Volume 10 Issue 41 (September 2025) PP. 429-443
DOI 10/35631/JTHEM.1041029

Similarly, the environmental concern can be viewed as a significant coefficient in the model of community-based ecotourism (CBET) on horseshoe crab. As demonstrated by Salman et al. (2021), incorporating environmental awareness activities into the model would result in a more accurate prediction of tourist behavior, enabling stakeholders, tourists, and the public to avoid environmental degradation. A pleasant environment can be represented as a variable that significantly affects the value of tourist sites, thereby increasing the attractiveness of these sites to potential visitors. This aligns with the findings of Lee and Son (2016), which identified a positive and significant correlation between environmental concern and ecotourism intention among Vietnamese travelers visiting ecotourism locations. The tourists' experience with the environment would improve, leading to increased environmental consciousness, provided that the environment is protected from negative externalities.

Ecotourism is a process of participation of local people, and it contributes to sustainable tourism development. It is possible to reduce the environmental impact of disasters by involving locals. Increasing environmental awareness is critical to the success of conservation programs in preserving the environment. This study is confined to experts, but it can be expanded to include non-experts such as industry representatives, local communities, and tourists. This study applies Fuzzy DEMATEL methodology to analyze the complex relationships between ecotourism, local participation, and sustainable development. By involving experts, industry representatives, local communities, and tourists in the evaluation process, we can identify the relative importance of factors influencing the environmental impact of ecotourism and prioritize actions to mitigate disasters and promote environmental conservation. The fuzzy set approach enables us to consider the uncertainty and subjectivity inherent in evaluating the relationships between these attributes, ultimately providing a more comprehensive understanding of the role of ecotourism in sustainable development.

This research has provided an alternative perspective on evaluating potential destinations for conservation efforts in a system, with specific application to the problem of preserving horseshoe crab populations. The fuzzy DEMATEL approach offers a novel method for identifying and ranking the relative importance of attributes that will guide decision-makers in prioritizing key factors for effective conservation strategy implementation.

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