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Barriers to Sustainable Waste Management in Mountain Tourism: Evidence from India

Abstract

Goal 15 of the sustainable development goals calls for efforts to protect fragile mountain ecosystems. Waste generated due to mountain tourism leads to environmental degradation and biodiversity loss and poses a significant challenge to achieving this goal. Mountains are characterized by uninhabitable terrain and remoteness, and current tourism practices compound this challenge. The paper resolves this challenge by understanding barriers to sustainably managing waste using the classical DEMATEL method. Based on data from 36 experts in India's mountain tourism industry, barriers to the sustainable management of nonbiodegradable waste are analyzed. The results suggest that *enforcement of regulations, waste collection infrastructure,* and *lack of transportation for waste transfer* are the most prominent barriers that can be mitigated by collectively leveraging four tangible barriers: *tourists' motivation or achievement mentality, local government initiative, economic value of waste*, and *tourists' lack of environmental awareness*. Based on this, a policy intervention mandating certification standards for tourists before they embark on mountain tourism is suggested.

Keywords: sustainable development goals; nonbiodegradable waste; mountain tourism; barriers; classical DEMATEL, India

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1. Introduction

Tourism plays a vital role in achieving sustainable development goals (SDGs). The 2030 Agenda for Sustainable Development has 17 SDGs and 169 associated targets aimed at attaining sustainable economic, social, and environmental development outcomes. The tourism industry has the potential to address these SDGs including measures for eliminating poverty (SDG 1), ending hunger and achieving food security (SDG 2), combating climate change (SDG 13), and protecting, restoring, and promoting sustainable use of terrestrial ecosystems (SDG 15) (Carić, 2018; World Tourism Organization & United Nations Development Programme, 2017). Specific to SDG 15, target 15.4 states: "By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development" (United Nations, 2015). To achieve this target, a proper understanding of the reasons for the

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degradation of mountain ecosystems and biodiversity is critical. Mountain tourism accounts for 15-20% of worldwide tourism and is the major source of income for many countries (Debarbieux et al., 2014). The expansion of the tourism industry has increased pressure on mountain ecosystems and biodiversity (Carlisle et al., 2022). This pressure has brought the problems out into the open. One of the significant problems is the waste generated in mountain ecosystems and the consequential loss of biodiversity (Alfthan et al., 2016; Hoppstadius & Sandell, 2018; Lopes et al., 2020). Mountains are characterized by uninhabitable terrain and remoteness, and current tourism practices contribute to the challenge of sustainably managing this waste. Understanding waste management is particularly important in the context of mountain ecosystems because of its critical role in sustainable development (Volgger, 2015; Zeng et al., 2022). However, empirical studies on this topic are limited in the tourism literature (Chang & Katrichis, 2016). This study aims to fill the gap in tourism studies concerning waste management in mountain tourism.

This paper is organized as follows. Section 2 reviews the literature and articulates the research questions. Section 3 explains the methodology to answer the research questions. Managerial and policy implications of the results are discussed in Section 4. The final section concludes with contributions and suggestions for future work.

2. Literature review

The 1992 United Nations Conference on Environment and Development in Rio de Janeiro, recognized mountains as a prime tourism asset that needs to be conserved. Chapter 13 in Agenda 21 focused on the protection, conservation and sustainable development of mountain tourism (Ives, 1995). The third session of the United Nations Commission on Sustainable Development in 1995, agreed to develop guidelines to plan and implement sustainable mountain development programs (Ives, 1995). The Rio+20 UN Conference on Sustainable Development released the report titled "The Future We Want" (United Nations, 2012). This report pointed out that mountains are an essential resource for human survival and acknowledged the negative impact on mountain ecosystems due to tourism-related activities. The report also highlighted the need to develop national policies that conserve mountain ecosystems through sustainable development (United Nations, 2012). The United Nations further established 17 SDGs to achieve sustainable economic, social, and environmental development outcomes by 2030. Two targets in Goal 15 (SDG 15) directly addressed sustainable development in mountain areas (United Nations, 2015). They reinforced the importance of international agreements and collaborative efforts by tourists, governments, and local communities to conserve mountain ecosystems for sustainable development.

This study directly addresses SDG 15 by focusing on the sustainable management of nonbiodegradable waste (NBW) in mountain tourism destinations. It is guided by the following research questions:

- What are the key barriers to the sustainable management of NBW in mountain tourism?
- How do these barriers causally influence each other?

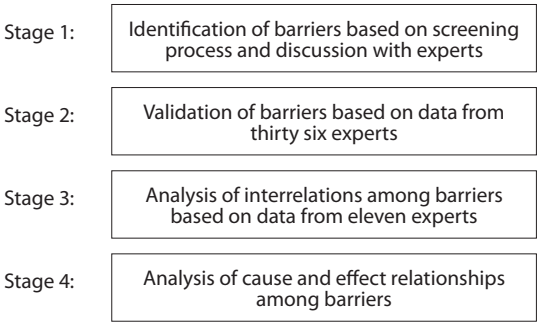
Even though solid waste management is a significant problem in tourism destinations, it is a topic that needs deeper research in the tourism literature (Kuniyal, 2005a; Matai, 2015; Semernya et al., 2017; Zeng et al., 2022). A lack of sustainable waste management leads to a loss of tourism revenue. In the coastal tourism context, it has been estimated that unmanaged waste causes a loss of $622 million in the Asia-Pacific region alone (McIlgorm et al., 2011). Interestingly, managing this waste has the potential to increase tourism revenue by 30% (Qiang et al., 2020). Thus, sustainably managing waste in mountain tourism helps protect fragile ecosystems and has the potential to increase tourism revenue. This research contributes to the literature on sustainable tourism in two ways: it systematically analyzes barriers to the sustainable management of NBW and fills the research gap in the study of waste management systems in mountain tourism destinations. Prior research has given scant attention to developing a systematic understanding of these barriers. From a theory point of view, the analysis of barriers helps to develop an initial exploratory understanding of the underlying dynamics of the sustainable management of NBW in mountain tourism. This can serve as a stepping stone to build an overarching theory

of waste management in mountain tourism. From a practical point of view, awareness and understanding of these barriers are the first steps toward finding ways to overcome them. Practitioners and policy-makers will be better equipped to formulate strategies and policies to counter the identified barriers. In the context of a developing economy, India, this paper investigates the key barriers to managing NBW sustainably.

3. Methodology

This study follows a four-stage framework for understanding barriers to the sustainable management of NBW (Bhatia et al., 2020; Si et al., 2018). First, seven barriers are identified based on a review of the literature and discussions with experts. Second, these barriers are validated by 36 experts in mountain tourism. Third, data regarding interrelations between these barriers are obtained from 11 experts, and the structure of the relationships between the barriers is characterized by a multicriteria decision-making (MCDM) technique, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) (Kandakoglu et al., 2019). Fourth, the cause-and-effect relationship between the barriers is depicted using a causal diagram. Finally, sensitivity analysis is conducted to check the robustness of the results. The framework to analyze barriers to the sustainable management of NBW is presented in Figure 1.

Figure 1
The four-stage framework to analyze barriers



3.1. Choice of DEMATEL

Decision-making in sustainability-related contexts is a complex exercise because the decision-maker must evaluate alternatives by simultaneously considering conflicting social, environmental, and economic criteria (Kandakoglu et al., 2019). As a result, MCDM has been widely used to structure problems and make decisions in sustainable development contexts (Kandakoglu et al., 2019). MCDM is a subdiscipline in operations research that helps evaluate multiple, usually conflicting, criteria ('barriers' in this study) for decision-making (Köksalan et al., 2011). DEMATEL is an MCDM technique used when these barriers are dependent on each other (Gölcük & Baykasoğlu 2016). For example, among the identified barriers (Section 2.2), there is a dependence between *tourists' awareness* and *local government initiatives* (Williams & Kelly, 2003). DEMATEL also provides the degrees of influence among barriers and differentiates barriers as cause or effect (Lin, 2013; Mangla et al., 2018). The origins of DEMATEL can be traced to the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 (Fontela & Gabus, 1972). DEMATEL was developed to generate insights from a focused set of experts with deep expertise in the phenomenon of interest.

The DEMATEL technique, with variations (classical, fuzzy, gray, etc.) to suit the unique nature of the problem, has been used in multiple topics within sustainability as follows:

- critical factors to adopt sustainability initiatives and environmental management in the automotive industry (Bhatia et al., 2020; Luthra et al., 2018)
- critical factors of corporate social responsibility in the textile industry (Li et al., 2020)
- critical factors of green business failure (Cui et al., 2019)

In this paper, the classical DEMATEL technique is used to understand/analyze the dependence among the multiple conflicting barriers to the sustainable management of NBW in mountain tourism. Classical DEMATEL is intuitive, i.e., practitioners can easily interpret this for strategic decision-making (Si et al., 2018). The procedure for classical DEMATEL is described below:

- Step 1: Calculate the direct relation matrix. Experts were requested to share interrelationships among barriers in the form of linguistic ratings. Linguistic ratings and their corresponding crisp values are shown in Table 2.
- Step 2: Calculate the final direct relation matrix using the responses of the eleven experts. All experts are given equal weights, and the average of their responses is calculated.
- Step 3: Calculate the total relation matrix T.
- Step 4: Calculate the sum of the row elements (R) and column elements (C) for the total relation matrix T. The prominence (R+C) and cause-effect (R-C) values are computed.
- Step 5: Finally, causal relationships among barriers are analyzed using the prominence and cause-effect values.

3.2. Identification of barriers

A three-step process was followed to identify and validate barriers. First, research articles indexed in Google Scholar were searched using the following keyword combinations: "waste management" + "mountain tourism", "waste management" + “himalaya”, and "waste management" + “alps”. Two prominent waste management journals (*Waste Management & Research, Waste Management*) were also searched using the following keywords: “mountain” and “himalaya”. Second, prominent journals and magazines related to mountains/ mountain tourism were referred to: the *Journal of Sustainable Tourism*; the *Himalayan Journal*; the *American Alpine Journal*; the *Alpine Journal*; *Mountain Research & Development*; and the *Journal of Mountain Science*. As a result of this screening process, seven distinct barriers were identified. In the third and final step, discussions were held with three experts from industry and academia to validate the relevance of the research question and the identified barriers (the interview protocol followed for these discussions can be found in Appendix A). One expert is a renowned Himalayan mountaineer, another is a tourist guide who was born and raised in the mountain region (i.e., a member of the local community), and still another is a scientist who works in Himalayan ecology and conservation. Individual discussions with each expert were conducted by phone or audio-conferencing technology. All experts found the research to be relevant and agreed upon the seven identified barriers. No new barriers were suggested by them. The list of seven barriers, their rationale, and literature references are presented in Table 1.

Table 1
Barriers to sustainable management of NBW

No.	Barriers	Rationale	References
1	Tourists' lack of environmental awareness	Tourists' lack of environmental awareness causes them to behave in ways that impact the environment negatively. If they appreciate the fragile ecosystem of mountains, they would do the following: (i) not litter across the trails and bring back self-generated waste after the tour, and (ii) reduce the quantity of nonbiodegradable items and use biodegradable packaging before the tour.	Bishop & Naumann (1998); Debnath et al. (2020); Hu et al. (2018); Kuniyal (2002, 2005a, 2005b); Kuniyal et al. (2003); McConnell (1991); Moddie (1995)
2	Tourists' motivation or achievement mentality	Tourists' achievement mentality—sense of "conquest"—causes them to disregard the fragile ecosystem of mountains.	Bishop & Naumann (1996); Kuniyal (2002); Moddie (1984, 1995)
3	Lack of transportation for waste transfer	There are no systematic transportation systems to transport waste items from mountains to the valleys/lowlands. There is a need for climbers, mountaineers, helicopters, and domestic animals to transport waste. This is due to the inherent nature of mountain terrain. Thus, although certain waste items have an economic value attached, it is not profitable to transport them due to high costs.	Bishop & Naumann (1996); Kuniyal (2005a, 2005b); Kuniyal et al. (2003); Lebersorger et al. (2011); Semernya et al. (2017)

Table 1 ***(continued)***

4	Waste collection infrastructure	The trails and man-made accommodation huts do not have waste bins where tourists can dispose of nonbiodegradable waste. Due to this reason, medical waste that needs safe treatment/disposal is often mixed with other wastes. Although setting up waste collection and recycling centers in mountains is a good idea, it is not viable due to three reasons: (i) lack of scale economies due to the seasonal nature of mountain tourism, (ii) lack of appropriate space owing to hilly topography, and (iii) lack of relevant labor.	Debnath et al. (2020); Geneletti & Dawa (2009); Kuniyal (2005a, 2005b); Kuniyal et al. (1998); Kuniyal & Jain (2001); Lebersorger et al. (2011); McConnell (1991)
5	Economic value of waste	Certain waste items do not have any economic value attached, i.e., there is no market for reuse or recycling. Such items are less likely to be collected and transported downstream to valleys/lowlands.	Bishop & Naumann (1996, 1998); Kuniyal (2005a, 2005b)
6	Local government initiative	Local village councils, government bodies, and communities need to coordinate to set up collection centers and mass awareness campaigns. Apart from lack of coordination, such initiatives are also hampered by a lack of funding to local governments.	Debnath et al. (2020); Kuniyal (2005a); Kuniyal et al. (1998); Kuniyal & Jain (2001); Semernya et al. (2017)
7	Enforcement of regulations	Existing regulations to manage waste in mountains are not enforced strongly. For example, regulations on banning plastics, directing tourism revenues to set up waste collection infrastructure, etc., are not enforced.	Kuniyal et al. (1998); Kuniyal & Jain (2001); Semernya et al. (2017)

3.3. Validation of barriers

Based on a comprehensive screening process and discussion with experts, a total of seven barriers were identified. Next, to validate the barriers, a questionnaire listing these barriers was prepared (refer to Appendix B). Respondents to the questionnaire were requested to rate the relevance of each barrier on a 5-point Likert scale (1: very less relevant; 5: extremely relevant). To ensure that any other important barriers were not missed, responding experts were also requested to add any other barrier that they believed to be important for the sustainable management of NBW.

For the validation of barriers, more than 70 experts were contacted through phone calls and emails during April-May 2020. Thirty-six experts shared their responses. These 36 experts are professionals working in mountain tourism i.e., guiding tourists and enthusiasts for trekking, expeditions, mountaineering, and so on. Some of the experts who participated in this study are luminaries in the field of mountain tourism. For example, two experts were recipients of one of the highest civilian awards in recognition of their distinguished contributions to mountaineering. The rationale was that these experts had participated in mountain tourism activities (such as trekking, expeditions, mountaineering), had observed the behavior of other tourists and local communities as part of their professional guidance, and could incorporate perspectives from this diverse mountain tourism experience. For example, one expert has more than 20 years of experience in mountain tourism, having extensively traveled in the Indian Himalayan region, climbed Mount Everest, and received one of the highest civilian awards from the government of India for mountaineering, and is now the founder of a mountain adventure tourism company. This expert is classified as "self-employed/entrepreneur". Another expert, with less than 5 years of experience, works for one of India's largest trekking companies managing trash control programs during mountain trekking. This expert is classified as "employed with an organization". Twenty-eight percent of these experts are employed with tourism organizations, whereas the rest are self-employed/entrepreneurs. The experts are classified based on their years of work experience in Table 2.

Table 2
Professionals classified based on their experience

Experience (in years)	Number of experts
Less than 5 years	13
5-10 years	7
10-15 years	5
15-20 years	1
More than 20 years	10

3.4. Applying DEMATEL

After the validation of barriers was complete, 20 experts (professionals in the tourism industry) were contacted to share interrelationships among these barriers. The questionnaire used to capture interrelationships among these barriers is included in Appendix C. The experts shared the interrelationships in the form of linguistic ratings. The linguistic ratings and their corresponding gray numbers and crisp values are shown in Table 3.

Table 3
Linguistic scale for expert's responses

Linguistic term	Values
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

Eleven experts shared their responses on the interrelationships among barriers. These experts have extensive experience in mountain tourism in India and are well-informed about the issues of the sustainable management of NBW. The profiles of these eleven experts are provided in Table 4.

Table 4
Profile of respondents

	Experience (in years)	Employed in a tourism organization/self-employed
Expert 1	10-15 years	Employed
Expert 2	More than 20 years	Self-employed
Expert 3	Less than 5 years	Employed
Expert 4	10-15 years	Self-employed
Expert 5	Less than 5 years	Self-employed
Expert 6	5-10 years	Self-employed
Expert 7	More than 20 years	Self-employed
Expert 8	More than 20 years	Employed
Expert 9	10-15 years	Self-employed
Expert 10	5-10 years	Employed
Expert 11	Less than 5 years	Employed

The initial direct relation matrix "D" provided by Expert 1 is presented in Table 5.

Table 5
Direct relation matrix given by Expert 1

	B1	B2	B3	B4	B5	B6	B7
B1: Tourists' lack of environmental awareness	0	VL	H	H	VL	VH	H
B2: Tourists' motivation or achievement mentality	L	0	H	H	H	VH	VH
B3: Lack of transportation for waste transfer	L	H	0	H	H	VH	VH
B4: Waste collection infrastructure	L	L	H	0	H	VH	VH
B5: Economic value of waste	H	H	H	H	0	H	L
B6: Local government initiative	H	H	H	H	H	0	VH
B7: Enforcement of regulations	H	H	H	VH	L	VH	0

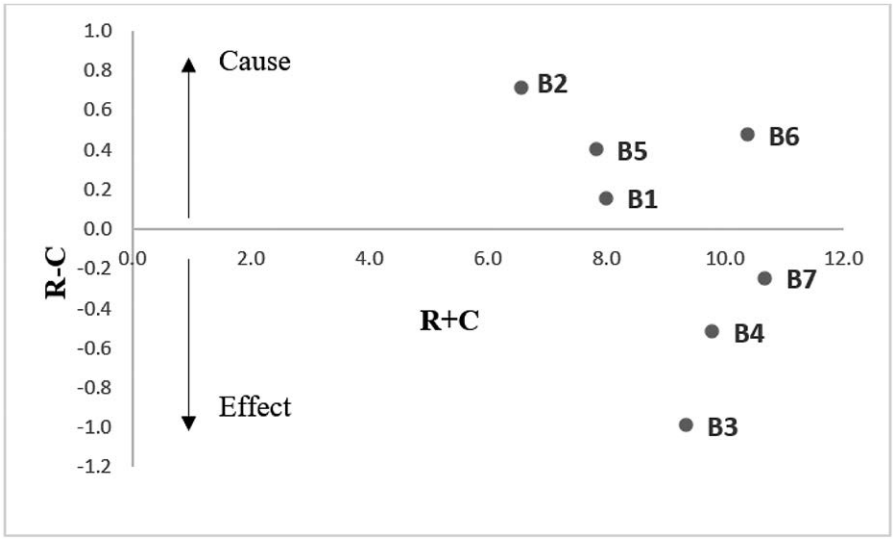
Note. L: Low, VL: Very low, H: High, VH: Very high.

The above Table 5 indicates that B1 has a very low (VL) influence on B2, B2 has a very high (VH) influence on B6, B3 has a low (L) influence on B1, and so on. The final direct relation matrix is calculated using the responses of all eleven experts. These eleven experts are given equal weights (i.e., their opinions were considered equal), and the average of their responses is calculated. The final direct relation matrix is produced in Table D1 (i.e., Table D1 in Appendix D). Next, the total relation matrix T is calculated as shown in Table D2.

Next, the sum of the row elements (R) and column elements (C) for the total relation matrix T is calculated. The total influence of a given barrier on other barriers is represented by R. The total influence of other barriers on a given barrier is represented by C. (R+C) represents the prominence of the barrier. A higher value of (R+C) means that both types of influence are high i.e., the barrier has a high influence on other barriers and is highly influenced by them. A lower value of (R+C) means that the two types of influence are low. (R-C) represents the net influence of the barrier. A positive value of (R-C) indicates the barrier to be a "cause", i.e., this barrier influences other barriers more than being influenced by them. A negative value of (R-C) indicates the barrier to be an "effect", i.e., this barrier is influenced more by other barriers than influencing them. The prominence (R+C) and cause/effect (R-C) values are computed and presented in Table D3.

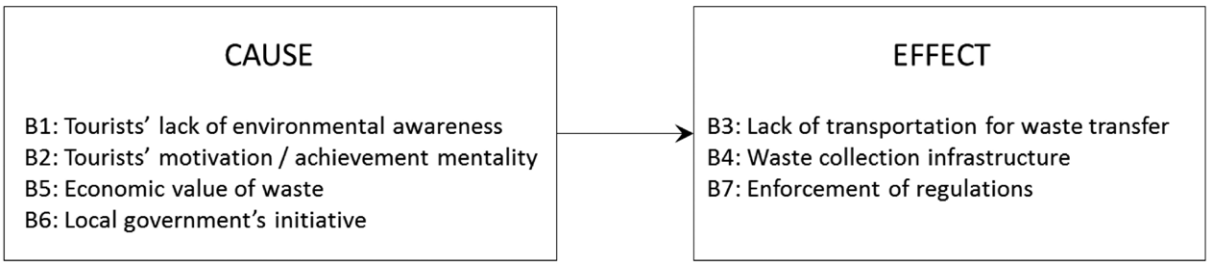
The analysis reveals the most prominent barriers as *enforcement of regulations*, followed by l*ocal government initiative*, *waste collection infrastructure*, and *lack of transportation for waste transfer*. Table D3 reveals the significant causal barriers as follows: *tourists' lack of environmental awareness, tourists' motivation or achievement mentality, economic value of waste*, and *local government initiative*. The significant effect barriers are as follows: *lack of transportation for waste transfer, waste collection infrastructure*, and *enforcement of regulations*. The cause-and-effect barriers are demonstrated in Figure 2. The causal relations among barriers are illustrated in Figure 3. Based on the sensitivity analysis conducted, it is concluded that these results are robust (refer to Appendix E for details)

Figure 2
Cause-and-effect diagram



Note. R+C: Prominence values; R-C: Cause/effect values; R-C: Positive (Cause); R-C: Negative (Effect).

Figure 3
Causal relation among barriers



4. Managerial and policy implications

In this research, two sets of results are derived.

First, the key barriers are prioritized based on the prominence score (R+C). The higher the (R+C) value, the more important a barrier is. The key barriers were ranked as follows: B7>B6>B4>B3>B1>B5>B2. The three most prominent barriers that need immediate attention are *enforcement of regulations, local government initiative*, and *waste collection infrastructure*.

(1) *Enforcement of regulations*: This is the most important barrier owing to the presence of weak institutions in a developing economy context (Acemoglu & Robinson, 2012). For example, Alfthan et al. (2016) noted the presence of illegal plastic waste dumping and burning practices in mountain regions, despite regulations against it. Stronger enforcement of such regulations from the government has the potential to reduce such waste crimes (Alfthan et al., 2016).

(2) *Local government initiative*: Next, it is important to understand the advantage of local governance. Local government initiatives could be one of the differentiating factors for the sustainable management of NBW. For example, Kuniyal (2005a) stressed the need to form solid waste management participatory groups in Pindari Valley (a trekking destination in the Himalayas). This involves bringing together local government (i.e., village councils), tourists, social activists, and the host community under an umbrella and putting systems in place for waste collection and segregation. One of the experts (a native of Meghalaya) also mentioned the community-driven waste management system in Mawlynnong. It is situated in the East Khasi Hills district of the Meghalaya state in Northeast India and is known as the cleanest village in Asia (A picture-perfect hamlet: Asia's cleanest village, Mawlynnong, 2016). Mawlynnong may be an extreme case due to the small homogenous community (Khasi tribes). However, from the perspective of waste management, the message is that a top-down centralized approach need not work in the case of mountain destinations and a local approach is the need of the hour.

(3) *Waste collection infrastructure*: The enforcement of regulations and local government initiatives cannot work without a proper infrastructure for waste collection. A lack of waste collection infrastructure (i.e., dustbins) leads to more waste. This follows from broken windows theory (Kelling & Coles, 1997; Kelling & Wilson, 1982), which says that unrepaired broken windows in a neighborhood (visible signs of small antisocial activity) create an environment that further encourages antisocial activities and serious crimes. In the context of waste management, waste that is not properly disposed of is analogous to broken windows.

Second, the identified barriers are classified as cause-and-effect barriers. The cause group barriers are B2, B6, B5, and B1 in decreasing order of influence. In essence, cause-and-effect analysis reveals a counterintuitive finding of managing NBW in mountain tourism. This finding is explained as follows:

(1) *Tourists' motivation or achievement mentality*: This achievement mentality is one of the major causes of overtourism. For example, the 2019 spring climbing season on Mount Everest reported that climbers "lined up on a ridge just below the peak, awaiting their chance to stand atop the world's highest mountain" (Minter, 2019). Many tourism economies (for example, Bhutan) have dealt with this achievement mentality by restricting the number of tourists and imposing a tax on them (Nepal & Nepal, 2019; Wallen, 2019).

(2) *Economic value of waste*: Attaching economic value to various types of NBW or creating markets for their reuse and recycling incentivizes waste collection. For example, the cash-for-trash program introduced by the Eco Everest Expedition was able to collect 13,500 kilograms of garbage from the Himalayas in less than 3 years (Sherpa, 2011). Such market-based initiatives can be scaled systematically to collect waste from mountains.

(3) *Tourists' lack of environmental awareness*: Tourists need to be made conscious of the environmental benefits of managing NBW so that they can help reduce NBW. Tourist management organizations can make tourists environmentally conscious through awareness campaigns using technologies such as virtual reality (Nelson et al., 2020). Insights from behavioral economics reveal that consumers (tourists) can be 'nudged' to make environmentally friendly consumption choices (Li et al., 2019; Sunstein & Reisch, 2014). For example, tourists had to forgo their initial deposit for not bringing back their waste (Mission to clean up the Himalayas, 2015).

A practical suggestion to address the achievement mentality and lack of environmental awareness is to mandate certification standards for tourists before they embark on mountain tourism. Certification helps to codify a set of standard practices for mountain-friendly tourism and filter out tourists who wish to 'conquer' the mountains. The certification can be designed with difficulty levels proportionate to the fragility of mountain destinations i.e., tourists who wish to trek the Himalayas would have to pass a higher difficulty level when compared to tourists who wish to trek Chikmagalur (a destination in South India). Certifications paid for by tourists can also serve as an income source to fund sustainability-related activities such as awareness campaigns. The Report of Working Group II–Sustainable Tourism in the Indian Himalayan Region released by the NITI Aayog (a policy think tank of the government of India, established to achieve sustainable development goals) highlighted the issue of solid waste management in mountain tourism (Gaur & Kotru, 2018). This report explains the activities of the "Waste Warriors Society", a localized community-led initiative that cleans up waste accumulated in the mountain areas of Dharamshala (a hillside city in the Indian state of Himachal Pradesh). Such initiatives placate tourists' achievement mentality through creative marketing, i.e., creating behavioral changes through persuasive sustainability communication. This research finds empirical support for this idea and justifies the need for scaling such initiatives across other locations. Based on this research, it is recommended that NITI Aayog initiate discussion on potential national policies that incentivize tourism organizations to placate tourists' achievement mentality through creative marketing.

5. Conclusions and future work

This research systematically lays out the barriers and their interrelationships and serves as a guide for policy-makers in mountain tourist destinations for planning waste management activities. An important finding is that the three prominent hard-to-change barriers unique to mountain tourism in an emerging economy context (i.e., enforcing regulations, waste collection, and transportation systems) can be mitigated by collectively leveraging four tangible barriers: tourists' achievement mentality, local initiatives, creating markets for waste, and spreading environmental awareness. A major reason for the lack of systematic waste collection and transportation systems is the unique topography of mountains. Wealthy mountain regions in developed economies (for example, the Alps) can afford to transport waste using helicopters (Alfthan et al., 2016). However, emerging economies would need to rely on humans or animals to transport waste.

This research is a response to calls made by tourism scholars to study the environmental impacts of mountain tourism (Nepal & Chipeniuk, 2005, Zhang et al., 2022). This research establishes *tourists' motivation or achievement mentality* as an important barrier. This relation between motivation (based on psychology) and waste management is new in the mountain tourism context. Motivation or achievement mentality can be considered an additional psychological driver in the "push and pull motivation theory" of tourists (Caber & Albayrak, 2016). The insights from this research contribute to building knowledge on the environmentally sustainable management of tourist destinations. Prior research has studied waste management in mountain tourism using qualitative case studies and descriptive statistics. This research serves as an exploratory quantitative study of significant factors associated with mountain tourism waste. This helps to develop an overarching theoretical framework that explains waste management in mountain tourism. Such a framework can help develop hypotheses and measures for large sample statistical studies.

This study has a few limitations. First, as noted by Luthra et al. (2018), barriers may have a temporal dimension, i.e., the relevance of barriers may change with respect to the external environment. Given the efforts by tourism stakeholders to achieve sustainable development goals by 2030, some barriers may become less or more significant. Second, the results of this study are applicable only for the sustainable management of NBW in mountains. Hence, one needs to be careful when interpreting the results in other contexts, and additional barriers may play a role. For example, during this study, an expert pointed out the presence of a free-ranging dog population in mountain tourist destinations that influences organic waste management (Bhatnagar, 2019).

There are potential avenues for future research. This research can be used as a stepping stone for studying barriers to biodegradable waste management, protecting biodiversity, and so on. The current study can be replicated by collecting data from experts in other emerging economies. This would help to compare the prominence and causal relations of barriers across countries. Further investigations that include government experts in charge of sustainable policies, stand-alone tourists, and local community members would bring in complementary perspectives that could enrich the understanding (Kala & Bagri, 2018). This research is based on classical DEMATEL. Future research could try to understand this phenomenon by considering uncertainty and vagueness in experts' responses. Different weights can be provided to capture varying knowledge and skill levels of experts. These can be done using variations of DEMATEL, such as gray, fuzzy, etc.

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Appendix A

Interview protocol

1. Introduce the authors/researchers and topic of study – solid waste management in mountain tourism, focussing on non-biodegradable waste.
2. Is it important to study this topic? Why?
3. What are the reasons (barriers) which makes it difficult to manage this waste?
4. Why?
5. What all could be done to manage this waste?
6. Based on what scholars have studied, we have prepared a list of reasons which makes it difficult to manage this waste.
   - What is your opinion on these reasons? Are these meaningful?
   - Are there more reasons which we have not captured? What are they?

Appendix B

Questionnaire to validate identified barriers

Solid waste (non-biodegradable) generated as part of mountain tourism (trekking, expedition, pilgrimage, sightseeing, etc.) is causing severe damage to the ecosystem. Potential ways to sustainably manage this waste is to reduce, reuse, and recycle. However, achieving this is easier said than done. This research is an endeavour to understand the barriers to sustainable management of solid waste.

In this context, we request you to kindly fill the questionnaire. This will take only around 7 minutes. Your response is important for this research. Your response will be kept confidential and utilized only for research purpose. We are grateful for your time and knowledge. In case, you need any clarification please feel free to mail us at abc@xyz.com

• Please indicate if you are associated with mountain tourism: ☐ Yes ☐ No

• You association with mountain tourism:
☐ Self-employed/Entrepreneur
☐ Employed with an organization (Can you please share the name of organization)

• Your experience in mountain tourism?
☐ Less than 5 years
☐ 5 - 10 years
☐ 10 -15 years
☐ 15 - 20 years
☐ More than 20 years

• How relevant are the following barriers for solid waste (non-biodegradable) management in mountain tourism? Description of the barriers is given below the Table B1.

Table B1

	Very less relevant	Less relevant	Relevant	Very relevant	Extremely relevant
Tourists' lack of environmental awareness					
Tourists' motivation or achievement mentality					
Lack of transportation for waste transfer					
Waste collection infrastructure					
Economic value of waste					
Local government's initiative					
Enforcement of regulations					

1. **Tourists' lack of environmental awareness:** Tourists' lack of environmental awareness causes them to behave in ways that impacts the environment negatively. If they appreciate the fragile ecosystem of mountains, they would do the following: (i) not litter across the trails and bring back self-generated waste after the tour (ii) reduce the quantity of non-biodegradable items and use biodegradable packaging before the tour.
2. **Tourists' motivation or achievement mentality:** Tourists' achievement mentality – sense of "conquest" – causes them to disregard the fragile ecosystem of mountains.
3. **Lack of transportation for waste transfer:** There are no systematic transportation systems to transport waste items from mountains to the valleys/lowlands. There is a need for climbers, mountaineers, helicopters, domestic animals to transport waste. This is due to the inherent nature of mountain terrain. Thus, though certain waste items have an economic value attached, it is not profitable to transport them due to high costs.
4. **Waste collection infrastructure:** The trails and man-made accommodation huts do not have waste bins where tourists can dispose non-biodegradable waste. Due to this reason, medical waste that needs safe treatment/disposal is often mixed with other wastes. Though setting up waste collection and recycling centers in mountains is a good idea, it is not viable due to two reasons: (i) lack of scale economies due to the seasonal nature of mountain tourism (ii) lack of appropriate space owing to hilly topography (iii) lack of relevant labour.
5. **Economic value of waste:** Certain waste items do not have any economic value attached i.e. there is no market for reuse or recycling. Such items are less likely to be collected and transported downstream to valleys/lowlands.
6. **Local government's initiative:** Local village councils, government bodies, and communities need to coordinate to setup collection centers and mass awareness campaigns. Apart from lack of coordination, such initiatives are also hampered by lack of funding to local governments.
7. **Enforcement of regulations:** Existing regulations to manage waste in mountains are not enforced strongly. For example, regulations on banning plastics, directing tourism revenues to set up waste collection infrastructure, etc. are not enforced.

- Any other barriers that should be added?_____
- Gender: ☐ M ☐ F
- Your name: _____
- Age: _____ years_____

Appendix C

Questionnaire to capture interrelations among barriers

Solid waste (non-biodegradable) generated as part of mountain tourism (trekking, expedition, pilgrimage, sightseeing, etc.) is causing severe damage to the ecosystem. Potential ways to sustainably manage this waste is to reduce, reuse, and recycle. However, achieving this is easier said than done. This research is an endeavour to understand the barriers to sustainable management of solid waste.

In this context, we request you to kindly fill the questionnaire. This will take only around 14 minutes. Your response is important for this research. Your response will be kept confidential and utilized only for research purpose. We are grateful for your time and knowledge. In case, you need any clarification please feel free to mail us at abc@xyz.com

Please fill the following information:

• Please indicate if you are associated with mountain tourism: ☐ Yes ☐ No

• You association with mountain tourism:
☐ Self-employed/Entrepreneur
☐ Employed with an organization (Can you please share the name of organization)

• Your experience in mountain tourism?
☐ Less than 5 years
☐ 5 - 10 years
☐ 10 -15 years
☐ 15 - 20 years
☐ More than 20 years

Following is the list of barriers for solid waste management in mountain tourism:

1. **Tourists' lack of environmental awareness:** Tourists' lack of environmental awareness causes them to behave in ways that impacts the environment negatively. If they appreciate the fragile ecosystem of mountains, they would do the following: (i) not litter across the trails and bring back self-generated waste after the tour (ii) reduce the quantity of non-biodegradable items and use biodegradable packaging before the tour.
2. **Tourists' motivation or achievement mentality:** Tourists' achievement mentality – sense of "conquest" – causes them to disregard the fragile ecosystem of mountains.
3. **Lack of transportation for waste transfer:** There are no systematic transportation systems to transport waste items from mountains to the valleys/lowlands. There is a need for climbers, mountaineers, helicopters, domestic animals to transport waste. This is due to the inherent nature of mountain terrain. Thus, though certain waste items have an economic value attached, it is not profitable to transport them due to high costs.
4. **Waste collection infrastructure:** The trails and man-made accommodation huts do not have waste bins where tourists can dispose non-biodegradable waste. Due to this reason, medical waste that needs safe treatment/disposal is often mixed with other wastes. Though setting up waste collection and recycling centers in mountains is a good idea, it is not viable due to two reasons: (i) lack of scale economies due to the seasonal nature of mountain tourism (ii) lack of appropriate space owing to hilly topography (iii) lack of relevant labour
5. **Economic value of waste:** Certain waste items do not have any economic value attached i.e. there is no market for reuse or recycling. Such items are less likely to be collected and transported downstream to valleys/lowlands.
6. **Local government's initiative:** Local village councils, government bodies, and communities need to coordinate to setup collection centers and mass awareness campaigns. Apart from lack of coordination, such initiatives are also hampered by lack of funding to local governments.
7. **Enforcement of regulations:** Existing regulations to manage waste in mountains are not enforced strongly. For example, regulations on banning plastics, directing tourism revenues to set up waste collection infrastructure, etc. are not enforced.

Indication of the degree to which each barrier affects or influences every other barrier.

An example:
Table C1

N	**no influence**
VL	**very low influence**
L	**low influence**
H	**high influence**
VH	**very high influence**

Table C2

		Column 1	Column 2	Column 3	Column 4
		B1	**B2**	**B3**	**B4**
Row 1	**B1**	-	VL	N	H
Row 2	**B2**	H	-	L	VH
Row 3	**B3**	VL	L	-	VL
Row 4	**B4**	L	VL	VH	-

In table C2, VL (first row, second column) indicates
B1 has very low influence on B2
Similarly, VH (second row, fourth column) indicates
B2 has very high influence on B4.

In the same fashion, in the context of mountain tourism, please fill the following table based on your experience:

Table C3

	B1	B2	B3	B4	B5	B6	B7
B1: Tourists' lack of environmental awareness	-						
B2: Tourists' motivation or achievement mentality		-					
B3: Lack of transportation for waste transfer			-				
B4: Waste collection infrastructure				-			
B5: Economic value of waste					-		
B6: Local government's initiative						-	
B7: Enforcement of regulations							-

- Gender: ☐ M ☐ F
- Your name: _____
- Age: _____ years_____

Appendix D

DEMATEL Analysis

Table D1
Normalized final direct relation matrix(X)

	B1	B2	B3	B4	B5	B6	B7
B1	0	.12	.09	.11	.09	.16	.16
B2	.13	0	.09	.09	.08	.12	.13
B3	.08	.08	0	.18	.11	.13	.17
B4	.07	.06	.19	0	.14	.18	.19
B5	.08	.05	.16	.17	0	.14	.13
B6	.16	.09	.19	.19	.13	0	.22
B7	.18	.11	.19	.19	.10	.18	0

Table D2
Total relation matrix(T)

	B1	B2	B3	B4	B5	B6	B7
B1	.43	.43	.65	.66	.49	.68	.74
B2	.50	.29	.59	.58	.43	.59	.65
B3	.51	.39	.59	.73	.52	.67	.76
B4	.56	.42	.81	.65	.59	.77	.85
B5	.51	.37	.72	.72	.41	.67	.72
B6	.71	.51	.92	.92	.66	.72	.98
B7	.69	.51	.89	.89	.61	.85	.77

Table D3
Prominence and net cause/effect values

	R	C	R+C	R-C	Cause/Effect
B1	4.08	3.92	7.99	0.16	Cause
B2	3.63	2.92	6.56	0.72	Cause
B3	4.18	5.17	9.34	-0.99	Effect
B4	4.64	5.15	9.79	-0.52	Effect
B5	4.11	3.71	7.82	0.40	Cause
B6	5.43	4.95	10.38	0.48	Cause
B7	5.21	5.46	10.68	-0.25	Effect

Appendix E

Sensitivity analysis

Sensitivity analysis helps analyze robustness in experts' judgments (Cui et al., 2019), and assesses variations in the cause-and-effect groups by assigning different weights to experts (Luthra et al., 2018). Sensitivity analysis is done to bring out any biases among the experts. The difference in opinion will be highlighted when the particular expert's response gets more weight. In the current study, one respondent is randomly assigned a weight of .2, and all other respondents are assigned an equal weight of .08 (the possibility of assigning weights different than the assigned weights cannot be ruled out). Thus, a total of 11 experiments are conducted. Weights assigned to each respondent across experiments are presented in Table E1.

The results of sensitivity analysis for all experiments are displayed in Table E2. Based on the prominence scores, it can be observed that B7, B4, B6, B3 are the most prominent barriers in all experiments. In agreement with the cause/effect scores, the causal factors are B2, B6, B5, and B1, whereas the effect barriers are B7, B4, and B3. Minor variation in the rankings is acceptable and do not pose any threat to the robustness of results (Cui et al., 2019; Luthra et al., 2018). As we do not observe a significant change in the results when different weights are given to each expert, we conclude that the results are robust. For example, the cause-and-effect for the first sensitivity analysis are shown in Figure E1, which is similar to the case when all the experts are assigned equal weights (Figure 2).

Table E1

Weights provided to experts in each experiment

Experiment	Ex1	Ex2	Ex3	Ex4	Ex5	Ex6	Ex7	Ex8	Ex9	Ex10	Ex11
Ex1	.2	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08
Ex2	.08	.2	.08	.08	.08	.08	.08	.08	.08	.08	.08
Ex3	.08	.08	.2	.08	.08	.08	.08	.08	.08	.08	.08
Ex4	.08	.08	.08	.2	.08	.08	.08	.08	.08	.08	.08
Ex5	.08	.08	.08	.08	.2	.08	.08	.08	.08	.08	.08
Ex6	.08	.08	.08	.08	.08	.2	.08	.08	.08	.08	.08
Ex7	.08	.08	.08	.08	.08	.08	.2	.08	.08	.08	.08
Ex8	.08	.08	.08	.08	.08	.08	.08	.2	.08	.08	.08
Ex9	.08	.08	.08	.08	.08	.08	.08	.08	.2	.08	.08
Ex10	.08	.08	.08	.08	.08	.08	.08	.08	.08	.2	.08
Ex11	.08	.08	.08	.08	.08	.08	.08	.08	.08	.08	.2

Table E2

Sensitivity analysis

	Equal Weights				Sensitivity Analysis 1				Sensitivity Analysis 2				Sensitivity Analysis 3			
Barriers	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank
B1	8.00	5	0.16	4	9.01	5	0.15	4	7.42	6	0.31	3	9.34	6	0.04	4
B2	6.56	7	0.71	1	7.78	7	0.84	1	6.37	7	0.66	1	7.84	7	0.79	1
B3	9.34	4	-0.99	7	10.55	4	-0.90	7	8.77	4	-1.04	7	10.77	4	-1.02	7
B4	9.79	3	-0.52	6	10.98	3	-0.53	6	9.58	3	-0.45	6	11.43	3	-0.53	6
B5	7.82	6	0.40	3	8.88	6	0.45	2	7.61	5	0.30	4	9.44	5	0.41	3
B6	10.38	2	0.48	2	11.71	2	0.31	3	9.95	2	0.51	2	11.75	2	0.55	2
B7	10.67	1	-0.25	5	11.94	1	-0.32	5	10.25	1	-0.29	5	12.10	1	-0.23	5
	Sensitivity Analysis 4				Sensitivity Analysis 5				Sensitivity Analysis 6				Sensitivity Analysis 7			
Barriers	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank
B1	8.10	5	0.26	4	8.61	5	0.15	4	9.36	6	0.40	2	7.50	5	0.14	4
B2	6.54	7	0.51	3	7.27	7	0.59	1	7.61	7	1.13	1	5.67	7	0.62	1
B3	9.25	4	-1.20	7	9.86	4	-0.90	7	11.40	4	-1.10	7	8.61	4	-0.90	7
B4	9.58	3	-0.40	6	10.10	3	-0.50	6	11.90	3	-0.60	6	9.15	3	-0.50	6
B5	7.44	6	0.62	1	8.25	6	0.52	2	9.83	5	0.25	3	6.76	6	0.36	3
B6	10.10	2	0.53	2	11.00	2	0.36	3	12.50	2	0.25	4	9.80	2	0.48	2
B7	10.30	1	-0.30	5	11.20	1	-0.30	5	12.90	1	-0.40	5	10.40	1	-0.20	5
	Sensitivity analysis 8				Sensitivity analysis 9				Sensitivity analysis 10				Sensitivity analysis 11			
Barriers	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank	R+C	Rank	R-C	Rank
B1	8.21	5	0.21	3	7.59	5	0.26	4	7.61	6	0.15	4	6.22	5	-0.20	5
B2	6.69	7	1.04	1	5.75	7	0.50	2	6.42	7	0.60	1	5.05	7	0.69	2
B3	9.83	4	-0.90	7	8.78	4	-1.00	7	8.86	4	-0.80	7	7.35	4	-1.10	7
B4	10.10	3	-0.60	6	9.25	3	-0.50	6	9.23	3	-0.40	6	7.62	3	-0.70	6
B5	7.77	6	0.18	4	7.58	6	0.48	3	7.65	5	0.33	3	5.91	6	0.49	3
B6	10.80	2	0.35	2	9.74	2	0.60	1	10.00	2	0.44	2	8.02	2	0.77	1
B7	11.10	1	-0.30	5	10.00	1	-0.30	5	10.30	1	-0.20	5	8.23	1	-0.10	4

Figure E1
Cause-and-effect diagram for sensitivity analysis 1