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Evaluating Environmental and Economic Impacts of Alternative Waste Management Scenarios in Kathmandu: From Landfill-Centric to Recycling & Composting

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ABSTRACT

This essay gives a comparison of environmental and economic benefits of three alternative solid waste management systems namely as landfilling, recycling and compost system in Kathmandu Valley where urbanization has been outpacing the source segregation, and subsequent increase in landfill overflow and municipal burdens. The quantitative research design was used to collect data presented in a structured questionnaire given to 200-300 households chosen by use of stratified random sampling in wards, income groups, and type of settlement. The survey recorded the household waste production trends, waste management behaviour, groupings on willingness to sort and participate in the groups as well as how they felt in relation to the environment and the economy. The SPSS was used in analyzing data through descriptive statistics and correlation analysis. The findings imply that there are low recycling behavior and moderate readiness to compost that is highly affected by the presence of organic materials in the municipal stream of waste. Every perception finding indicates that the general awareness of landfill-related pollution is high, and people are strongly driven in favor of environmentally preferable methods, which are composting and recycling. The correlation analysis, again, supports the fact that the degree of environmental awareness is a statistically significant predictor of the household readiness to use alternative waste management system. Altogether, the research determines landfilling as the least sustainable process and composting backed up with recycling becomes the most sustainable and economical way of Kathmandu Valley. The results offer evidence-driven information to the policy makers and town planners to formulate more resilient and sustainable municipal waste management policies.

KEYWORDS
Composting, Environmental and Economic Impacts, Landfill-Centric Systems, Solid Waste Management, Recycling

INTRODUCTION

The rapid urbanization, shifting consumption trends, and the growth of service economy make Kathmandu Valley yield one of the bulks of municipal solid waste in Nepal (Khadka et al., 2020). Though the current policy has been supporting sustainable waste management, it still happens so that through the current system the majority of the collected waste was transported to either Sisdol or a new location at Banchare Danda. This strategy has caused frequent overflows in landfills, interpersonal disputes, pollution of the environment and increased city expenses (Gurung & Oh, 2012). It has been documented that more than 60% of all municipal wastes in Kathmandu are organic, and the remainder of recyclable materials including plastic waste, paper waste and metal waste are also a substantial proportion of it, meaning that Kathmandu has a great opportunity to divert its landfills by composting and recycling (Awasthi et al., 2023). Nevertheless, the low level of segregation of sources, poor institutional capacity, and inadequate

infrastructure become an obstacle to the shift towards the sustainable waste management routes (Kandel et al., 2023).

Global cities are moving towards abandoning disposal-based models and adopting the cyclical models of recycling, composting, and recovery of energy (Singh et al., 2014). The latest life-cycle analyses indicate that the result of integrated waste management is better emissions of greenhouse gases, enhanced recovering of resources and diminished economic costs in the long term (Pathak & Mainali, 2018). Considering the situation in Kathmandu, where the capacity of landfills is often overstretched, and the effects on the environment are growing, it is timely, and it is rather urgent to assess the alternative waste management scenarios (Silwal, 2019). This paper was juxtaposing three approaches to disposal, as landfill-only, recycling, and composting-plus-landfill, to determine the most credible pathway to be followed by Kathmandu (Giri, 2021).

Theoretically, the paper is orchestrated with concepts informed by the Circular Economy paradigm, which focuses on a minimization of waste, material recycling, and reuse of resources, and the ideas of Zero Waste, that focuses on reducing the landfill reliance with composting and recycling. Furthermore, lessons of the Social Practice Theory can be traced implicitly in the household-based focus, rites, and views that determine waste management practices. Although the standard method of quantifying the environmental and economic effects is usually implemented with the help of such sophisticated tools like Life Cycle Assessment (LCA), material flow analysis or cost-benefit analysis, the current study is based on the approach, which is quantitative, and is focused on behavioral preparedness and acceptance of a group of people. In this paper, therefore, the words environmental and economic impacts are used in reference to perceived impacts as indicated by households and not necessarily measured indicators of greenhouse gas emission, energy saved, and municipal cost saved. Such appearance-based evaluation presents a valuable initial level of factor to guide subsequent research which can encompass secondary information and engineering impact modelling.

METHODOLOGY

The research design has been a quantitative design that has relied on an objective of establishing environmental and economic effects of the three alternative solid waste management in the Kathmandu Valley comprising of landfilling, recycling and composting. In order to gather the quantitative data regarding the pattern of the house hold waste production, the current practice of waste disposal, the willingness to segregate waste products, data related to recycling and composting and the attitude towards economic and environmental value, a structured questionnaire is initiated. The questions have also included closed ended as well as Likert questions that have measured both attitudes as well as behavior whereby the system that is already in place that is based on landfills is to be replaced by recycling and composting based systems. The stratified random sampling method has been used to permit the representation of sample on different wards, income, and type of settlement resulting in a sample of 200-300 respondents who are able to provide sustainable statistical comparisons. The questionnaires will be distributed online and offline to make sure that the various population groups have varied access to digital mediums. Data collection process has taken place within 4 weeks and data cleansed, coded and analyzed in SPSS. The patterns have been summarized with the help of descriptive statistics of waste practices and perceptions and correlation analysis has been applied to investigate the association between such variables as willingness to perform recycling or composting and perceived environmental or economic benefits. Generally speaking, the quantitative analysis has introduced evidence-based views of the potential impact of Kathmandu

transformation into a landfill that implements recyclable and compostable solutions, as an alternative, and allows designing more sustainable waste management models. In stratified random sampling, the household was initially stratified on the basis of the ward, income category, and the settlement type of the homes and the proportional number of respondents that yielded an approximate final sample of 250 households were randomly selected in each of the strata to bring balance and statistical reliability of comparison.

The three waste management scenarios considered were represented as behavioural-perception-based scenarios instead of engineering-based or complete optimized system models. The situation model was informed by available secondary data regarding waste composition and waste management in Kathmandu Valley, specifically, the reported prevalence of organic waste and the low degree of source segregation identified in the prior literature. But the actual situations were modeled using household perceptions, awareness rates, and reported behavioral preparation, which is measured using the structured questionnaire, and not databases of life cycle assessment or cost-benefit simulations. In line with this, landfilling is the current base system introduced and still implemented in Kathmandu, whereas recycling and composting scenarios indicate alternative courses of management as viewed and assessed by the households regarding their environmental and economical connotations.

RESULTS

The quantitative survey that has been carried out among households in Kathmandu Valley has provided the numeric outputs in the form of waste generation behaviour, level of awareness, and the perception on environmental and economic effects of alternative waste management scenarios. Based on the approach to the methodology used in the study, descriptive statistics and correlation analysis were used to arrive at the results. The waste practices by the respondents, their willingness to modify new waste systems and their perceived environmental and economic profits of landfilling, recycling and composting have helped directly to assess the three scenarios.

Table 1: Household Waste Composition and Behavioral Readiness for Scenario Shift

Indicator	Percentage / Mean	Implication
Households segregating waste	45%	Supports composting feasibility
Households recycling materials	18%	Moderate readiness for recycling scenario
Households disposing waste properly	67%	Supports scheduled collection for all scenarios
Overall positive waste behavior score	36%	Indicates slow transition from landfill dependency

(Source: Field Work, 2025)

The quantitative data on the household has been summarized in Table 1 based on the structured questionnaire. The findings have indicated that 45 % of the households have been separating

organic and inorganic waste, which is very consistent with the composting situation. It has only 18% adopted recycling habits and this shows moderate preparedness towards recycling-based system. The disposal off behavior is at 67% indicating that it operates well with the structured waste collection in any case. All in all, only 36% have shown positive practices in relation to the wastes being constant, hence the move towards not being dependent on landfills will need behavioral fortification. The results have been a direct reflection of the quantitative measurement that was taken by the descriptive statistics. We have clarified the construction of the "positive waste behavior score" by explicitly explaining its composite calculation based on multiple questionnaire items and by providing the full survey instrument and scoring procedure in Appendix A to enhance methodological transparency and reproducibility

Table 2: Environmental Perception Scores for Waste Management Scenarios

Environmental Indicator	Mean Score (1–5)	Interpretation
Landfill causes pollution	4.3	Strong awareness of environmental harm
Recycling reduces pollution	4.1	High perceived benefit
Composting reduces methane	4.4	Highest environmental value perceived
Need to reduce landfill use	4.5	Strong community support

(Source: Field Work, 2025)

The scores of the respondents on the environmental perception moving on the Likert-scale items of the questionnaire have been reflected in Table 2. The mean values have indicated that composting (mean 4.4) and recycling (mean 4.1) has been perceived by the households as the most eco-friendly situation. The view that the use of landfills has resulted in extreme form of pollution has been well upheld (mean 4.3). Scoring high (4.5) on curbing landfill dependency has shown that the people in general are in support of the idea of implementing alternative systems of waste management. These findings have directly been obtained based on the perception variables assessed based on the survey and interpreted using the descriptive statistics, which are consistent with the quantitative methodology. Despite the fact that the main scope of this work is descriptive and exploratory, all the correlation coefficients as described are checked on their basis to identify the level of statistical significance at the traditional confidence levels with the help of SPSS. The research findings suggest statistically significant relationships between the levels of awareness and the support of the alternative waste management scenario; the relationships, however, must be regarded as the associative, but not causal ones. The lack of experiments and longitudinal data restricts the possibility of causality and extrapolation outside the field of the study. The presentation of the environmental and economic perception tables is done randomly, to ensure clarity of concepts between the two dimensions, but they are collectively addressed in the interpretation, to show relatedness between the two concepts.

Table 3: Economic Perception Scores of Waste Management Scenarios

Economic Indicator	Mean Score (1–5)	Interpretation
Landfilling is costly long-term	4.2	Strong belief in high future costs

Recycling creates value	3.9	Moderate acceptance
Composting reduces municipal expenses	4.1	High economic benefit perceived
Willingness to pay for better waste services	3.7	Moderate economic readiness

(Source: Field Work, 2025)

The economic perceptions by the quantitative survey have been introduced in Table 3. It has been demonstrated that respondents are of the strong belief that landfilling has created rising costs in the long-term perspective, which in turn is a positive economic argument towards discarding landfill-based systems. Recycling has been considered as providing a rather average economic benefit (mean 3.9), whereas composting has achieved a greater perceived economic benefit (mean 4.1). The desire to pay higher prices on better waste services (mean 3.7) has shown some mediocre preparedness to upgrade the system. These economic observations have been generated by quantitative analysis, which is in line with the methodology approach based on Likert-scale items and SPSS-based statistics.

Table 4: Correlation Results between Awareness and Support for Scenario Shift

Variables Correlated	Correlation (r)	Interpretation
Awareness of pollution × Support for composting	+0.61	Strong positive relationship
Knowledge of recycling × Support for recycling	+0.54	Moderate positive relationship
Awareness of landfill problems × Desire to reduce landfill use	+0.67	Strong positive relationship
Environmental concern × Willingness to adopt new systems	+0.58	Moderate–strong relationship

(Source: Field Work, 2025)

The results of the correlation based on SPSS have been provided in Table 4. Support of composting has been positively correlated with awareness of pollution (r = 0.61), and such an outcome supports the claim that well-informed households have been more inclined to support waste systems based on composting. Recycling information has been found to be moderate (r = 0.54) and support of recycling. The best correlation (r = 0.67) has been found between the knowledge about landfill issues and the pursuit of the reduction of the landfill dependency. The concern about the environment and the readiness to use new systems have also been significantly correlated. Such findings have been a direct result of correlation analysis that is outlined in the methodology.

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the

				Estimate
1	.846[a]	0.716	0.704	0.39862

[a] **Predictors:** (Constant), Environmental Awareness, Economic Perception of Recycling and Composting, Waste Segregation Practice, Municipal Collection Adequacy

Source: Field Survey Data Analysis, 2025

Table 5 demonstrates the overview of the multiple regression model that takes a closer look at the degree to which the variables of environmental awareness and perceptions chosen forecast household support the idea of a switch in landfill-centric waste management to recycling and composting systems in Kathmandu Valley. The model presents a good overall correlation between the independent variables to include the awareness of pollution, the knowledge of recycling, awareness of landfill problem, and the environmental concern with the dependent variable, which is the support to forestall the shift of the scenario. The multiple correlation coefficient (R = 0.846) shows the high level of association between the aggregate predictors and the household support of alternative waste management systems. This is an indication that all the factors selected, based on the awareness and perception factor, have a significant contribution in influencing the tendency of the population to abandon the landfill dependency. The coefficient of determination (R 2 = 0.716) implies that the model provides a sufficient explanation of (71.6 percent) of the total variation in household support of recycling and composting. Such a high degree of explanatory power is believed to be high in behavioral and environmental research designs where the issues of awareness and perception play a significant role in shaping waste management preferences. The adjusted R square (0.704) is almost equal to the R square value that implies that the model is still robust even by considering the number of predictors introduced. This low value indicates that all the independent variables provide significant contribution to the model and the findings are not exaggerated because of meaningless sorts of predictors. Moreover, the standard error of the estimate (0.39862) is not very high, which means that the results obtained by prediction (the values) are very close to the observed ones and that the model is rather stable in terms of an approximation to the household support behavior.

DISCUSSION

The quantitative results of the current work signal that the switching of the existing waste management model based on landfills to the one focused on recycling and composting in Kathmandu Valley relies heavily on the household waste management practices, the rate of environmental awareness, and the perception of environmental and economic effects (Dangi et al., 2017). The research offers a systematic insight into the perceptions and behavior of households with respect to various waste management choices through the application of structured questionnaires and the use of descriptive statistics and correlation analysis (Bohara and Ichihashi, 2022). The findings point without any doubts to the fact that composting can be considered as the most reasonable as well as the most common solution, because of a significantly high percentage of the organic waste produced at the household level and a relatively high level of the awareness of the environmental advantages among the inhabitants. Recycling can also be viewed as another fruitful way, but because of improper source segregations and insufficient knowledge on material recovery processes, its role is also limited among the population (Pant, 2024). The findings of the correlation also show that the environmental awareness of the household predetermines the more of them support composting and recycling programs, which confirms the importance of knowledge as one of the key factors in the adoption of alternative disposal methods. Simultaneously, residents always perceive

landfill disposal to be an ecologically damaging and economically unsustainable procedure, which correlates with more general international evidence on the adverse effects of landfill dependency over the long run (Shrestha & Joshi, 2024). The scores based on economic perception also indicate that households are aware of the potential of composting and recycling and reduce the future municipal spending which positively influences the support of the population to the alternative systems (Kandel et al., 2025). Altogether, the results indicate that the decrease of Kathmandu to landfills demands not only technical solutions but also behavioral change, greater awareness as well as better waste separation, and composting proves always to be the best probably solution, which is also environmentally friendly and has the highest suitability to the situation.

On top of the behavioral dimension, the institutional-structural setting has a final influence on the result of waste management in Kathmandu Valley. Small-scale scrap dealers, waste pickers and kabadiwalas, are informal networks in material recovery systems and play an important role in determining the effectiveness of recycling processes even though they still do not regularly receive formal recognition by the municipality. The municipal collection capacity, application of segregation policies, presence of compost market and the application of regulatory provisions contained in the Solid Waste Management Act 2011 of Nepal are all essential in the success of both the composting and recycling operations. Although, these institutional factors are not majorly addressed in the current study due to the primary concern on the household perceptions and behavioral preparedness, they play a critical role in translating the willingness into practice on the ground and so should be given more analytical consideration in the studies to come. To enhance the quantitative evaluation of the impact of scenarios, descriptive and correlational results were supplemented with inferential statistics in the study. ANOVA was used to determine that statistically significant difference between the environmental perceptions and economic perceptions and behavior preparedness in the three waste management scenarios namely landfilling, recycling and composting. Besides this, the predictive power of important explanatory variables of environmental awareness, waste segregation behavior and household economic perceptions were evaluated using multiple regression analysis, regarding reach to willingness to switch to non-landfill reliant systems. Those inferential analyses can bring more understanding of the interaction between awareness and behavioral factors to influence the preference of the situation and the subsequent support to use composting, as the most suitable variant of waste management conditions, which exist in Kathmandu Valley in the current socio-economic and institutional environment.

The result of composting that is favored to recycling in this study is a material and socio-cultural fact and not necessarily the superiority of composting as a waste management activity. The preponderance of biodegradable waste in the household waste stream at Kathmandu intuitively fits into the category of composting, as a technically basic, locally adaptable, and technically simple, and officially simple, upgradeable system of waste management that requires little capital and infrastructure to execute at household or community scales. Contrastingly, recycling is facing significant cultural, economic, and structural hindrances that are not limited to individual willingness such as the habit of poor segregation, low market demand of recyclables, price fluctuations, and huge reliance on the informal recycling system. Strong collection logistics, sorting and downstream processing infrastructure are also needed to recycle, and these are disproportionately distributed throughout the Valley. These are restrictions on the instant scalability of the recycling process in comparison to composting. Simultaneously, the research does take critical omissions and limitations into consideration. Waste-to-energy technologies and

anaerobic digestion, despite being highly used elsewhere in the urban setting, were deemed out of Kathmandu because its organic waste composition is composed of high moisture levels, poor segregation habits, and capacity of the institutions. Furthermore, the research manuscript also acknowledges the behavior intention gap: high level of awareness and positive attitudes are not necessarily related to the existence of long-term behavioral change. In line with observations of the Social Practice Theory, it is found that actual waste practices are related to routines, material conditions, convenience and institutional support instead of awareness per se. Equity lens also highlights the fact that waste management effects are skewed towards the low-income and marginalized population who tend to be under greater environmental threat with limited resources to implement alternatives such as home composting or subsidized recycling services. In the absence of specific policy action, the gains of any possible increase in waste management systems have disproportionately favor households that are better off.

CONCLUSION

This paper has contrasted the environmental and economic effects of three solid waste management options, namely landfilling, recycling, and composting, in terms of a detailed quantitative analysis in Kathmandu Valley. The results have always revealed that the existing landfill-based model has proved to be ecologically harmful, economically weighty and more unsustainable. The proportion of organic wastes in the municipal waste stream has caused households to have low recycling tendency and moderate composting willingness. The perception scores have reflected that people are well aware of the environmental negative impact of the landfills and the opportunities available through recycling and composting. The correlation analysis has proved that higher environmental and waste related awareness has raised willingness to embrace the alternative waste systems. The greatest environmental and economic benefits that have been accrued by composting have been low emissions of methane, decreased landfill requirements and cost-saving in the long-term to the municipality. Recycling has proved to be moderately viable and with positive attitude being the driving force but limited segregation practices are the limiting factors. Throughout these findings, the study has come to the conclusion that the best sustainable and steady way ahead of Kathmandu has been through composting that is being complemented by the recycling. These findings have given evidence-based suggestions to policy makers aiming to transform the city to more efficient, environmentally friendly and economically viable waste management system. It is worth mentioning that the scenario comparison used in the current study assumes house-level perception and behavioral variables as opposed to direct environmental or economic quantification with the application of engineering-based instruments, such as the life cycle assessment or the cost-benefit analysis. Although this may minimize the capacity to quantify specific reduction in emissions or even financial savings, the method is useful in getting the willingness, approval, and constraints on behavior, which are important indicators of the viability and effectiveness of the alternative waste management system. Future studies can extend the findings by combining the perception-based survey data with the secondary data on the waste composition, emission factors, and municipal spending on these indicators to create a complex impact measurement.

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