Sustainable Waste Management at Pashupatinath Temple: Challenges and Improvement Strategies

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Abstract:

Solid waste management (SWM) is a critical issue in urban areas, particularly in cultural and religious hubs like Kathmandu, Nepal. The Pashupatinath Temple, a UNESCO World Heritage Site, faces immense pressure due to millions of visitors, especially during festivals, leading to increased waste generation. This study aimed to identify the types and quantities of solid waste generated, assess existing waste management practices, and explore methods for improving sustainable waste management at Pashupatinath. Using purposive sampling, 100 respondents, including pilgrims, shop owners, and temple staff, were surveyed. Data collection involved structured surveys, Likert scale questionnaires, and stakeholder interviews. Quantitative data were analyzed using descriptive statistics, while qualitative data were thematically analyzed. The results showed that biodegradable waste accounts for 52.15% of the total, followed by non-biodegradable waste (31.19%) and recyclable materials (16.66%). Shop owners generated the highest amount of waste (1.03 kg/day), followed by Pujaris (0.32 kg/day) and pilgrims (0.11 kg/day). Municipal collection was the primary disposal method (60%), but open dumping (10%) and burning (10%) were still common. Satisfaction with waste bins and regular collection was moderate (mean scores of 3.2 and 3.0), while awareness programs scored low (mean 2.5), underscoring the need for better public education. The study concludes that improving waste segregation, enhancing composting and recycling, and increasing public awareness are essential for better waste management at Pashupatinath. Collaborative efforts among religious leaders, local authorities, and the community are crucial for implementing these sustainable practices.

Keywords: solid waste management, pashupatinath temple, biodegradable waste, public awareness, recycling

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Introduction

With rapid urbanization, population growth and increasing consumption patterns solid waste management (SWM) is one of the most pressing issues facing urban environment around the globe. In urban regions especially in regions with intricate cultural and religious significance, the struggle to oversee waste appropriately gets more intricate. The capital city of Nepal, Kathmandu is a classic example of how managing solid waste can be such a complicated proposition. The dual role of Kathmandu as an administrative as well as a cultural center present it with a daunting challenge of reconciling urban development with an efficient and effective system of waste disposal. Migration from rural areas and natural increase in resident population of the city has further compounded the waste problem, making development of an efficient SWM system essential for public health, environmental preservation and economic sustainability.

Pashupatinath Temple is one of the most important cultural and religious landmarks of Kathmandu, included in the list of UNESCO World Heritage Sites. This sacred Hindu temple is a place of pilgrimage and of course, tourism for millions of admirers around the globe. While the temple is overwhelmed with visitors — especially during festivals like Shivaratri and Makar Sankranti — its infrastructure, including its waste management system, is struggling to keep up. Therefore, the temple and surrounding area is also threateningly exposed to waste related problems like pollution and environmental degradation. But the temple's vocation as a community hub and also a place of worship makes waste management even more difficult, at least in part, because pilgrims and local businesses generate waste within the area in equal measure.

Previous research in Kathmandu has shown inefficiencies in solid waste management in that city, especially in culturally and religious areas. Recent works, including Dangi et al. (2011) and Maharjan et al. (2019) have indicated that the Kathmandu SWM system has not been able to keep up with the city’s fast urbanization and population growth. These studies have pointed out to some structural problems like incompetent waste collection facility, inadequate resources and manpower to handle the waste management properly. With the sheer volume of waste material generated by religious activities and the influx of tourism in the Pashupatinath area, these challenges are

further compounded and render a compelling need for making purposeful develop that deal with the one of a kind requests of this social significant locale.

These Pashupatinath area waste types are varying from biodegradable waste to non biodegradable waste which includes plastics and other synthetic materials. Religious festivals, when millons of visitors gather around the temple, create very large volume of waste which overwhelms the existing waste management infrastructure. Consequently, there is poor practices of waste disposal, such as open dumping and incineration which causes environmental degradation and infringe into people public health. These peak periods untreated waste disrupts the local ecosystem, contaminants water bodies and potentially threatens culture of the site (Kunwar et al., 2021; Vaidya, 2017). Furthermore the problem is compounded by the lack of public awareness about the waste segregation and recycling, many visitors as well as local businesses are unaware of how to dispose of waste properly.

Although many studies have looked at the more general South West Street SWM problems in Kathmandu, very little research has focused specifically on the Pashupatinath area. The lack of such studies in this region, and the gap in our current knowledge about the role of socio-cultural and environmental factors in both waste generation and management in this region, adds urgency to a broader research on the subject. In the line with Durán-Díaz et al., (2023) and Nyaupane,(2019), the sources and types of the waste and the existing management policies and strategies in place for the waste in the Pashupatinath area need to have a deep understanding regarding developing effective strategies to mitigate the growing waste problem in the Pashupatinath area.

A lack of a comprehensive dataset about the types, quantities, and sources of the solid waste being generated is one of the important issues of the Pashupatinath region. Formulating better strategies to manage waste without accurate data is really hard. In addition to increased pressure from growth in population and changing consumption patterns, the growing volume of waste it generated has led to considerable increase in volume of waste generated and the existing waste management infrastructure (Khadka et al., 2021). Add to this inadequate infrastructure — namely, lack of waste collection points, transportation systems, and processing facilities — which make the situation that much more challenging. Open dumping and burning of the waste are also unsound

practices making waste disposal environment pollution prone and health hazard prone to the residents and visitors.

These socio-economic system makes manifestations in the waste management challenges, paid prominent by lack of interest from policymakers to incorporate informal collectors of waste and recyclers into the formal socio-economic system. Basically, these financially vulnerable groups are disproportionately associated with apprehension of waste management practices, since they are often exposed to hazardous materials without protective measures (Maharjan et al., 2019). Additionally, waste management is bad, which then impacts the tourism because a dirty environment will scare off visitors and admittedly damage the reputation of the temple as holy and clean.

As one of the most significant religious and cultural landmarks and tourism engine of Kathmandu Valley, waste management of the Pashupatinath Temple area is extremely dire due to the urgency for a holistic approach. A proper tactic to this would be to build the modern waste management infrastructure with corresponding waste minimization, recycling, and public awareness strategies. Before developing or implementing effective waste management strategies that address the temple's environmental and public health protection as well as cultural and spiritual integrity of the temple, local authorities, religious leaders and community must work together.

To fill in the gaps in existing knowledge about solid waste management at the Pashupatinath Temple premises, this research aims to evaluate the existing waste generation patterns, management policies and practices, and possible solutions for responsible waste management. The study seeks valuable insights on how waste is generated, handled and perceived by waste actors (visitors, temple staff, local businesses and municipal authorities) within this specific area. Additionally, this research will explore possible methods for improving waste management practices in the Pashupatinath area, with the goal of creating a more sustainable and effective system that can serve as a model for other cultural and religious sites in Nepal and beyond.

The primary objectives of this study are to identify the types and quantities of solid waste generated in the Pashupatinath area, document the existing waste management

practices, and explore potential methods for improving these practices in a sustainable manner. Specifically, the research will seek to answer the following questions: (1) What types of solid waste are generated in the Pashupatinath area, and what are their potential sources and volumes? (2) What are the existing waste management practices in the Pashupatinath area? (3) What methods can be employed to improve solid waste management in the Pashupatinath area?

The findings from this research are expected to have significant implications for both local and national waste management strategies. By providing a detailed analysis of the waste generation and disposal processes at one of Nepal's most important cultural and religious sites, this study will contribute to the development of more effective waste management systems that prioritize sustainability, public health, and the preservation of cultural heritage. Moreover, this research will serve as a foundational study for future efforts to improve solid waste management practices at other religious and cultural heritage sites, both in Nepal and in other countries facing similar challenges.

Methodology

Study Area

Pashupatinath Temple, Kathmandu Valley in Nepal which is the study area is one of the famous temples in all over Hinduism - and, for that matter, the rest of Asia). The temple experiences a heavy influx of devotees and the volume of solid waste generated in its precincts increases manifold during religious festivals. The selection of Pashupatinath as a study area is attributed to the importance of this pilgrimage site both in terms as cultural and religious considerations that identifies it very seriously for penalties related waste management. With the high flow of visitors, especially around festivals keeping away all kinds of garbage out is an issue that needs to be solved. Further, it requires immediate and effective waste management interventions considering the mounting pressure on temple precincts due to solid wastes. Purposive sampling technique will be used in selecting a sample for this study, and there were going to get 100 respondents. This range will encompass both visitors, as well Pujaris (priests), and temple management committee members to provide a broad view of the waste dumping dynamics in that area.

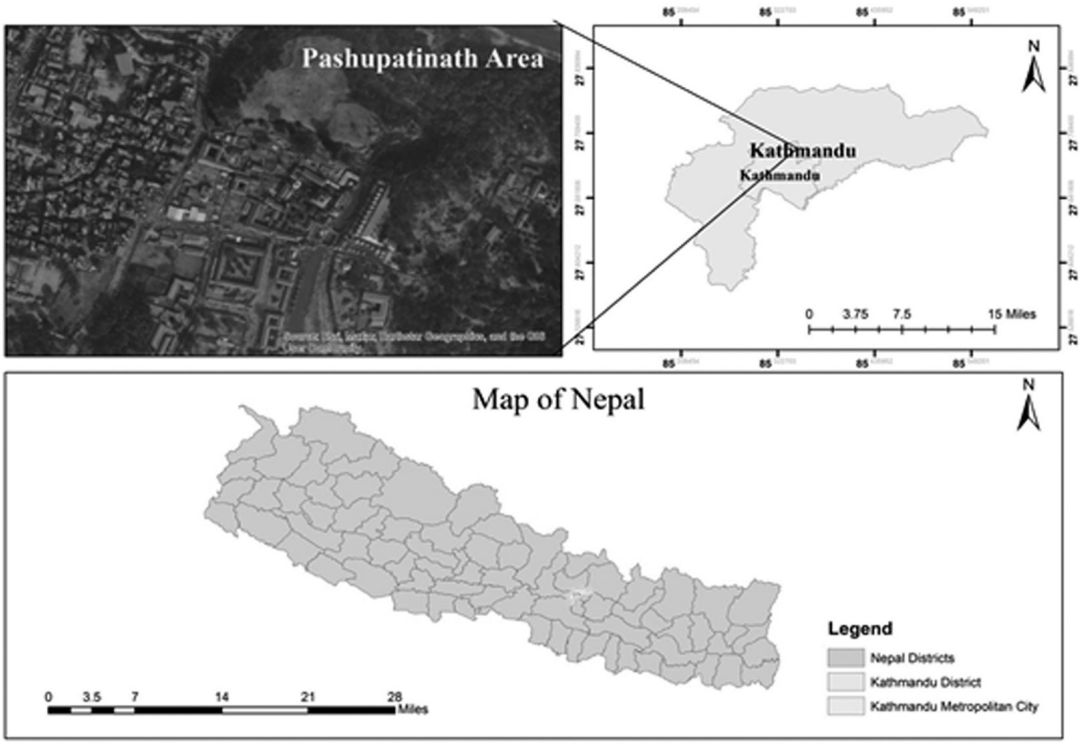

Figure: Study area showing Pashupatinath

Data Collection

Sampling Method

Purposive sampling was employed to select representative religious visitors from various clusters within the study area. The sample comprised 100 respondents, including religious visitors, Pujaris, and members of the management committee. Specifically, the sample included 69 Pilgrim, 10 Pujaris, and 21 shop owners. This method was chosen to ensure that the sample accurately represented the different stakeholders involved in or affected by waste management practices in the Pashupatinath area.

Methods of Data Collection

Primary Source:

Surveys: Data collected through structured surveys administered to visitors. These surveys captured information on waste generation rates, disposal methods, and the

socio-demographic characteristics of the respondents. The surveys included questions designed to quantify the amount and types of waste generated, as well as the methods used for waste disposal.

Likert Scale Questionnaires: To gain insights into the attitudes and perceptions of respondents towards sustainable waste management, a Likert scale questionnaire was used. This questionnaire assessed the respondents' views on the effectiveness of current waste management practices and their willingness to adopt more sustainable methods.

Stakeholder Engagement:

Engaging with local authorities, community leaders, and environmental groups was crucial for gathering comprehensive insights and fostering collaborative waste management solutions. Key informant interviews and focused group discussions were conducted to gather qualitative data and understand the perspectives of various stakeholders involved in waste management efforts. These interactions provided valuable context and help identify potential barriers and facilitators to effective waste management.

Secondary Sources:

Relevant information from various government documents, NGO/INGO reports, and research papers was reviewed to gain an in-depth understanding of the current waste management situation in the Pashupatinath area. These secondary sources provided background information and help triangulate the data collected from primary sources.

3.4 Data Analysis

Quantitative Data Analysis

The quantitative data collected through surveys and waste audits will be analyzed using descriptive statistics such as means, frequencies, and percentages. This analysis was summarized waste generation patterns related to waste disposal. Data was stored and cleaned in Excel, ensuring accuracy and consistency. Statistical analysis was conducted using R Studio to perform more detailed analysis and inferential statistics.

Qualitative Data Analysis

The qualitative data gathered from key informant interviews and focused group discussions was analyzed. This method involves identifying, analyzing, and reporting patterns (themes) within the data.

Results

The demographic information from the study at the Pashupatinath Temple premises indicates a diverse sample population, predominantly falling in the 31-45 age group (43%), followed by those aged 18-30 (29%), 46-60 (20%), and 61-65 (8%). The gender distribution shows a higher representation of males (63%) compared to females (37%). Occupationally, pilgrims form the largest group (69%), with shop owners (21%) and temple staff (10%) also represented. In terms of education, most respondents have completed secondary (33%) or higher secondary (27%) education, with smaller proportions having primary (9%), undergraduate (20%), and postgraduate (11%) qualifications. This diverse demographic composition suggests that middle-aged individuals, primarily males, who are either pilgrims, shop owners, or temple staff, predominantly visit the temple. The educational background indicates a significant portion of visitors are well-educated, potentially aiding in the promotion of effective waste management practices. Understanding these demographic details is crucial for developing targeted waste management strategies that cater to the specific needs and behaviors of different segments, ultimately contributing to the sustainable management of waste at the Pashupatinath Temple.

Table

Demographic Information

Variable	Categories	Frequency	Percentage
Age	18-30	29	29%
	31-45	43	43%
	46-60	20	20%

	61-65	8	8%
Gender	Male	63	63%
	Female	37	37%
Occupation	Shop Owner	21	21%
	Pilgrim	69	69%
	Pujari	10	10%
Education Level	Primary	9	9%
	Secondary	33	33%
	Higher Secondary	27	27%
	Undergraduate	20	20%
	Postgraduate	11	11%

On average, visitors generate 0.11 kg of waste per day with a standard deviation of 0.02 kg, Pujaris generate 0.32 kg with a standard deviation of 0.09 kg, and shop owners generate the most at 1.03 kg with a standard deviation of 0.2 kg. The types of waste generated are predominantly biodegradable (52.15%), followed by non-biodegradable (31.19%) and recyclable waste (16.66%). The disposal methods show that municipal collection is the most common practice (60%), followed by recycling (10%), composting (10%), burning (10%), and open dumping (10%). The higher waste generation by shop owners highlights the need for targeted waste management strategies in commercial areas, while the prevalence of biodegradable waste suggests potential benefits from composting initiatives. The significant reliance on municipal collection underscores the importance of improving municipal waste management infrastructure to handle the diverse waste types effectively.

Table

Waste generation and Segregation

Variable	Categories	Average waste produce per day/ visitor	Standard Deviation
Daily Waste Generation	Visitor	0.11kg	0.02 kg
	Pujari	0.32 kg	0.09kg
	Shop owner	1.03 kg	0.2 kg
Types of Waste	Biodegradable	52.15%	5%
	Non-biodegradable	31.19%	5%
	Recyclable	16.66%	3%
Disposal Methods	Open dumping	10.50%	7%
	Municipal collection	60%	6%
	Recycling	9.50%	5%
	Composting	10%	4%
	Burning	10%	4%

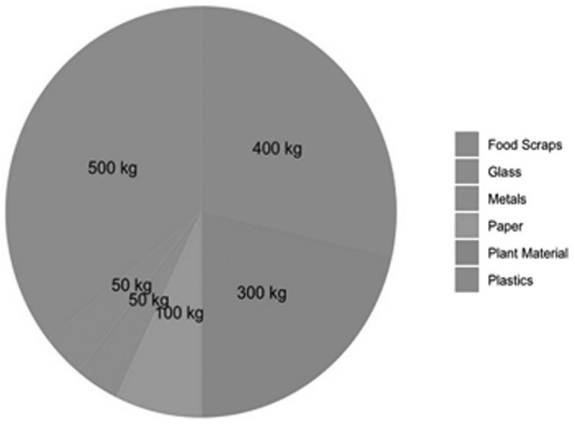

Figure 2 : Average waste generation

The average daily waste generation by different waste types, revealing significant insights into waste composition (Fig.2). Biodegradable waste, including food scraps and plant material, accounts for a large portion of the waste, with 500 kg and 300 kg respectively.This indicates a substantial presence of organic waste that could be effectively managed through composting programs. Non-biodegradable plastics, contributing 400 kg daily, represent a major environmental concern due to their persistence in the environment, emphasizing the need for robust recycling initiatives. Recyclable materials, including paper (100 kg), glass (50 kg), and metals (50 kg), although generated in smaller quantities, present high recycling potential. Enhancing recycling programs for these materials can significantly reduce waste sent to landfills and recover valuable resources.

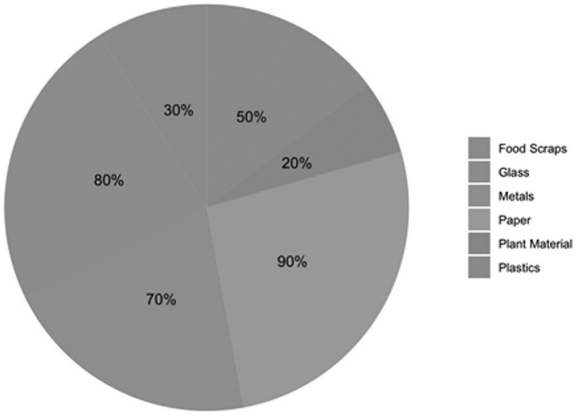

Figure 3 : Potential of recyclable waste

The recycling potential of various waste types, which is crucial for formulating effective waste management strategies (Fig.3). Biodegradable waste, specifically food scraps and plant material, has a recycling potential of 30% and 20% respectively. These percentages highlight the need to improve composting processes to better utilize organic waste. Non-biodegradable plastics, with a recycling potential of 50%, represent a significant opportunity for reducing landfill waste through enhanced recycling initiatives. Recyclable materials show the highest recycling potential: paper at 90%, glass at 80%, and metals at 70% .

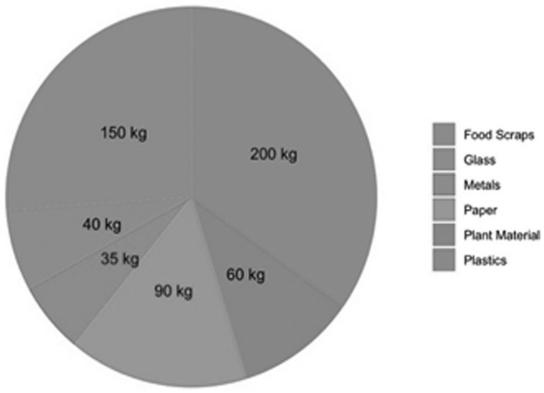

Figure 4 : Potential amount of waste

There is the potential amount of waste that can be recycled daily for each waste type, emphasizing significant opportunities for improving waste management practices (Fig.4). Biodegradable food scraps and plant material, with potential recycled amounts of 150 kg and 60 kg per day respectively, underscore the importance of implementing effective composting practices to convert organic waste into useful compost. Non-biodegradable plastics, with the highest potential recycled waste of 200 kg per day, illustrate the critical need for robust plastic recycling programs to mitigate environmental pollution. Recyclable materials, such as paper, glass, and metals, show significant recycling potential, with 90 kg, 40 kg, and 35 kg per day respectively.

Likert Scale Responses

The adequacy of waste bins received a mean score of 3.2 with a standard deviation of 0.8, indicating a moderate level of satisfaction. Regular waste collection scored slightly lower with a mean of 3.0 and a standard deviation of 0.9, suggesting room for improvement. The cleanliness of the temple premises was rated lower, with a mean of 2.8 and a standard deviation of 1.0, highlighting concerns about the current state of hygiene.

Awareness programs on waste management had an even lower mean score of 2.5 with a standard deviation of 1.1, pointing to a significant need for enhanced educational efforts. On a positive note, respondents showed a strong willingness to segregate waste, with a high mean score of 4.0 and a standard deviation of 0.7. Support for recycling initiatives was also favorable, with a mean of 3.8 and a standard deviation of 0.8 Participation in cleanliness drives received a mean score of 3.6 with a standard deviation of 0.9, indicating a reasonably good level of engagement.

The perception of environmental impact scored a mean of 3.5 with a standard deviation of 0.8, reflecting a general awareness of the environmental consequences of waste. However, satisfaction with current waste management efforts was relatively low, with a mean score of 2.9 and a standard deviation of 1.0, underscoring the need for significant improvements in waste management practices at the temple premises.

Table

Likert Scale Responses

Likert Scale Responses

Question	Mean	Standard Deviation
Adequate waste bins	3.2	0.8
Regular waste collection	3	0.9
Cleanliness of the temple premises	2.8	1
Awareness programs on waste management	2.5	1.1
Willing to segregate waste	4	0.7
Support for recycling initiatives	3.8	0.8
Participation in cleanliness drives	3.6	0.9
Perception of environmental impact	3.5	0.8
Satisfaction with current waste management efforts	2.9	1

Stakeholder engagement :

It was found that several informants felt more bins were needed and pointed out areas in which bins could be placed to help manage waste . This problem is widespread, and it becomes urgent to provide a solid framework to manage waste after hundreds of thousands of pilgrims visit daily.

The second major theme drawn from the interviews is that, regular maintenance is a must. There is a regular cleaning schedule on the temple, dumping of daily waste into specially marked areas being among them. But there was a consensus among all respondents on the critical significance of prompt collection of solid and liquid waste to prevent avert overflow within or around the premises to help ensure glossier environment. The maintenance focus suggests that supplementary systems are difficult to operate and more effective waste collection arrangements may be possible, albeit with higher associated costs.

As an fundamental component for sustainable waste management in the future, public awareness and education programs were also stressed. One informant mentioned that it is also really important to educate the visitors, as well as the shop owners and the local vendors about proper waste disposal methods. When well designed awareness campaigns generate improvements in waste segregation and disposal behaviors, the overall waste management strength is enhanced. This underlies the critical role of societal education in getting effective waste practices through awareness and knowledge improvement through permanent, targeted educational activities.

Another critical factor of the theme was collaboration. To manage waste effectively, these stakeholders need to join hands: religious leaders, local government or even community organizations. Collaborative approach can improve the waste management process using the cons of one group and the resources from another. Finally, the interviews revealed common barriers that prevent effective waste management.

The waste accumulation was one major concern but that would bring about health and hygiene risks. It was found that allowing unmanaged waste to spread would attract pests, and in doing so spread infections, and were considered a huge health hazard to

visitors. This shows that there is a need of a timely and efficient waste management role to curb the waste which has health related issues. Another concern was visual pollution because the waste takes away from the spiritual sanctity of the area. Waste pollutes the spiritual experience of visitors, taking away from pleasure of the area and could deter future visits. To solve these concerns and keep the temple places sacred, there are need of sustainable and culturally acceptable waste strategy management.

Discussion

Biodegradable waste takes up a large share of generated waste followed by non biodegradable and recyclable waste generated in Pashupatinath Temple premises. Commercial activities of shop owners in all heritage sites are the largest contributors, similar to other heritage sites including Makkah during Hajj pilgrimage where waste generation rises when there is a large influx of visitors like this. Simultaneously, the high percentage of biodegradable waste suggests a strong potential for composting initiatives that can compensate a large share for the need of the conventional disposal methods. Other religious and cultural locations have documented similar waste generation patterns of Hoornweg and Bhada-Tata (2012).

Municipal collection, open dumping, and recycle are all used in current waste management practices but do so extensively. This reliance is with a centralised setting but open dumping is used, the same is seen in other settings in urban developing countries (Hoornweg & Bhada-Tata, 2012). The challenges confronted are similar to the problems in other urbanising areas where resource limitations exist in comprehensive waste management (Kuniyal & Jain, 2000).

Through interview and focus group of stakeholders in Pashupatinath, they identified various barrier to effective waste management including lack of waste bins, irregular collection schedules and little public awareness. As it turns out, these findings match known problems with cultural heritage sites: a lack of awareness, and poor infrastructure, in other studies including the Valley of Flowers in India. To do this you must have effort in other fields, for instance widening the infrastructure, improving waste collection or with a full information of public to what they should do with their waste.

The Likert scale responses give the idea on how respondents have viewed or interpreted the waste management at the Pashupatinath Temple premises. Moderately adequacy of waste bins and regular waste collecting was recorded. The cleanliness of the temple premises got a lower score for its matters of hygiene, despite the fact that the place is very dirty. The score for awareness programs on waste management reflected a strong need for a better educational work as well.

Interestingly, Respondents showed high mean score for these two aspects, such as willingness of segregating waste and supporting recycling initiatives. The attitude of these positive is a possible indicator of the implementation of the waste segregation and recycling program successfully if the infrastructure and educational campaigns are a sufficient augmentation. Engagement has also been reasonably good in participation in cleanliness drives, signifying community willingness to participate in waste management activities. Results found in these attitudes agree with other studies' findings such as by Sinha (2019) in Vanarashi, India, state that successful waste management requires public participation and awareness.

Using these findings, recommendations were made to achieve a more sustainable waste management at the Pashupatinath Temple premises. First off, you can reduce littering and increase waste collection efficiency by increasing the number of waste bins and carefully inventing placement for them. A proper collection of solid waste and preventing overflow and waste pollution is essential to saving time and effort. These recommendations are compatible with Byers et al. (2020) recommendations for waste management in ecologically sensitive places of Sagarmatha National Park.

The education and awareness of the waste management among the public is important in order to instill the habit of responsible waste disposal behaviors. They can facilitate the improvements in waste segregation and disposal practices which occur with well designed awareness campaigns. Essential to the development of and implementation of effective waste management strategies are collaboration from stakeholders including religious leaders and local government organizations with community organizations. The way that can be taken to reduce waste is to use the strengths of different groups to achieve the goal of waste management in a common way. Our findings, consistent

with other studies (e.g. Khatib et al., 2008) that focus on the relation between socio-economic and cultural factors and the practices of waste management.

Identified from this study was the high potential for resource recovery which can be capitalized through composting and recycling initiatives. Increasing composting programs for the biodegradable waste and a stronger recycling systems for non biodegradable and recyclable waste leads to reduce the environmental impact of waste disposal and it is sustainable. Partnership with waste management companies and benefits of technologies like waste to the energy technologies can further increase the efficiency and sustainability in waste management practice. These strategies are in according with the global trends in waste management mentioned by Kothari et al. (2017) as well as the World Bank (2018) regarding waste to energy and recycling as the major components of waste management.

Conclusion and Recommendations

This study on solid waste management (SWM) at Pashupatinath temple suggests which kinds of waste are being generated and what are the existing waste management practices. Most of that waste is produced biodegradable, followed by nonbiodegradable waste and recyclable waste, with shop owners identified to be the largest waste producers. The practice of existing waste management consists mostly of municipal collection but open dumdging and informal recycling continue to be very prevalent. This is centralized, but not enough, poor infrastructure system to deal with what is in here. Moreover, there is a lot of feedback from the stakeholder on blatant issues such as irregular waste collection and lack of public awareness about the right way of waste disposal. While these shortcomings exist, there is a strong willingness among stakeholders to adopt better practice, for example, waste segregation, recycling.

Taking into consideration the findings, we argued that improving waste management at Pashupatinath is also critical. If you tackle infrastructure gaps immediately you just make a few simple improvements like increasing the amount of strategically placed bins and create a more regular waste collection timetable. In addition to this, stakeholders also need to inform public about the need of proper waste segregation and disposal. It should be noted for shop owners and visitos. For such practices and to maximise the

motivation of stakeholders to do their part in clearing the air, such collaboration among religious leaders, local government and the community is imperative.

This study's findings indicate the need for a wholesome approach to, i.e., infrastructure improvements, on the one hand, and community engagement, on the other. Waste reduction steps include growing trash bins, promoting circulation and reuse, and holding instructive crusades. However, you can also gain financial support and leverage waste to energy technologies to help clean up waste and make your sustainability efforts easier. Regular analyses and stakeholder feedback (and continuously improving) will also be monitored regularly (and continuously improving) toward preservation of the cultural and environmental integrity of the Pashupatinath Temple.

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