Waste Literacy towards Sustainable Development

Introducing the Waste Literacy Framework (WLF) for Environmental and Economic Development in Sri Lanka

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Abstract **-** This research provides rigorous explanation about waste knowledge. Waste is very critical problem among world as well as Sri Lanka. The escalating global waste crisis, with municipal solid waste generation reaching 2.01 billion tons annually, demands urgent attention, particularly in developing nations where inadequate infrastructure and limited public awareness exacerbate environmental degradation. This study introduces the Waste Literacy Framework (WLF), a comprehensive cognitive infrastructure designed to equip individuals, communities, and nations with the knowledge and competencies necessary to transform waste from a liability into a valuable resource. Grounded in the Knowledge-Attitude-Behaviour Model, Theory of Planned Behaviour, and Environmental Literacy Framework, the WLF comprises six essential components: knowledge of waste generation, reduction and reuse, classification, disposal, recycling, and waste as an innovative economic resource. Employing a mixed-methods approach with quantitative surveys of 112 households and qualitative interviews in Sri Lanka's Sooriyapaluwa East Grama Niladhari Division, the study reveals a strong negative correlation between waste literacy and environmental degradation (-0.687 $p < 0.01$), demonstrating that targeted waste literacy exerts a more powerful influence on environmental outcomes than general education alone (-0.534). These findings validate the WLF as a strategic framework for policymakers, offering a pathway to achieve Sustainable Development Goals 11 and 12 while building circular economies, creating green employment, and fostering sustainable communities.

Key Words – Waste Literacy, Waste Literacy Framework, Policy Planning, Sustainable Development

I. INTRODUCTION

The escalating global waste crisis, with municipal solid waste generation reaching 2.01 billion tons annually, represents one of the most pressing environmental challenges of the contemporary era. This crisis is particularly acute in developing nations like Sri Lanka, where rapid urbanization and consumption patterns have overwhelmed inadequate waste management infrastructure, generating approximately 7,000 tons of solid waste daily, 65-66% of which comprises organic materials. The catastrophic 'Meethotamulla' garbage dump collapse in 2017 serves as a stark reminder of the human and environmental consequences of systemic waste management failure. While these challenges are well-documented, the behavioral and cognitive dimensions of waste management specifically, the concept of "waste literacy" remain critically underexplored, representing a significant gap in both academic literature and policy planning. This study addresses this gap by introducing the Waste Literacy Framework (WLF), a comprehensive cognitive infrastructure designed to equip individuals, communities, and nations with the knowledge and competencies necessary to transform waste from a liability into a valuable resource, thereby enabling the transition from linear consumption to a circular, regenerative economy.

History of Waste Management

The history of waste management reflects humanity's changing relationship with consumption and disposal. Archaeological evidence from ancient civilizations reveals that waste management has been a persistent human challenge for millennia. In ancient Crete (3000 BCE), residents dug deep pits for waste disposal, while Athens implemented regulations around 500 BCE requiring waste to be deposited at least one mile from the city (Andy Rihan, 2021). The Romans developed sophisticated sanitation systems including water pipes and

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sewage networks, demonstrating early recognition of the public health implications of improper waste disposal (Rathje & Murphy, 2001).

During the medieval period (500-1500 CE), waste management practices varied significantly across regions. While many European cities experienced deteriorating sanitary conditions with open waste accumulation, cities like Venice established rudimentary collection systems. The Renaissance period brought renewed attention to cleanliness and urban planning, leading to the development of waste disposal regulations (Russell, 2008; Bonta, 2018).

The Industrial Revolution (18^{th}-19^{th} centuries) fundamentally transformed waste generation patterns. Rapid urbanization and industrialization created unprecedented volumes of waste, leading to public health crises and environmental degradation. This period saw the emergence of organized waste collection services and public health movements (Worshman, 2015).

The 20^{th} century witnessed the rise of consumer culture and plastic packaging, dramatically increasing waste volumes. Landfills became the predominant disposal method, though growing environmental concerns led to the development of recycling programs and waste-to-energy technologies (Hirad, 2017; De Vito, 2018).

Waste Generation: Global and National Perspectives

Waste generation is intrinsically linked to population growth, consumption patterns, and economic development. The United States Environmental Protection Agency (2023) reports that solid waste generation correlates with economic activity and population growth. Globally, municipal solid waste generation has reached 2.01 billion tonnes annually, with significant variation across income levels and regions.

Sri Lanka faces a particularly acute waste challenge. According to the Provincial Council Waste Management Reports (2021), the country generates approximately 7,000 tonnes of solid waste daily, with 65-66% comprising organic materials. The Western Province contributes the largest share, with Colombo District being the primary contributor. This waste burden places immense pressure on limited land resources and environmental systems.

The waste crisis in Sri Lanka manifests through inadequate infrastructure, illegal dumping, and limited public awareness. Research indicates that improper waste management has led to soil, water, and air pollution, creating significant public health risks (The Diplomat, 2018). The ‘Meethotamulla’ garbage dump collapse in 2017 exemplified the catastrophic consequences of inadequate waste management systems.

Waste Classification and Management Practices

Waste classification systems vary internationally, reflecting different regulatory frameworks, cultural contexts, and environmental priorities. A comparison of practices across Germany, Japan, Singapore, and the United States reveals how countries have developed sophisticated yet distinct approaches to managing the primary waste categories that form the foundation of modern waste management.

Germany

Germany has established one of the world's most comprehensive waste classification systems, operating a four-tier survey system supported by waste balance cross-validation. German households typically separate waste into six distinct streams: paper (blue bins), organic waste/garden clippings (brown bins), light packaging such as yoghurt cartons and drink boxes (yellow bins), similar non-packaging waste including toys and tools (orange boxes), glass separated by colour (white and green recycling bins), and residual waste. This detailed classification extends to the national level through the List of Waste (LoW) and EWC-Stat systems, which differentiate primary and secondary waste while maintaining material flow consistency. Germany's system has achieved recycling rates exceeding 80% for paper and glass, and 65% for plastics.

Japan

Japan employs a classification system based on waste properties and treatment processes, with Tokyo's municipal authorities implementing a four-category system since 1982: recyclable waste (collected weekly), combustible waste (twice weekly), non-combustible waste (once weekly), and bulky waste requiring advance reservation. This process-oriented approach integrates source separation with strict collection schedules, contributing to Japan's consistently high recycling rates. Under Japan's Wastes Management and Public Cleansing Law, waste is broadly divided into "general waste" (municipal solid waste from households and businesses) and "industrial waste," comprising 20 specified categories generated from business activities.

Singapore

This country implements a six-stream classification system introduced in 2019, administered by the Ministry of Environment and Water Resources: paper (blue bins), plastic (red bins), glass (green bins with glass logos), metal (yellow bins), and non-recyclable household waste. This system integrates waste minimization, recycling, and energy recovery within the 3R principle (Reduce, Reuse, Recycle), with public education playing a crucial role. Singapore's approach emphasizes recyclable waste separation while maintaining clear distinctions between recyclable and non-recyclable materials.

The United States

The USA takes a more decentralized approach, with New York City's Department of Sanitation operating a three-stream system since 1989, paper (green bins), metal/ glass/ plastic/ cartons (blue bins), and mixed waste (black bins). At the federal level, the Environmental Protection Agency (EPA) emphasizes the waste management hierarchy as a guiding framework: source reduction and reuse (most preferred), recycling and composting, energy recovery, and treatment and disposal (least preferred). This hierarchy provides a systematic approach to minimizing environmental impacts, recognizing that no single management strategy is suitable for all waste streams and circumstances. The EPA's framework has been widely adopted as a foundational principle in waste management policy across the United States.

Across these countries, the primary waste categories Municipal Solid Waste, Hazardous Waste, E-waste, Biodegradable Waste, and Construction and Demolition Waste are managed through diverse classification systems that balance environmental priorities, regulatory frameworks, and public engagement strategies

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Waste Literacy is Not Waste Management

The distinction between literacy and functional competency is critical to understanding why high general literacy rates do not automatically translate into effective waste management behaviours. UNESCO's foundational definition of functional literacy emphasizes the knowledge and skills which enable one to engage effectively in various activities in their daily life. Contemporary scholarship has extended this concept beyond basic reading and writing to encompass domain-specific literacies, with environmental literacy existing on a continuum from functional to critical higher levels characterized by complex issue identification and system-level action competence. Within this framework, waste management represents operational logistics the "how" of collection, transport, processing, and disposal while waste literacy constitutes the cognitive infrastructure enabling individuals to understand waste's origins, flows, and systemic consequences. This conceptual distinction is empirically significant: Germany's renowned "Green Dot" system, the world's first extended producer responsibility legislation introduced in 1991, has achieved packaging recycling rates of 80% or more for paper and glass, and 65% for plastics. Yet despite intensive consumer education, approximately 30% of packaging waste still ends up in residual waste, escaping the recycling cycle. This persistent gap demonstrates that even sophisticated infrastructure cannot fully compensate for inadequate literacy. Similarly, Sweden's comprehensive waste-to-energy systems, Japan's advanced source separation programs, and the Netherlands' circular economy promotion all demonstrate that high-performing waste management depends upon literate citizenries who understand material lifecycles.

In stark contrast, Sri Lanka's 92.6% general literacy rate has not translated into waste literacy, revealing a fundamental gap between abstract educational achievement and practical environmental competency. This paradox is exemplified by the annual SriPada pilgrimage, where approximately one tonne of garbage is collected daily, including three tonnes of plastic bottles within a single season despite signboards warning of Rs. 5,000 fines and regular public announcements urging pilgrims to take their waste home. Environmentalists note that the volume of plastic retrieved each year surpasses previous records, and dialogues with the Central Environmental Authority have been largely fruitless as multinational corporations continue selling plastic products to visitors. The core failure lies in Sri Lanka's approach, where environmental protection is often viewed as the sole responsibility of government and environmentalists, with inadequate recognition that the general public plays the central role in waste management outcomes. The Central Environmental Authority's awareness programs remain constrained by resource limitations, weak public engagement, and a tendency toward sporadic, media-driven initiatives rather than sustained, everyday engagement with communities.

The waste management constitutes one component of the broader waste literacy concept. While operational systems address the physical handling of waste, the Waste Literacy Framework provides the cognitive infrastructure enabling individuals to make informed decisions at every stage of the resource lifecycle from generation to disposal to economic transformation. Without this cognitive foundation, even the most sophisticated waste management systems remain vulnerable to contamination, miss-sorting, and public disengagement, ultimately perpetuating environmental degradation.

Identify the Research Gap

The global evidence base demonstrates that targeted waste literacy interventions are substantially more effective than general education in driving behavioural change. De Frond et al. (2024) introduced the Home Waste Audit (HWA), a community science activity designed to increase waste literacy and reduce household waste; prior to the audit, 60% of participants underestimated their weekly waste generation, but throughout the four-week program, household waste decreased by 31%, with several behavioural changes maintained one year after participation. Similarly, gamified interventions such as the Samp App demonstrated quantifiable behaviour changes: waste sorting improved by 28%, official waste collection use increased by 13%, and littering and waste burning declined. Experimental studies on visual prompts for waste sorting reveal that Miss Order waste dropped from 40.9% at baseline to 10.2% after intervention, confirming that combining educational materials with visual cues bridges the knowledge-practice gap. Kidztainia 3.0, an Indonesian school initiative using interactive narrative-based education and practical skills training, achieved an 85% improvement in students' ability to classify plastic types, demonstrating the potential of experiential, participatory learning supported by the Pentahelix model (academia, industry, community, government, media).

A critical gap persists across all studies: the translation of awareness into consistent action. Scholars increasingly recognize that waste literacy must be complemented by enabling infrastructure, sustained policy support, and behavioural reinforcement mechanisms. Laila et al. (2024), in a family-based food waste intervention, demonstrated that TPB-grounded programs are feasible and well-received, yet require ongoing engagement to sustain behaviours change. Studies from Ethiopia, Vietnam, and the Philippines consistently report that while knowledge predicts positive attitudes, structural barriers inadequate facilities, unreliable collection services, and established cultural practices hinder the translation of intention into action. This evidence validates the Waste Literacy Framework's six-component structure (Knowledge of Waste Generation, Reduction & Reuse, Classification, Disposal, Recycle, and Waste as Innovative Economic Resource), which progressively builds competency from foundational understanding to empowerment and economic transformation, thereby addressing the multidimensional challenges identified in the literature.

Theoretical Foundation for the Waste Literacy Framework (WLF)

The Waste Literacy Framework (WLF) is grounded in three established behavioral and environmental theories: the Knowledge-Attitude-Behavior (KAB) Model, the Theory of Planned Behavior (TPB), and the Environmental Literacy Framework. Together, these theories provide a robust foundation for understanding how waste-related knowledge translates into environmental conservation.

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Knowledge, Attitude, Behaviour (KAB) Model

The KAB Model conceptualizes environmentally responsible behaviour as a sequential process in which knowledge constitutes the cognitive foundation for attitude formation and subsequent actions. Wei et al. (2026) demonstrated that environmental knowledge influences behavioural intention indirectly through attitude formation, highlighting the importance of subjective cost-benefit evaluation in translating positive attitudes into action. Their study, based on field questionnaires, revealed a significant serial mediation process: environmental knowledge shapes attitudes, which subsequently influence willingness to sacrifice personal convenience, ultimately affecting proactive waste management behaviour. Jou et al. (2024) confirmed that environmental knowledge significantly influences environmental concerns while affecting personal values and environmental attitudes. From respondents in the Philippines, they found that intention was affected by personal attitudes and convenience, which subsequently impacted waste management behaviour. This supports the KAB framework's proposition that knowledge is the essential first step toward behavioural change. Gómez-Oliván et al. (2025) developed and validated an environmental literacy diagnostic tool for Mexican schoolchildren, revealing significant knowledge gaps: only 7.7% answered correctly on recycling, 28.2% on waste management, and 15.4% on water conservation. This finding underscores the critical importance of foundational knowledge in developing environmental competence.

Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (Ajzen, 1991) posits that behavioural intention is influenced by three determinants: attitude toward the behaviour, subjective norms, and perceived behavioural control. Hu et al. (2025) conducted a comprehensive meta-analysis and confirming that waste separation behaviour is most strongly associated with perceived behavioural control, intention, infrastructure, and attitude. Their findings revealed that intention is positively associated with attitude, perceived behavioural control, moral norms, subjective norms, consequence awareness, and past behaviour. A study of dental professionals in Scotland (2024) applied TPB to understand sustainable waste segregation behaviour, finding that knowledge gaps and lack of awareness were often linked with attitudes associated with low intention to engage with sustainable waste management. This demonstrates the TPB's utility in explaining the intention-behaviour gap in waste management contexts. Jou et al. (2024) confirmed that intention is affected by personal attitudes and convenience, which impact waste management behaviour, supporting TPB's applicability to community-based waste management.

The Environmental Literacy Framework

The Environmental Literacy Framework provides the educational and competency-based foundation for waste literacy. The California Environmental Literacy Framework identifies three key content areas: the Natural Environment, the Built Environment, and the Personal Environment, with waste conceptualized as a by-product of life where responsible individuals recognize their attitudes and actions impact environmental outcomes. Jurin et al. (2010) defined environmental literacy as "a set of abilities and commitments necessary to find, understand, assess, and act on information about the health of our environment." This holistic framing has been operationalized through school-based interventions such as Indonesia's Adiwiyata program, which integrates waste literacy into formal education through composting, recycling, and "trash banks" that serve as both educational and financial assets supporting circular economy concepts. Recent scoping reviews reveal that effective waste literacy programs incorporate interdisciplinary learning, place-based and experiential methods, values-driven pedagogy, and participatory assessment techniques. Critically, studies show that general environmental education is insufficient. Hicks (2022) found that neither US high school students (average score 42.8%) nor teachers (60.4%) achieved passing scores on waste literacy surveys, and enrolment in Environmental Science classes had no statistically significant effect on performance. This paradox high general literacy coexisting with low waste-specific competency is also documented in South Africa, where 54% of citizens report knowing 'a lot' about recycling, yet only one-third 'always' or 'often' participate in recycling activities

II. IDENTIFY, RESEARCH AND COLLECT IDEA

Research Objectives and Hypothesis

Objective 1: To examine the determinants of waste literacy among households in Sri Lanka

This objective seeks to identify the key socio-demographic and economic factors that influence household-level waste literacy. Building upon the Knowledge-Attitude-Behaviour (KAB) Model and the Theory of Planned Behaviour (TPB), which posit that knowledge constitutes the cognitive foundation for environmentally responsible behaviours (Wei et al., 2026; Ajzen, 1991), this objective operationalizes waste literacy as a measurable competency determined by education, income, gender, household size, and residency duration. The empirical validation of these determinants will inform targeted policy interventions, particularly in light of the documented paradox where Sri Lanka's 92.6% general literacy rate coexists with critically low waste-specific literacy (74.1% lacking knowledge about waste generation and 83% lacking recycling knowledge). This objective is further justified by international evidence demonstrating that general environmental education is insufficient for building waste-specific competencies (Hicks, 2022), and that structural factors—not just curriculum content—significantly affect waste literacy outcomes.

H_1: *Socio-demographic and economic factors significantly influence household waste literacy.*

Objective 2: To assess the impact of waste literacy on environmental outcomes.

This objective evaluates the causal relationship between waste literacy and perceived environmental degradation, testing the central proposition that higher waste literacy is associated with fewer environmental problems. Grounded in the Environmental Literacy Framework, which conceptualizes waste as a by-product of life where responsible individuals recognize their attitudes and actions impact environmental outcomes (Jurin et al., 2010), this objective operationalizes environmental outcomes as a composite index measuring waste-related problems including contamination

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of soil/water, waste accumulation on agricultural fields, and open burning. This objective is validated by international evidence: De Frond et al. (2024) demonstrated that experiential waste literacy interventions reduced household waste by 31%, with behavioural changes sustained one-year post-intervention; Hu et al. (2025) confirmed in a meta-analysis that perceived behavioural control and intention are strongly associated with waste separation behaviour and the South African Citizens' Environmental Awareness Index (2022-2024) documented a 19-percentage point gap between knowledge and consistent action, reinforcing the need to assess literacy's direct impact on environmental outcomes.

H_2: *Higher waste literacy is significantly associated with lower environmental degradation.*

Study Area

This study was conducted in the '*Sooriyapaluwa East*' grama niladhari division. It is located in '*Mahara Kadawatha*' Divisional secretariat division in the Gampaha district in western province. Western province is the most populated province in sri lanka. Every day collect massive waste count. According to the western province waste management authority (WMA-WP), 4000-4300 metric tonnes of urban waste is generated in the western province. The western province generates more than 59% of Sri Lanka's total solid waste.

Research Design

The study employs a quantitative approach. The design is structured as applied field research aimed at solving real-world waste management problems in the Sooriyapaluwa East Grama Niladhari Division. Quantitative design: The research utilizes structured questionnaires administered to a sample of 112 families selected through simple random sampling from a population of 1,340 families. This component collects numerical data on household demographics, waste generation patterns, and existing knowledge about waste management. Statistical analysis is performed using SPSS and Excel software. Qualitative design: The design incorporates in-depth interviews with key stakeholders including the Grama Niladhari officer, Samurdhi officer, and officials from the Central Environmental Authority. Participatory observations and case studies are also employed to understand community behaviours and attitudes toward waste disposal.

The study adopts an inductive reasoning approach, moving from specific observations to broader generalizations. The research proceeds through the following stages, Problem Identification: Recognizing waste literacy as a critical gap in environmental conservation. Data Collection: Gathering empirical evidence through field surveys. Analysis: Using Econometric models and processing data using SPSS, Excel. Generalization: Drawing conclusions about waste literacy levels based on collected evidence this approach allows the researcher to examine the actual waste literacy status of the community and its impact on community, rather than testing predetermined hypotheses. The mixed-method design ensures comprehensive understanding of both measurable patterns and underlying social factors influencing waste management behaviours.

Sample and Sampling techniques

Data is categorized as primary and secondary data, which can be further classified as quantitative and qualitative data. Primary data was collected through,

Questionnaires: Administered to 112 family units selected through simple random sampling

Interviews:

- Personal interviews with the Grama Niladhari officer
- Interviews with officials from the Central Environmental Authority (CEA), including the Waste Management Unit, Environmental Awareness Unit, and Laboratory Division

Observations: Participatory observation method was used to observe waste disposal practices in the study area.

Secondary data collected from, the department of census and statistics (sri lanka), Central environmental reports, environmental quality assessment reports, Grama Niladhari office records, Waste collection and disposal reports, UN reports and Research Articles.

Data Variables and Analysis

The empirical analysis employs two econometric models to examine the determinants and impacts of waste literacy. The first model specifies Waste Literacy (KW) as a function of five independent variables, EDUCATION (measured as an ordinal scale from no schooling to graduate level), INCOME (categorized monthly household income from below LKR 10,000 to above LKR 100,000), GENDER (a dummy variable where 1 = female, 0 = male), HH_SIZE (the total number of family members residing in the household), and RESIDENCY (the number of years the household has lived in the area).

The second model specifies Environmental Outcomes (ENV_OUTCOME) as a function of the calculated Knowledge of Waste (K_w), along with INCOME, EDUCATION, and HH_SIZE as control variables. ENV_OUTCOME is a composite index constructed from survey responses measuring the number of waste-related environmental problems perceived by households, including waste mixing with soil/water, waste on agricultural fields, and open burning. All variables are derived from primary survey data collected from 112 households in the Sooriyapaluwa East Grama Niladhari Division, with data analysis conducted using SPSS

Empirical Models

Waste Literacy (1)

$$K_W = \alpha_0 + \alpha_1\, education_i + \alpha_2\ income_i + \alpha_3\, gender_i + \alpha_4 hhsize_i + \alpha_5\, residency_i + \varepsilon_i$$

Waste Literacy Impact (2)

$$ENV_{OUTCOME} = \beta_0 + \beta_1\, Kw_i + \beta_2\, income_i + \beta_3\, education_i + \beta_4\, hh_{sizei} + \mu_i$$

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I I I FINDINGS

Basically, focused two parameters from collected primary data. Those are correlation with waste knowledge and correlation with knowledge about waste and environmental outcomes. Table 01 shows correlation with waste knowledge and independent variables (education, income, gender, household size, and residency). Table 02 shows correlation with waste knowledge and independent variables (waste literacy, income, education, household size).

There is a strongest relationship between education and knowledge of waste. Household heads with higher education levels (A/L, Graduate) should have significantly higher literacy. This aligns with the research findings that the study area has 47.3% A/L holders and 13.4% graduates, yet waste literacy remains low, suggesting education is a foundation but not sufficient alone. While education and knowledge of waste is strong (0.724), 74.1% of respondents still lack knowledge about waste generation, and 83% lack recycling knowledge. This suggests general education does not automatically translate to waste literacy - targeted interventions are needed.

Income and knowledge of waste is moderate-strong relationship. Higher-income households tend to have greater waste literacy. This may be due to better access to information, exposure to diverse products, and awareness of waste management systems (though the research notes income alone doesn't guarantee proper waste behaviour). The income and knowledge of waste (0.583) and income and household size (0.456) correlations indicate higher-income, larger households generate more waste, aligning with the research's regression analysis that every additional family member increases waste by 0.294 units.

Education and income show strong relationship. Education is a primary driver of income levels. Higher educated individuals secure better-paying jobs, which is evident from the occupational distribution in the research (e.g., government sector 8.9%, private sector 9.8%). household size and income show Moderate relationship. Larger households tend to have higher combined incomes. The research shows an average household size of 3.91 members, and that larger families generate more waste.

According to these reflections are demonstrating *Hypothesis 1* proofing with the evidence.

H₁: *Socio-demographic and economic factors significantly influence household waste literacy.*

Table 01: Pearson correlation matrix for waste knowledge

Variable	WLC_CON	EDUCATION	INCOME	GENDER	HH_SIZE	RESIDENCY
WLC_CON	1.000					
EDUCATION	0.724***	1.000				
INCOME	0.583***	0.612***	1.000			
GENDER	-0.128	-0.095	-0.182*	1.000		
HH_SIZE	0.415***	0.387***	0.456***	-0.104	-0.067	
RESIDENCY	0.289**	0.213*	0.341***	-0.067	0.394***	1.000

Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01 (two-tailed tests)

Table 02 shows Strongest negative relationship between knowledge of waste and environmental outcomes (-0.687). This is the most critical finding. Higher waste literacy is strongly associated with fewer perceived environmental problems. As WLC increases, environmental degradation decreases. This directly supports the research's central hypothesis. The strong negative correlation (-0.687) confirms that low waste literacy directly contributes to high environmental degradation.

Knowledge of waste and education (0.724) is showing strong positive relationship. Higher education strongly correlates with higher waste literacy, confirming that education is a key determinant of knowledge and alongside environmental outcomes and education (-0.534) shows Moderate-strong negative relationship. Higher education levels are associated with fewer environmental problems. However, the correlation is weaker than with WLC, suggesting that general education alone is less effective than specific waste literacy in improving environmental outcomes. Precisely this outcome means Education alone is insufficient. While education and environmental outcome is significant (-0.534), it is weaker than knowledge of waste and environmental outcomes (-0.687). This proves that targeted waste education is more effective than general education.

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Between income and environmental outcomes shows (-0.419) moderate negative relationship. Higher income households report fewer environmental problems, possibly due to better access to waste management services or living in better-maintained areas.
Environmental outcomes and household size (0.456) shows positive relationship. Larger households report more environmental problems. This aligns with the research finding that every additional family member increase waste generation by 0.294 units, leading to greater environmental impact. Means that larger households generate more waste, leading to more environmental problems.
According to these reflections are demonstrating *Hypothesis 2* proof with the evidence.

H₂: *Higher waste literacy is significantly associated with lower environmental degradation.*

Table 02: Pearson correlation matrix for environmental outcomes

Variable	ENV-_OUTCOME	WLC_CON	INCOME	EDUCATION	HH_SIZE
ENV-_OUTCOME	1.000				
WLC_CON	-0.687***	1.000			
INCOME	-0.419***	0.583***	1.000		
EDUCATION	-0.534***	0.724***	0.612***	1.000	
HH_SIZE	0.456***	0.415***	0.456***	0.387***	1.000

Significance levels: *** p < 0.01 (two-tailed tests)

IV CONCLUSION

The econometric analysis from this study provides compelling evidence that waste literacy is the most powerful determinant of environmental outcomes in the Sooriyapaluwa East community. The Pearson correlation matrix reveals a striking negative relationship between Waste Literacy Concept (WLC_CON) and environmental degradation (ENV_OUTCOME) at -0.687 ($p < 0.01$), demonstrating that higher waste literacy is strongly associated with fewer perceived environmental problems. This relationship is substantially stronger than the correlation between general education and environmental outcomes (-0.534), confirming that targeted waste literacy education is more effective than general education alone in reducing environmental harm.
The findings further reveal critical insights for policy and practice,

First, education exhibits the strongest positive correlation with waste literacy (0.724, $p < 0.01$), yet 74.1% of respondents still demonstrated inadequate knowledge about waste generation, and 83% lacked recycling knowledge. This paradox high general literacy (92.6% nationally) coexisting with low waste literacy illuminates a fundamental gap in Sri Lanka's educational system. Despite possessing general cognitive skills, citizens lack the specific competencies required to manage waste effectively. Second, the positive correlation between household size and environmental degradation (0.456) indicates that population pressures exacerbate waste challenges, requiring systematic interventions that address both individual behavior and community infrastructure. Third, the moderate-strong relationship between income and waste literacy (0.583) suggests that lower-income households require targeted support, including access to information, waste management services, and community-based education programs.
These empirical findings validate the theoretical foundations of the Waste Literacy Framework grounded in the Knowledge-Attitude-Behavior (KAB) Model, the Theory of Planned Behavior (TPB), and the Environmental Literacy Framework while demonstrating that waste literacy operates through multiple channels simultaneously. Households with higher waste literacy not only demonstrate superior waste segregation practices but also exhibit greater awareness of environmental consequences, stronger motivation to adopt sustainable behaviors, and enhanced capacity to identify innovative solutions.
Waste literacy is not merely an environmental virtue but an economic imperative and a cornerstone of sustainable development. The statistical relationships confirmed in this study provide the empirical foundation for introducing the Waste Literacy Framework (WLF) as a comprehensive cognitive infrastructure for building circular economies, empowering communities, and achieving the United Nations Sustainable Development Goals, particularly Goal 12 (Responsible Consumption and Production) and Goal 11 (Sustainable Cities and Communities).
Having established the empirical importance of waste literacy, this study now presents the Waste Literacy Framework in detail, a six-component model designed to equip individuals, communities, and nations with the knowledge and competencies necessary to transform waste from a liability into a valuable resource.

Introducing the Waste Literacy Framework

The empirical findings from study area confirm that waste literacy exerts a powerful influence on environmental outcomes, significantly stronger than general education alone. These findings, combined with the theoretical foundations of the Knowledge-Attitude-Behavior (KAB) Model, the Theory of Planned Behavior (TPB), and the Environmental Literacy Framework, provide the basis for the development of a comprehensive Waste Literacy Framework (WLF).
The Waste Literacy Framework (WLF) is a strategic competency framework that defines the six essential knowledge stages required to understand, think, manage, and transform waste. It serves as a roadmap for individuals, communities, and policymakers to transition from linear consumption to a circular, regenerative economy. Alongside it provides a blueprint for building waste-literate societies capable of achieving environmental sustainability, economic prosperity, and social equity.

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Definition of Waste Literacy

"Waste Literacy is the multidimensional competency to understand waste generation, apply reduction and reuse strategies, classify waste accurately, engage in recycling, practice safe disposal, and harness waste as an innovative economic resource enabling the transition from linear consumption to a circular, regenerative economy."

Waste Literacy Framework (WLF)

WLF has six pain parts,

1. Knowledge of Waste Generation
2. Knowledge of Waste Reduction & Reuse
3. Knowledge of Waste Classification
4. Knowledge of Waste Disposal
5. Knowledge of Waste Recycle
6. Knowledge of Waste as Innovative Economic Resource

Table 03: Defining co areas of framework

Component	Core area	Outcome
Knowledge of Waste Generation	Sources, types, quantities, and drivers of waste.	Understanding the scale and nature of the waste problem.
Knowledge of Waste Reduction & Reuse	Strategies to prevent waste at the source through mindful consumption, repair, and sharing.	Minimizing waste generation and conserving resources.
Knowledge of Waste Classification	Segregation of waste into appropriate categories (organic, recyclable, hazardous, inert).	Enabling efficient downstream processing and reducing contamination.
Knowledge of Waste Disposal	Environmental and health implications of landfills, incineration, and open dumping; safe and regulated containment practices	Recovering materials and reducing virgin resource extraction.
Knowledge of Waste Recycle	Environmental and health implications of landfills, incineration, and open dumping.	Protecting environmental and public health.
Knowledge of Waste as Innovative Economic Resource	Latent economic value in waste; entrepreneurial opportunities; green markets.	Building circular economies, creating jobs, and driving sustainable development.

Difference between waste management and waste literacy framework

The fundamental difference between Waste Management and the Waste Literacy Framework (WLF) lies in their focus and operational logic. Waste Management is defined as an operational and logistical system encompassing the collection, transport, processing, recycling, and disposal of waste materials, including monitoring and regulation, covering all activities required to manage waste from its inception to its final disposal. A typical waste management system comprises collection, transportation, pre-treatment, processing, and final abatement of residues. The purpose of waste management is to provide sanitary living conditions, reduce the amount of matter that enters or leaves society, and encourage the reuse of matter within society. In contrast, the Waste Literacy Framework (WLF) is a cognitive and educational construct designed to build human competency to understand, prevent, and transform waste. Grounded in behavioral theories such as the Knowledge-Attitude-Behavior (KAB) framework, which conceptualizes environmentally responsible behavior as a sequential process where knowledge constitutes the cognitive foundation for attitude formation and subsequent actions, the WLF cultivates the knowledge, attitudes, and skills necessary to drive sustainable waste behaviors from the source. Research confirms that environmental knowledge influences behavioral intention through attitude formation, highlighting the importance of translating positive attitudes into action. Studies also demonstrate that knowledge positively influences behavior, though the presence of an attitude-behavior gap suggests that knowledge alone is insufficient without enabling infrastructure and behavioral support. The WLF is designed to fill this gap by equipping individuals with the cognitive tools necessary to participate effectively in and improve upon existing waste management systems. While Waste Management addresses the physical handling of waste, the WLF provides the cognitive infrastructure that enables individuals to make informed decisions at every stage of the resource lifecycle from generation to disposal to economic transformation thereby driving the transition from linear consumption to a circular, regenerative economy.

Ṿ DISCUSSION

The empirical findings of this study provide compelling evidence for the distinct role of waste literacy in shaping environmental outcomes. The strong negative correlation between the Waste Literacy Concept (WLC) and environmental degradation (-0.687, $p < 0.01$) demonstrates that waste literacy exerts a more powerful influence than general education alone (-0.534). This discussion situates the Waste Literacy Framework within the broader scholarly discourse, engaging with international research that validates and extends these findings. Discussion would be divided several parts to more clearance.

Theoretical Foundation Gap

The Waste Literacy Framework draws upon the Knowledge-Attitude-Behaviour (KAB) model, the Theory of Planned Behaviour (TPB), and the Environmental Literacy Framework. Recent international research provides robust empirical support for these theoretical foundations while revealing important complexities. Nisa et al. (2025) conducted a mixed-methods study of waste management literacy among 357 participants in Indonesian secondary schools, applying the KAB model within the 3R (Reduce, Reuse, Recycle) framework. Their findings are

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particularly instructive: while knowledge positively influences behaviour, attitude unexpectedly correlates negatively, revealing a persistent attitude-behaviour gap. Although respondents held positive attitudes toward waste management, these attitudes did not consistently translate into active engagement. This mirrors the present study's finding that high general literacy (92.6%) coexists with low waste literacy (74.1% lacking knowledge about waste generation and 83% lacking recycling knowledge). The Indonesian study identified individual, social, and structural barriers including inadequate facilities and established waste practices that hinder the translation of positive attitudes into effective action.

The Theory of Planned Behaviour, another pillar of the WLF, has been extensively validated in waste management contexts. Sun and Hsiao (2023) conducted a TPB-based study examining the relationship between waste management literacy and behavioural intention, developing a structural equation model with five factors: self-efficacy, waste management literacy, perceived social good, attitude, and behaviour intention. Their findings indicate that increasing literacy levels can positively influence people's intentions to actively sort their waste. The conceptual analogy they draw is instructive: individuals may know that physical exercise benefits health, yet still require conscious effort to develop a healthy regime. This intention-behaviour gap, also observed in the present study, suggests that waste literacy must be complemented by enabling infrastructure and behavioural support a principle embedded in the WLF's six-component structure.

Waste Literacy Interventions and Behavioural Change

The effectiveness of targeted waste literacy interventions is strongly supported by programmatic evidence. De Frond et al. (2024) introduced the Home Waste Audit (HWA), a community science activity designed specifically to increase waste literacy and reduce household waste. Their findings are striking: before the audit, 60% of participants underestimated their weekly waste generation; throughout the four-week program, weekly household waste decreased by 31%; and several behavioural changes were maintained one year after participation. The HWA's success highlights that experiential, participatory learning where individuals directly engage with their own waste streams effectively builds both knowledge and sustained behavioural change. This aligns with the WLF's component on "Knowledge of Waste as Innovative Economic Resource," which encourages individuals to see waste not merely as a problem but as an opportunity.

Complementary evidence comes from technology-mediated interventions. An evaluation of Samp App, a gamified learning app designed to build waste literacy, demonstrated quantifiable behaviour changes among over 370 surveyed users: waste sorting improved by 28%, use of official waste collection services increased by 13%, and littering and waste burning declined by 12% and 5% respectively. Interviews revealed that learners actively discussed waste-management options within their communities, suggesting the app's influence extended beyond individual habits to social diffusion. This finding is particularly relevant to the WLF's emphasis on community-level transformation.

Institutional and School-Based Waste Literacy

School-based interventions represent a critical pathway for building waste literacy across generations. Indonesia's Adiwiyata program, initiated by the Ministry of Education and Culture in 2015, provides a large-scale example of institutionalized waste literacy education. A recent evaluation of Adiwiyata-implementing schools found marked improvements in waste segregation, composting, and recycling, alongside enhanced student and teacher engagement in environmental care. The research underscores the importance of "trash banks" as both educational and financial assets that support circular economy concepts. However, the study also notes sustainability and resource allocation challenges, suggesting that policy support and sustained funding are essential for long-term effectiveness.

In contrast, Hicks (2022) examined waste sorting literacy among high school students in the United States and found that neither students (average score 42.8%) nor teachers (60.4%) achieved a passing score on waste literacy surveys. Critically, enrolment in Environmental Science classes showed no statistically significant effect on survey scores, and observations revealed a surprising gap: while 38.6% of students could correctly identify how to dispose of pencils on a survey, 56.4% actually sorted them correctly in practice. This finding confirms the present study's argument that general environmental education is insufficient for building specific waste literacy competencies. The study attributed low teacher scores to the STEM teacher shortage in high-poverty districts, where teachers are 2.7 times more likely to lack full credentials, suggesting that structural factors not just curriculum content affect waste literacy outcomes.

The Kidztainia 3.0 initiative at SDN Cihuni III in Indonesia offers a promising intervention model, achieving an 85% improvement in students' ability to classify plastic types through interactive narrative-based education, practical skills training, and intergenerational collaboration. The program's success, supported by the Pentahelix model (academia, industry, community, government, media), demonstrates the potential of school-based service-learning programs to support SDG 4 and SDG 12 while providing a replicable model for other urban school contexts.

Bridging Awareness and Action: The Knowledge-Behaviour Gap

The persistent gap between environmental awareness and consistent action is a recurring theme in international research. The South African Citizens' Environmental Awareness Index (2022-2024) found that while 54% of citizens reported knowing 'a lot' or 'a fair amount' about recycling, only one-third 'always' or 'often' participate in recycling activities, with more than three-fifths reporting they 'sometimes' to 'never' recycle. This finding a 19-percentage point gap between knowledge and consistent action echoes the present study's identification of a fundamental gap between general literacy and specific waste literacy. The South African study identified lack of awareness or access to recycling facilities as barriers, reinforcing the WLF's position that waste literacy must be supported by enabling infrastructure.

The international evidence reviewed here consistently validates the central premise of the Waste Literacy Framework: that targeted, domain-specific literacy is more effective than general education alone in driving sustainable waste behaviours. Studies

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from Indonesia, the United States, South Africa, and Canada all demonstrate that while knowledge is a necessary foundation for behavioural change, it is not sufficient. The attitude-behaviour gap, the intention-behaviour gap, and the knowledge-action gap represent distinct but related challenges that the WLF addresses through its six-component structure, which progressively builds competency from understanding waste generation to harnessing waste as an economic resource.

VI POLICY IMPLICATIONS

Educational Policy Reforms

The study's finding that 74.1% of respondents lacked knowledge about waste generation and 83% lacked recycling knowledge, despite Sri Lanka's 92.6% general literacy rate, reveals a critical gap in the national education system. This paradox demands urgent educational policy reform.

National education ministries should mandate the integration of waste literacy competencies into formal curricula from primary through tertiary education. Drawing from Indonesia's Adiwiyata program, which has demonstrated marked improvements in waste segregation, composting, and recycling through school-based interventions (Warmadewanthi et al., 2025), Sri Lanka should establish a national framework for waste literacy education that progresses from foundational awareness in early grades to advanced competencies in higher education. The WLF's six-component structure (Knowledge of Waste Generation, Reduction & Reuse, Classification, Disposal, Recycle, and Waste as Innovative Economic Resource) provides a ready-made curricular scaffold. Hicks' (2022) finding that US teachers scored only 60.4% on waste literacy surveys and that enrolment in Environmental Science classes showed no statistically significant effect on student performance underscores the necessity of targeted teacher training. Policy must ensure that educators possess the competencies they are expected to impart. Professional development programs should be institutionalized, with waste literacy certification becoming a requirement for teachers in relevant subject areas. De Frond et al. (2024) demonstrated that the Home Waste Audit (HWA) reduced household waste by 31%, with behavioral changes sustained one-year post-intervention. This evidence supports policies that mandate experiential learning components, such as school-based waste audits, composting programs, and "trash bank" initiatives. The Kidztainia 3.0 program's 85% improvement in students' ability to classify plastic types (Lolita et al., 2025) further validates participatory approaches. Educational policy should allocate resources for hands-on waste literacy activities and establish partnerships with local waste management authorities to provide real-world learning opportunities.

Integration with Sustainable Development Goals

The WLF directly supports the achievement of multiple United Nations Sustainable Development Goals, particularly Goal 12 (Responsible Consumption and Production) and Goal 11 (Sustainable Cities and Communities). Policy should explicitly link waste literacy initiatives to SDG frameworks:

- **SDG 4 (Quality Education):** Waste literacy as a measurable learning outcome
- **SDG 12 (Responsible Consumption):** Waste literacy as foundation for sustainable consumption
- **SDG 11 (Sustainable Cities):** Waste literacy as enabler of sustainable urban management
- **SDG 13 (Climate Action):** Waste literacy as tool for methane reduction through composting
- **SDG 8 (Decent Work):** Waste literacy as pathway to green employment

Economic and Employment Reforms

The WLF's component on "Knowledge of Waste as Innovative Economic Resource" highlights the economic potential of waste literacy. The significant negative correlation between waste literacy and environmental degradation implies that investments in literacy yield both environmental and economic returns.

Green Jobs and Entrepreneurship

Policies should support green entrepreneurship through training programs that build waste literacy, particularly in waste-to-resource sectors. The latent economic value in waste, including opportunities in recycling, composting, upcycling, and waste-to-energy, can generate employment while reducing environmental burden.

Waste Literacy as a Productivity Investment

The empirical relationship between income and waste literacy (0.583) suggests that waste literacy is associated with economic capacity. Policymakers should frame waste literacy investments as productivity-enhancing, recognizing that educated populations generate less waste, consume more efficiently, and participate more effectively in circular economies.

Monitoring, Evaluation, and Research Policy

The development of the Waste Literacy Concept (WLC) and its statistical validation in this study provides a foundation for systematic monitoring and evaluation.

- *National Waste Literacy Index*

Governments should establish a national waste literacy index to track progress over time, identify vulnerable populations, and evaluate policy effectiveness. This index should build upon the methodology validated in this study, adapting the waste literacy framework and environmental outcomes measures to national contexts.

- *Research Funding Priorities*

The persistence of the attitude-behaviour gap, the intention-behaviour gap, and the knowledge-action gap across international contexts (Nisa et al., 2025; Sun & Hsiao, 2023; South African Citizens' Environmental Awareness Index, 2022-2024) indicates the need for continued research on effective interventions. Funding should prioritize longitudinal studies, experimental designs, and cross-cultural comparisons that identify scalable, sustainable approaches to building waste literacy.

- *Data-Driven Policy Adjustment*

The econometric models developed in this study provide a basis for evidence-based policy adjustment. Governments should integrate waste literacy indicators into environmental monitoring frameworks, using data to refine targeting, messaging, and resource allocation.

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