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Made Adi Widyatmika
Department of Mechanical Engineering, Indian Institute of Technology Delhi

Nomesh B. Bolia
Department of Mechanical Engineering, Indian Institute of Technology Delhi

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Unveiling Segregation and Composting Behavior in Urban Communities: A Study Case of Sarbagita Municipality, Indonesia

Made Adi Widyatmika*[1,2], Nomesh B. Bolia[1]

[1]Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India

[2]Department of Engineering, Universitas Hindu Indonesia, Denpasar, Bali 80238, Indonesia

*Author to whom correspondence should be addressed:

Email: Made.Adi.Widyatmika@mech.iitd.ac.in

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Abstract: This paper analyses citizen perceptions and motivations in waste management of Sarbagita municipality, Bali. Binomial logistic regression reveals that demographic factors influence waste segregation and composting behaviours. Multinomial logistic regression explores the incentives that motivate waste management. Critical concerns at the household and community levels include the lack of post-collection waste management guarantees and the need for a comfortable living environment. The study recommends improving waste management techniques, reinforcing collectors' commitment, and advocating for centralized composting facilities prioritizing environmental comfort.

Keywords: composting; incentive; logistic regression; perception; segregation; solid waste management.

1. Introduction

Effective municipal solid waste management (MSWM) is a critical concern in modern society [1,2]. All levels of government must frequently confront this issue, as all previous low-cost and low-control disposal methods are no longer acceptable [3,4]. The new approach is centred on long-term environmental stewardship, regulating improvement, the standard of living, and the environment. Waste reduction, recycling, reusing waste, waste resource recovery, landfilling, and incineration are all part of environmental management. The primary global goal of waste management is to maintain the rising population's health and prevent environmental damage [5,6].

Solid waste management (SWM) is closely linked to several United Nations' Sustainable Development Goals (SDGs) published in 2015. These include SDG 11, which emphasizes the need for proper SWM to make cities and communities more sustainable and livable, and SDG 12, which aims to promote responsible consumption and production patterns through waste reduction and recycling promotion. SDG 13 focuses on mitigating climate change, with sustainable SWM strategies such as trash reduction, recycling, and safe disposal helping to lower carbon footprints. Similarly, SDG 14 seeks to conserve oceans and marine life, making sustainable waste management strategies essential to decrease marine pollution. Lastly, SDG 15 emphasizes reducing waste generation and appropriate garbage disposal to promote sustainable land use and minimise environmental damage.

In urban areas, particularly in cities that serve as significant migration hubs, such as Jakarta and Bali, the waste problem has become dynamic. Sarbagita is a metropolitan area in Bali Province consisting of Denpasar, Badung, Gianyar, and Tabanan regencies. Since Sarbagita is the epicentre of Bali's business and tourism activities, the waste problem is a susceptible issue that will negatively impact the island's tourism industry. Identifying community perceptions and developing strategies for waste management at the source is critical and should be a top priority in Sarbagita municipality.

According to BPS [7] and Partnership [8], the island generates 4281 tons of waste per day, or 1.5 million tons per year, of which approximately 52% is unmanaged waste, and 48% is managed. The Sarbagita area generates 50% of Bali's waste, with 70% ending up in the Suwung landfill at South Denpasar, the final disposal site. The Bali Provincial Government has issued a Governor's Regulation on waste management at source [9], but it has not been

implemented efficiently [10]. The Bali Provincial government's policy has been implemented in various programs, such as increasing the number of waste banks and 3R sites by providing active roles to traditional villages. However, the implementation must still be optimal due to a lack of community participation and communication obstacles between the community and waste management [10,11]. The Balinese chose to address waste management restrictions by implementing the 3R site, indicating their continued dependence on waste management services beyond their households [12]. This issue shows that community participation in managing waste at its source is essential in implementing waste management policies [13]. Hence, investigating social elements to tackle solid waste issues is crucial.

Inadequate waste management creates a breeding ground for an infinite number of diseases. The problem is frequently exacerbated in developing countries because of the limited capability of the public sector entities responsible for municipal solid waste management (MSWM) [14]. Experts believe that private businesses can play a role in closing the service delivery gap by working together with public sector entities. Citizens, on the other hand, are sometimes overlooked when looking for productive alternatives within the scope of service delivery [15]. Segregation at the source, within households, is an immediate manifestation of citizen participation, as effective waste management is nearly impossible without it. In general, people's responsibilities must fundamentally shift from passive recipients to active partners in service. This transformation doesn't always occur independently and may require external impetus. This motivation could stem from their awareness of environmental sustainability issues and the perceived benefits [16].

The waste management strategy of involving the community as active participants in lowering the amount of waste is the right choice for the anticipated increase in the volume of urban waste that continues to grow due to population growth [17]. The community or individual may take an active role in waste management by collecting, storing, segregating, and recycling waste to limit the volume and distribution of waste. Community involvement is defined as establishing the direction and strategy of policy activities, sharing the burden of carrying out activities and reaping the results and benefits of activities equitably. Participation entails contributing to and participating in determining the direction and goals of development, emphasising that participation is a right and obligation for all communities [18].

Community participation in waste management can segregate organic and inorganic garbage during the storage process, or it can take the form of manufacturing compost on a household scale and minimising the use of non-biodegradable materials [19,20]. Participation can be quantified in three stages: planning, implementation, and use. In the realm of waste management, community involvement encompasses more than just participating in implementing waste management practices. It also entails becoming an active member of waste-related organisations that contribute to establishing an effective waste management system [21].

Community participation can be approached comprehensively or through diverse avenues. The particular context of participation, such as resource management, environmental impact assessment, and regulatory decision-making, may sometimes guide the specifics. Conversely, participation results shape the configuration in other cases, including addressing objections to activities and initiating dialogues [19,22]. "Indirect participation" refers to community involvement in financial matters, specifically participation in waste management by paying retribution for waste services through relevant agencies that provide cleaning services. One form of participation in waste management involves the willingness to financially contribute towards enhancing waste management infrastructure to uphold cleanliness and environmental quality [23]. Community participation is commonly defined as the active involvement, engagement, and equitable participation of community members in a particular endeavour, whether through direct or indirect means, encompassing idea generation, policy development, program execution, and assessment.

Direct participation involves community members trying to help and support the activities undertaken, whereas indirect participation could even come as contributions of ideas, funding, and materials required. Community participation is characterised by a close relationship between one individual and another and a reciprocal and mutually influencing relationship [24–26]. Individuals have relationships with others, and groups have relationships with different groups. Generally, any development activity will be less effective if the community does not participate somehow [27].

Waste segregation and composting are the most common approaches to waste treatment at the source. Proper waste segregation is a crucial initial phase in the subsequent management procedures. The fundamental approach to waste categorisation involves separating organic waste from inorganic waste [17]. Organic waste refers to materials that can undergo decomposition within a relatively short timeframe, while inorganic waste consists of substances that do not decompose, including glass, metal, paper, and plastic.

Composting is an approach employed to manage and diminish the quantity of organic waste by harnessing the actions of microorganisms [28]. The presence of microorganisms facilitates the expedited breakdown of organic waste [29]. Several factors,

including temperature, humidity, nutrient content for microorganisms, soil pH, composting duration, and oxygen levels, must be considered to ensure the optimal proliferation of microorganisms and facilitate effective composting [30].

This study aims to determine how the public views household waste segregation and composting. Additionally, it is necessary to ascertain the factors that motivate residents to participate in waste segregation and composting. Developing waste separation programmes tailored to the specific requirements of the intended population is crucial for promoting sustainable practices in solid waste management [31]. The first step is to comprehend the patterns of public behaviour and the specific motivations that encourage individuals to take responsibility for managing their household waste [32].

The study also aims to study the measures that can be implemented to compel individuals to engage in composting and waste segregation independently. This study utilises binomial and multinomial models to provide insight into the types of people more likely to compost and segregate and determine the incentives for individuals belonging to various demographic groups.

2. Materials and methods

Section 2 presents the materials and methods to investigate the research questions outlined in the previous section. The experimental design and data collection procedures are described, detailing the sample selection, measurements, and techniques. Furthermore, we outline the statistical analyses conducted to interpret the gathered data.

2.1. Methodological framework

We developed the questionnaire for this study using literature reviews and insight from experts in the field. It can be initially tested on a small group to gather feedback and insights, which will then be incorporated into the final questionnaire.

The dependent variable is in categorical form with equivalent and non-meaningfully ordered categories, so logistic regression is employed for model development. Classification problems can also be solved using logistic regression. The argument of the sigmoid function indicates that logistic regression classifiers typically use a linear combination of numerous explanatory variables [33]. Multinomial logistic regression (MLR), a semiparametric classification statistic, solves multiclass problems by forecasting the likelihood of events for a categorically scattered dependent variable. It is a generalisation of logistic regression and can handle multiple classes. Binomial logistic regression (BLR) is used for segregation and composting models, while multinomial logistic regression is used for intervention models [34]. The independent variables in such cases may be nominal, ordinal, interval, or ratio [35]. This model estimates the likelihood of different potential outcomes of a dependent variable that follows a categorical distribution, considering a set of independent variables. Additionally, the MLR model estimates a model for each indicator variable separately. The resulting model is an *N-1* category binary logistic regression model when the dependent variable has *N* categories. Each model evaluates the effect of predictors on the probability of success in a specific category relative to the reference category.

Adopting the categories from earlier studies [18,21], this study utilises the following indicator variables: household head's occupation categorised as a government employee (O_1), private sector employee (O_2), entrepreneur (O_3), and agricultural and daily labourer (O_4). Meanwhile, the household head's income is categorised into low income (I_1), middle income (I_2), and high income (I_3). Age categories are grouped as 17 to 25 years old (A_1), 26 to 40 years old (A_2), and above 40 years old (A_3).

Segregation and composting play pivotal roles in managing municipal solid waste [18]. This study emphasises these crucial components and develops two distinct models for each aspect. The first model delves into understanding and examining individuals' diverse behaviours regarding segregation and composting, considering their socio-economic status. Meanwhile, the second model focuses on interventions targeting behavioural changes, seeking to identify effective interventions and how their impact varies based on socio-economic status. The segregation intervention variables are lower waste collection costs (S_1), rules that mandate segregation (S_2), free separated dustbin (S_3), special concern for the environment (S_4), and the assurance that waste does not mix after collection (S_5) as the reference variable. The composting intervention variables are nearby composting site (C_1), money for your composting product (C_2), and more concern about the environment (C_3) as the reference variable. Figure 1 depicts the methodological framework of the study.

The BLR model for segregation and composting is as follows:

$$log\left(\frac{P}{1-P}\right) = B_0 + \sum B_i x_i \quad (1)$$

A multinomial logistic regression model with *N* interventions can be conceptualised as a collection of *N-1* distinct, independent binary logistic regression models. Within these models, one intervention is designated as the "reference," while the remaining *N-1* interventions are individually regressed against the reference intervention. If category *N* is selected as the reference category, then the n^{th} intervention can be described as follows:

$$log[Pr(Y = n)/Pr(Y = N)] = B_{n0} + \sum_{k=1}^{K} B_{nk} x_{nk} \quad (2)$$

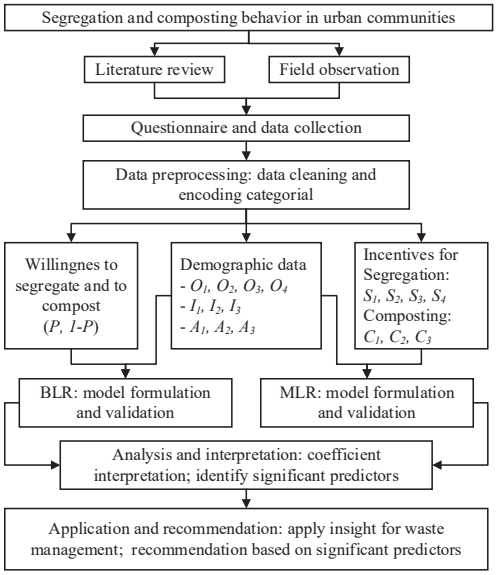

Fig. 1: Methodological frameworks

2.2. Study area

The Sarbagita region covers 192,828 hectares and includes the cities of Tabanan, Badung, Gianyar, and Denpasar. Sarbagita is home to 60.85% of Bali Province's total population [36]. The population of Sarbagita is shown in Table 1.

Table 1 Population of Sarbagita municipality

Sarbagita municipality	Population	Area (ha)	Density (/km^2)
Denpasar	962900	12778	7535.61
Badung	683200	41862	1632.03
Gianyar	516300	36800	1402.99
Tabanan	448000	101388	441.87

The Sarbagita municipality's waste generation rate per day by locals is calculated by multiplying the local population by the average daily waste production of its residents, which comes to 0.76 kg/day/person. Denpasar produces the most waste of the four regions, accounting for 32.41% of Sarbagita's total waste in 2020 [7,37]. Table 2 displays the amount of generated waste in Sarbagita.

Table 2 Waste generation in Sarbagita in the year 2020

Sarbagita municipality	Waste generation	
	Ton/day	%
Denpasar	827	32.41%
Badung	821	32.17%
Gianyar	469	18.38%
Tabanan	435	17.05%
Total	2552	100%

2.3. Data collection

This research employs a questionnaire about socio-economic status and waste management practices. The questionnaire had two parts. The first part considered the demographic profile, such as occupation, monthly income, age, education level, and housing status. Questions on waste management practices and how they work were considered in the second part.

Initially, a few issues appeared during the pilot survey with 50 respondents. The average time to fill out the questionnaire is 10 to 15 minutes. Furthermore, some individuals might respond merely by completing the survey. People were also worried that providing truthful responses would reveal that they did not properly dispose of their waste. Therefore, the questionnaire was rewritten to make it shorter while asking for the correct information. The questions in the survey were modified to create a more comfortable environment and eliminate any potential negative connotations or judgments regarding undesirable waste management practices. As a result of these alterations, the response rate and the survey quality improved significantly.

The following section presents the results and analysis of household surveys conducted among residents of the Sarbagita area. They demonstrate how people's responses to crucial waste management strategies differ depending on their socio-economic status.

3. Result and discussion

3.1.Statistical descriptions

We surveyed in August 2020 among 987 households, resulting in a favourable response rate of 888 participants. Figure 2 shows the willingness of Sarbagita's residents to segregate and compost their waste.

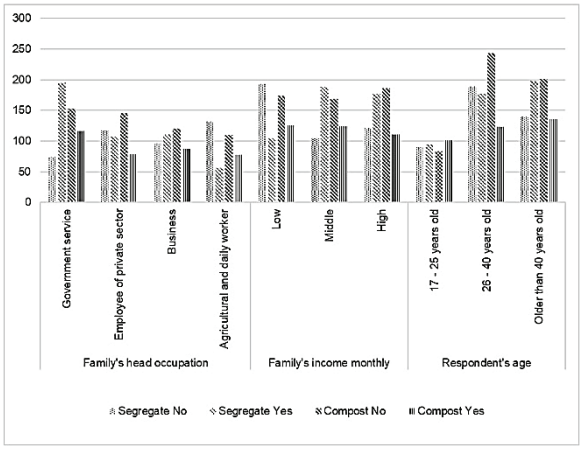

Fig. 2 Residents' willingness to segregate and compost their waste according to socio-economic status

In terms of the job of the family's head, 30.29% work as government officers, 25.23% are employees of the private sector, 23.31% do business, and 21.17% work in the agricultural sector and daily-worker. Regarding family's monthly income, 33.56% are in the low group (earn less than IDR 5.1 million per month), 33% in the middle group (earn between IDR 5.1 million and IDR 10 million), and 33.44% in the high group (earn more than IDR 10 million). When

asked about their willingness to segregate their waste, government employees, those with a mediocre income, and those over 40 years old are most inclined to do so. In contrast, 59.5% of respondents asked if they wished to compost were reluctant to do so. However, many individuals over 40 are interested in composting.

Concerning incentives for waste segregation, the survey findings indicate that 26% of respondents would be motivated to segregate their waste if measures were implemented to ensure that the collected waste remains separate and not mixed. Additionally, 27.6% of participants preferred fee reduction associated with door-to-door waste collection. A smaller proportion, 8.8%, preferred a legal requirement mandating waste segregation. On the other hand, 21.1% of respondents said they would be willing to segregate their waste if provided with a free separate dustbin. Notably, 16.5% of individuals identified environmental reasons as their motivation for waste segregation. Overall, the findings suggest that individuals are inclined towards improved services and amenities as incentives to engage in waste segregation practices.

Regarding incentives for composting, a significant majority of individuals, comprising 69.5%, preferred having a composting facility near their location. Additionally, 40.1% of respondents indicated that financial incentives, such as receiving extra money, would motivate them to engage in composting activities. A smaller proportion, 24.9%, mentioned that a legal requirement mandating composting would incentivise their participation. Furthermore, 16.6% of participants stated that increasing environmental awareness would drive them to adopt composting practices. These findings highlight the various incentives individuals consider influential in promoting composting behaviour.

3.2. Segregation model

We utilise binomial logistic regression to examine the segregation model, where the outcome variable is whether an individual engages in waste segregation (P_s). The family's head occupation (O), monthly income (I), and age (A) are the key independent variables in this model. Table 3, the omnibus test of segregation model coefficients, shows the *chi-squared* = 121,665 with $p < 0.05$. The *chi-square value* of more than df (7) indicates that adding independent variables has a real effect and that the model is fit.

Table 3 The Omnibus test of the segregation model coefficients

		Chi-square	df	Sig.
Step 1	Step	121.665	7	.000
	Block	121.665	7	.000
	Model	121.665	7	.000

Table 4, the segregation model summary, shows The *Nagelkerke R Square* value is 0.571. According to these values, the independent variable can explain 57.1% of the dependent variable. Consequently, 42.9% of the dependent variable is explained by factors other than the model.

Table 4 The segregation model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1106.548[a]	.328	.571
a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.			

From Table 5, we render the following model and interpretations:

$$log\left(\frac{P_s}{1-P_s}\right) = -0.314 + 1.553_{O_1} + 0.735_{O_2} - 0.989_{I_1} \quad (3)$$

Government employees (O_1) and individuals employed in the private sector (O_2) demonstrate a higher propensity for waste segregation than farmers and daily workers (A_4). This suggests that government and private sector workers exhibit a greater understanding of the importance of waste sorting than daily workers and those involved in agriculture.

Low-income individuals (I_1) are less likely to separate their trash than high-income individuals. This is unsurprising given that persons with higher incomes prefer to reside in residential clusters with efficient waste management and mindful communities.

Business (O_3), middle-income (I_2), and age categories (A_1, A_2, and A_3) are considered insignificant independent variables since the $p > 0.05$.

Table 5 Parameter estimates of the significant independent variables and the model summary of the segregation model

Variables[a]	*B*	*df*	*p*	*Exp(B)*
O_4*		3	0.000	
O_1	1.553	1	0.000	4.727
O_2	0.735	1	0.001	2.086
O_3	0.421	1	0.135	1.524
I_3*		2	0.000	
I_1	-0.989	1	0.000	0.372
I_2	-0.085	1	0.709	0.919
A_3*		2	0.207	
A_1	-0.094	1	0.652	0.91
A_2	-0.286	1	0.083	0.751
Constant	-0.134	1	0.607	0.874

[a] Variable(s) entered on step 1: Family's head occupation, Family's income monthly, Respondent's age; * reference category

3.3. Composting model

The omnibus test of composting model coefficients (Table 6), reveals that the inclusion of independent variables exerts a substantive impact on the model,

indicating its goodness of fit since the *chi-squared* (129.099) is greater than *df* (7) with $p < 0.05$.

Table 6 The Omnibus test of the composting model coefficients

		Chi-square	df	Sig.
Step 1	Step	129.099	7	.000
	Block	129.099	7	.000
	Model	129.099	7	.000

Table 7, the composting model summary, shows *The Nagelkerke R Square* value is 0.635. These results illustrate that the independent variable has an explanatory power of 63.5% to the dependent variable. Consequently, additional factors exist, accounting for 36.5%, which lie outside the model's scope and contribute to explaining the dependent variable.

Table 7 The composting model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	1169.955[a]	.322	.635

a. Estimation terminated at iteration number 3 because parameter estimates changed by less than .001.

Table 8 demonstrates I_2) and A_2 have $p > 0.05$. Thus, these variables are considered to have no significant impact. The following model and interpretations are derived from Table 8:

$$log\left(\frac{P_c}{1-P_c}\right) = -0.688 + 0.054_{O_1} - 0.219_{O_2} + 0.309_{O_1} + 0.376_{I_1} + 0.541_{A_1} - 0.289_{A_2} \quad (4)$$

O_1 and O_3 are less likely to compost O_4 and O_2. This can be explained by assuming that agriculture and daily workers aren't assigned fixed work hours, making it easier to schedule the composting of their waste. I_1 is more likely to compost than I_3. Composting produces organic fertiliser, which has a market value and highly benefits the agriculture industry. This can offer them additional revenue. A_2 are less likely to compost their waste than other groups. This demonstrates that elderly individuals and younger groups have more time to compost their waste.

Table 8 Parameter estimates of the significant independent variables and the model summary of the composting model

Variables[a]	*B*	*df*	*p*	*Exp(B)*
O_4*		3	0.023	
O_1	0.054	1	0.046	1.055
O_2	-0.219	1	0.029	0.804
O_3	0.309	1	0.027	1.362
I_3*		2	0.014	
I_1	0.376	1	0.012	1.457
I_2	0.429	1	0.051	1.536
A_3*		2	0	
A_1	0.541	1	0.006	1.718
A_2	-0.289	1	0.011	0.749
Constant	-0.688	1	0.007	0.502

[a]Variable(s) entered on step 1: Family's head occupation, Family's income monthly, Respondent's age; *reference category

3.4. Segregation incentive model

We performed a Likelihood Ratio test to assess the model's overall fit with all the included predictors (occupation, monthly income, and age). The model's chi-square statistic is 300.62 (df=28, p-value < 0.000). This highly significant result (p-value < 0.05) indicates that the model with all the included predictors provides a statistically better fit to the data than a baseline model with only an intercept term. The results suggest that the chosen predictors help explain the variation incentives that motivated citizens to segregate their waste. Table 9 presents the segregation incentive model fitting information.

Table 9 Segregation incentive model fitting information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	910.328			
Final	609.708	300.620	28	.000

Table 10 shows five dependent variables to build the models: S_1, S_2, S_3, S_4, and S_5 as the reference category. The predictors are the same as those used in the segregation model. The models are as follows:

$$log\left[\frac{Pr(S_1)}{Pr(S_5)}\right] = -1.461 - 0.349_{O_1} - 0.657_{O_2} - 3.327_{I_1} + 2.229_{I_2} + 0.54_{A_1} + 0.6_{A_2} \quad (5)$$

$$log\left[\frac{Pr(S_2)}{Pr(S_5)}\right] = -0.586 - 0.63_{O_1} + 0.622_{I_1} + 0.418_{I_2} - 0.596_{A_1} \quad (6)$$

$$log\left[\frac{Pr(S_3)}{Pr(S_5)}\right] = -0.465 - 1.031_{O_1} - 1.294_{O_2} - 3.327_{I_1} + 2.229_{I_2} + 0.54_{A_1} + 0.476_{A_2} \quad (7)$$

$$log\left[\frac{Pr(S_4)}{Pr(S_5)}\right] = -0.533 - 0.976_{O_1} - 1.039_{O_2} + 0.064_{I_2} + 1.032_{A_2} \quad (8)$$

In Table 10, the independent variables with $p<0.05$ are statistically significant. Table 10 demonstrates the construction of four models, incorporating five dependent variables as incentives for composting and ensuring the prevention of waste mixing post-collection. O_3 is the statistically insignificant variable ($p>0.05$) when lower waste collection costs are used as incentives for segregation. Similarly, when laws that mandate segregation are used as incentives for segregation, O_3 and A_1 are presumed insignificant. Furthermore, A_1 is negligible for the free separated dustbins incentive. In addition, the A_1, O_3, and I_1 are statistically insignificant when special concern for the environment is the incentive for segregation.

From Table 10, we infer that as an incentive to segregate their waste, O_1 and I_3 prefer assurances that waste will not be mixed as compared to other

incentives. In contrast, O_4 and I_1 would like a reduced price for waste collection as an incentive, with a likelihood of 27.851 times greater. Moreover, compared to other incentives, the assurance that waste will not be mixed during collection does not appear to help I_1, I_2, O_4, A_1 and A_2. Except for the law of segregation, A_1 favors the assurance of unmixed waste.

Table 10 Pivot table of parameter estimates of the segregation incentive model

Incentives for segregation[a]		*B*	*p*	*Exp(B)*
S_1	Intercept	-1.888	0.000	
	O_1	-0.349	0.030	0.705
	O_2	-0.657	0.046	0.518
	O_3	-0.556	0.253	0.574
	O_4	0[b]	.	.
	I_1	3.327	0.000	27.851
	I_2	2.229	0.000	9.292
	I_3	0[b]	.	.
	A_1	0.54	0.048	1.715
	A_2	0.6	0.012	1.822
	A_3	0[b]	.	.
S_2	Intercept	-0.586	0.020	
	O_1	-0.63	0.016	0.532
	O_2	-0.867	0.058	0.42
	O_3	-0.378	0.453	0.685
	O_4	0[b]	.	.
	I_1	0.622	0.018	1.864
	I_2	0.418	0.026	1.519
	I_3	0[b]	.	.
	A_1	-0.297	0.436	0.743
	A_2	-0.596	0.041	0.551
	A_3	0[b]	.	.
S_3	Intercept	-0.465	0.229	
	O_1	-1.031	0.002	0.357
	O_2	-1.294	0.000	0.274
	O_3	-1.197	0.006	0.302
	O_4	0[b]	.	.
	I_1	1.765	0.000	5.84
	I_2	1.249	0.000	3.487
	I_3	0[b]	.	.
	A_1	0.461	0.128	1.586
	A_2	0.476	0.047	1.609
	A_3	0[b]	.	.
S_4	Intercept	-0.533	0.183	
	O_1	-0.976	0.010	0.377
	O_2	-1.039	0.007	0.354
	O_3	-0.46	0.276	0.632
	O_4	0[b]	.	.
	I_1	0.25	0.524	1.284
	I_2	0.604	0.046	1.83
	I_3	0[b]	.	.
	A_1	0.404	0.226	1.497
	A_2	1.032	0.000	2.808
	A_3	0[b]	.	.

[a]The reference category is: S_5; [b]This parameter is set to zero because it is redundant.

3.5. Composting incentive models

Based on the results in Table 11, it is evident that the model including all the predictors offers a significantly better fit to the data compared to a baseline model that only includes an intercept term. Based on the findings, the selected predictors effectively contribute to understanding the factors that drive individuals to compost their waste.

Table 11 Composting incentive model fitting information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	896.146			
Final	624.134	272.013	28	.000

Table 12 shows that all independent variables are statistically significant, $p<0.05$, except O_2. From Table 12, we constructed the two models, wherein three dependent variables are employed as incentives for composting, with the environmental concern variable serving as the baseline reference. The two models are as follows:

$$log\left[\frac{Pr(C_1)}{Pr(C_3)}\right] = 1.461 - 0.444_{O_1} - 0.952_{O_3} - 0.108_{I_1} + 0.378_{A_2} \quad (9)$$

$$log\left[\frac{Pr(C_2)}{Pr(C_3)}\right] = -1.162 - 0.858_{O_1} - 1.694_{O_3} - 0.019_{I_1} + 0.105_{I_2} + 0.648_{A_1} + 1.959_{A_2} \quad (10)$$

When a nearby composting site is used as an incentive, O_2, I_2, and A_1 are statistically insignificant. Meanwhile, when money is used as an incentive, only the O_2 is estimated to be insignificant. Those variables have $p>0.05$.

Regarding environmental issues, neighboring composting sites appear to be the ideal alternative for A_2. In contrast, other groups of responders are more concerned with the environment as a stimulant. This group would like to live in a more pleasant environment, believing the composting facility will make their life less comfortable. In contrast to environmental concerns, the financial gains associated with composting emerge as the more preferred incentive for I_1, A_1 and A_2. Meanwhile, O_1 and O_3 regularly want the enhancement of environmental concerns as an incentive.

Table 12 Pivot table of parameter estimates of the composting incentive model

Incentives for composting[a]		*B*	*p*	*Exp(B)*
C1	Intercept	1.461	0.000	
	O_1	-0.444	0.041	0.641
	O_2	-0.225	0.401	0.798
	O_3	-0.952	0.004	0.386
	O_4	0[b]	.	.
	I_1	-0.108	0.039	0.898
	I_2	-0.164	0.052	0.849
	I_3	0[b]	.	.
	A_1	-0.08	0.071	0.924
	A_2	0.378	0.049	1.459

Incentives for composting[a]		*B*	*p*	*Exp(B)*
	A_3	0[b]	.	.
C2	Intercept	-1.162	0.022	
	O_1	-0.858	0.025	0.424
	O_2	-0.527	0.152	0.591
	O_3	-1.694	0.002	0.184
	O_4	0[b]	.	.
	I_1	0.019	0.032	0.981
	I_2	0.105	0.040	1.111
	I_3	0[b]	.	.
	A_1	0.648	0.040	1.912
	A_2	1.959	0.000	7.089
	A_3	0[b]	.	.

[a]The reference category is: C_3; [b]This parameter is set to zero because it is redundant.

4. Discussion and policy implications

The Bali province government has established a new paradigm in waste management, namely, waste reduction and handling at the source, in its long-term development plan [9]. The purpose is to minimise waste generation at the source and garbage disposal in landfills. Waste reduction is accomplished by limiting waste generation, reusing, and recycling, also known as the 3R method. Of course, waste management using the 3R method necessarily requires the active participation of the community. The community is both a waste producer and a significant player in waste management, with waste generation closely related to community behaviour. The public's willingness to sort and compost their household waste must be understood to obtain a basis for government policy managing waste. Likewise, incentives can motivate people to sort and compost their waste.

The implementation of source-based waste management requires policies for constructing waste management facilities. Meanwhile, in communal-based waste management, the priority policies are institutional strengthening and community empowerment [12].

It is interesting to understand the behaviour of the Balinese people in managing household waste, where they have a strong culture as a basis of environmental consciousness [38,39]. Surveys indicate that government officials are more inclined to endorse waste disposal, perhaps because of their familiarity with environmental legislation and procedures. Corporate and private sector employees might need educational programs tailored to their work environments. Individuals employed in agricultural and daily workers who know resource management techniques can benefit from initiatives that link these techniques to waste disposal.

We expect the survey to reveal a clear correlation between income and the propensity to segregate. The findings indicate a robust level of environmental consciousness among individuals of varying income levels in Bali. Additional investigation could delve more profoundly into the participants' underlying motivations for segregation.

The survey uncovered a direct correlation between age and the inclination to seek separation, indicating that individuals over 40 were more inclined to engage in such actions. Initially, the older generation may have grown up with a stronger emphasis on resource conservation and waste minimization than the younger generation.

Furthermore, individuals over the age of 40 may possess a more significant amount of available time to dedicate towards implementing effective waste management strategies compared to younger employees or households with young children. With a percentage of 59.5%, the survey revealed a notable aversion to composting in the manufacturing sector. This result could be due to a need for more information, leaving citizens unaware of the writing procedures or the benefits they offer. In addition, the limited living space in metropolitan areas may make composting appear impracticable, and concerns about odours or the time required to maintain a composting site may hinder participation.

4.1. Insight

From the results and discussion, we can figure out four critical parts of deep understanding int the context of Bali, as follows:

Compared to all other incentives, the preference for incentivising segregation lies in guaranteeing that waste will not be recombined after collection. This means that after door-to-door collection, the community desires a more attentive approach to waste management. They thought sorting the waste in their homes was meaningless when the collectors mixed it up again. This result is consistent with a study conducted in Delhi [18] and Jakarta [21], where the higher income groups are more worried about what happens to garbage after the waste collector has collected it. The likelihood of individuals engaging in waste separation would increase if they had assurance that the separated waste would not be mixed at a later stage. In addition, it is crucial to consider the garbage collector's comprehension and commitment to maintaining cleanliness and orderliness in waste handling, both during transportation and at the garbage collection site.

The extra money from selling composting products is the preferred incentive for people from low-income and young-middle age groups. This suggests that individuals with lower incomes desire to increase their earnings, highlighting the importance of considering the complexity of composting compared to waste separation. Additionally, establishing clear guidelines and regulations related to composting can serve as an incentive for their engagement. Under these circumstances, a decentralized system implemented at the local or regional level may be more effective than

individual home composting [19]. The environment and the comfort of their living spaces become a priority for high-income people, government officials, and business owners.

The presence of scavengers appears to have facilitated this process of segregation. They will sort through people's garbage and take cardboard and other desired items. Garbage owners don't need to sort out the trash and don't even pay for it. Collectors, as capital owners, have given instructions to scavengers. As long as the waste is regarded as less valuable, it is not recycled or discarded. Like the formal sector, the waste industry has links and networks ranging from scavengers to large collectors. Scavengers face a problem because they are in a far worse position to negotiate than *pelapak* (small-sized collectors) and *pengepul* (large collectors). Because collectors set the prices, they cannot determine the value of the used goods they collect, and the scavenger community is frequently powerless. Even more, scavengers are commonly associated with a negative stigma as a social problem that must be addressed immediately. Scavengers' activities are considered illegal and stink.

Although people have a sufficient understanding of waste management, they must also ensure that it continues to be done correctly. Since the waste collector plays a vital role in ensuring compliance [40], waste collector motivation and commitment (both formal and informal) must be considered and improved to achieve good waste management from upstream to downstream.

4.2. Action items

Assemble waste neatly after door-to-door collection. The community's most desired incentive is the assurance that waste will not be remixed after being collected from door to door. The door-to-door garbage collector bears the most responsibility in this case. The government must develop a standard operating procedure (SOP) for dealing with waste after collecting it from the source. In addition, a monitoring and evaluation process must be carried out to ensure that the SOP is appropriately followed. To ensure the process's long-term viability, it is necessary to investigate garbage collectors' behaviour and perceptions and identify factors that can be used as incentives for them to manage the waste properly.

Strengthening the informal sector. The scavenger community possesses untapped social capital that can be harnessed to improve the economy and society. However, the policy aspect often remains neglected. In this regard, the government plays a crucial role in addressing social exclusion, a pervasive challenge scavengers face across various aspects of their lives. Consequently, scavengers encounter limitations in accessing services, participating in decision-making processes, and enjoying fundamental rights and necessities. The government must emphasize scavenger inclusion through bottom-up policy initiatives. The community is positioned as both a policy objective and a policy subject. Communities must be free to express their aspirations to create an inclusive social environment that embraces all people intending to bring them prosperity.

Local waste management site. The composting incentives model states that people mostly expect a comfortable living environment. This means they are more likely to compost collectively than individually. Establishing such composting sites in residential areas would address the issue of environmentally friendly waste disposal and relieve part of the government's load. Composting regulations and purchasing compost products from local businesses will increase interest in household waste composting. As a result of this load-sharing, individuals will feel more accountable and perform better.

5. Conclusion and future scope

This study provides valuable insights into the perceptions and motivations of Sarbagita residents towards waste segregation and composting, which can inform waste management practices in this region and other areas facing similar challenges. The finding that the assurance of waste not being remixed after collection is a crucial incentive for waste segregation is consistent with similar studies conducted in other countries, suggesting that this incentive can play a vital role in promoting waste segregation in diverse contexts. However, the unexpected finding of no clear correlation between income and waste segregation calls for a deeper understanding of the underlying motivations.

The study highlights the importance of considering the perspectives of all stakeholders in waste management, including citizens as the waste generator, to develop effective and sustainable waste management policies and practices that account for the diverse needs and motivations of different groups. The study findings underscore the importance of establishing well-defined regulations and standardized procedures for incentivizing individuals to participate in composting through compensation for composting products.

This research contributes to the global conversation on waste management and sustainability by providing valuable insights into promoting sustainable waste management practices in diverse contexts. Policymakers and researchers can use these insights to develop more effective waste management policies and practices that consider each region's unique challenges and opportunities.

However, this study has a limitation that should be addressed in future research. It does not consider the viewpoints of waste collectors, who also play a crucial role in waste management, nor does it examine the

motivations and practices of scavengers and dealers who operate within the waste supply chain. Therefore, future research should address this limitation by examining the viewpoints and motivations of all actors involved in waste management to develop more comprehensive waste management policies and practices.

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Data availability

The datasets produced and analyzed during the present study can be obtained from the corresponding author upon reasonable request.

Conflict of interest

The authors affirm that no conflicts of interest are associated with this manuscript's publication. Furthermore, the authors have diligently adhered to all ethical considerations, including plagiarism, informed consent, research misconduct, data fabrication and falsification, duplicate publication and submission, and redundancy avoidance.

Nomenclature

P	the probability that people will sort and compost their waste
x_i	the independent variables
N	the intervention
K	the number of independent variables in total
Y	the specific intervention among the overall set of interventions
x_{nk}	the independent variable
B	coefficient of regression
p	significance indicator
$Exp(B)$	exponential of the estimated coefficient (B) in the model

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