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Assessing household willingness to pay for waste management services in Tamale Metropolis

Abdul Waris Salifu Suhuyini[1], Michael Akwotajie[2], Muhammad Mu-utasim Yahaya[3]
University of Ghana, Ghana[1]
University for Development Studies, Ghana[2&3]
awssalifu@st.ug.edu.gh[1], Michaelak1654@uds.edu.gh[2], Muhammadmu-utasim1627@uds.edu.gh[3]

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Abstract

Purpose: Increasing trends in urbanization have reportedly resulted in an increase in waste generation. Therefore, this study seeks to estimate the amount of domestic waste generated, the factors that influence waste generation among these households, and the willingness of households to pay for abatement in urban and peri-urban areas in Tamale Metropolis.

Research methodology: This study adopted quantitative research approaches with descriptive and inferential methods to assess the determinants of waste generation and the factors influencing households' willingness to pay in the Tamale Metropolis. A total of 156 households in (12) communities were sampled for this study.

Results: The results revealed that, while the average waste generated in a household was 9.9 kilograms, factors such as age, educational level, household size, WMS, and income influenced the generation of waste by households and their willingness to pay for the management of waste in the metropolis. In terms of abatement of waste, about 41.3 % of the respondents were willing to pay abatement costs for waste disposal with 3.12 USD (GHC 18.10), which is the average amount these people were willing to pay for these services.

Limitations: The study covered only urban and peri-urban suburbs within the metropolis; hence, extending the study to other settlements could have unearthed diverse findings.

Contribution: This study advances knowledge on the quantity and types of solid waste generated in the metropolis and the factors that influence households to pay for waste management services. This study will also inform policymakers in understanding the dynamics of waste management in metropolises to implement policies to address associated problems.

Keywords: *Waste, Abatement, Cost, Urban, Peri-urban*

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1. Introduction

Almost all human activities, including industrial, construction, manufacturing, and residential activities, lead to waste generation (Lanibiar, 2017). Globally, the amount of waste generated currently stands at 2.24 billion tonnes per year (Worldbank, 2022). Evidently, the quantity of waste produced globally is unprecedented, and therefore, appropriate actions are required to manage its disposal. When waste is poorly managed or disposed of, it becomes a threat to human survival and environmental sustainability (Adongo et al., 2015; Heydari, Keshtidar, Azimzadeh, Talebpour, & Ramkissoon, 2021). Increased waste generation is reportedly associated with rising patterns of urbanization and changing consumption habits resulting from globalization (Adongo et al., 2015). In affirmation, UNDP (2018) revealed that an increasing number of the world's population now lives in urban centers, with the world's urban population expected to reach 2.5 billion people by 2050. While the population in these towns and cities has increased, waste disposal has become problematic considering the associated problems of urbanization, including congestion and overcrowding. Owing to the rising trend of urbanization and increasing waste generation, waste management has become a matter of great concern worldwide.

In Africa, waste management systems are characterized by poor waste collection, disposal and treatment facilities which make countries within the continent unable to manage waste effectively (Kumar, Bailey-Morley, Kargbo, & Sanyang, 2022). According to Godfrey et al. (2019), poor management of solid waste in Africa accounts for most of the health and environmental problems faced on the continent. Godfrey et al. (2019) revealed that waste production in Africa is projected to reach 244 million tons per year by 2025. Given the growing production of waste and the inability of waste management systems to safely collect, dispose, treat, or recycle waste, it is alarming that waste management can culminate in environmental hazards stemming from improper waste management. The information provided by UNEP (2015) indicates that the solid waste collection rate in Africa ranges from 25% to 70%, with an average collection rate of approximately 55%. Mpofu (2013) described these collection services as inconsistent, inefficient, and highly influenced by the spatial plans of settlements and household income levels.

In Ghana, Volsuuri, Owusu-Sekyere, and Imoro (2023) characterized the efficacy of solid waste management as deceptive and non-existent, given the prevailing state of waste management in the country. According to Miezah, Obiri-Danso, Kádár, Fei-Baffoe, and Mensah (2015), the amount of waste generated in Ghana is 0.47 kg/person per day, equivalent to roughly 12,710 tons of waste per day when factoring in the country's population. In Ghana, the local government authorities (Metropolitan, Municipalities and District Assemblies) assumed the responsibilities of solid waste management and hence waste collection services were provided by these authorities. Additionally, to augment the efforts of local governments in the management of waste in Ghana, the government of the country contracted the services of Zoomlion Ghana Limited in the management of waste in the country. Nonetheless, waste management in Ghana is still faced with inadequate collection containers (skips and wastebins) and other institutional challenges that result in poor refuse disposal in many cities in the country (Volsuuri et al., 2023). Ontoaneyin (2015) argued that the adequate availability of waste collection bins and their collection in cities is fundamental to effective waste management. In this regard, this leaves most cities with choked gutters and heaped refuse dumps thereby making the environment polluted.

Considering the poor nature of solid waste management in the country, various private organizations have introduced private waste management services, including treatment services, to aid in the collection and disposal of waste. Moreover, several policies and partnerships implemented in the country that were geared towards waste management failed to live up to expectations due to various factors, including political and negative attitudes of households to support its implementation (Volsuuri et al., 2023). Additionally, Puopiel (2010) revealed that the inability of households to afford door-to-door and curb modes of waste collection also accounts for the poor management of waste in the country. The study further revealed that some other households were unwilling to pay for these services, citing that these user charges were exorbitant and unaffordable to them.

Solid waste generation and disposal constitute one of the major problems facing the Tamale Metropolitan Area (Denteh, Cobbina, Adam, & Aboka, 2018). According to Puopiel (2010), metropolitan areas are currently faced with high levels of indiscriminate dumping of waste, inefficient waste collection routines, and inadequate waste management resources and logistics. The study further estimated that a total of 810 tons of waste is generated daily in the metropolis, and only 216 tons of this waste is hauled daily. This implies that 73% of the waste produced daily is left uncollected, polluting the environment. As urbanization is on the rise, the perimeter of urban areas grows, as well as surrounding peri-urban areas, thereby increasing human housing in these urban and peri-urban areas. The increase in human habitation in the peri-urban areas of the Tamale Metropolis means that households within these areas are more likely to generate more waste and, consequently, an increase in environmental pollution. Puopiel (2010) reported that the ratio of skip to low-class areas population in the Tamale metropolis was 1:9378 whereas the actual standard ratio should have been 1:700 and the ratio of dustbins to the population living in high-class areas was 1:3 whereas the actual standard should have been 1:1.

Puopiel (2010) further indicated that this could be one of the reasons why about 40% of the people in the metropolis resort to disposing of their solid waste indiscriminately. According to GSS (2014), the most common method of waste disposal in the metropolis is through public dumps (containers), which accounts for 98.3% of households in urban areas and 1.7% in rural metropolises. However, disparities in terms of accessibility and availability of waste collection bins in households exacerbate the waste management situation in metropolitan areas (Volsuuri et al., 2023).

Numerous studies have been conducted in metropolises, especially in the field of waste management (Denteh et al., 2018; Lanibiar, 2017; Ontoaneyin, 2015; Puopiel, 2010; Volsuuri et al., 2023).

However, these studies failed to explore households' willingness to pay for waste management services. Therefore, this study intends to fill in the gap between how much waste is generated in these areas and how much people are willing to pay for their waste to be disposed of. This study explored the amount of domestic waste generated by households in both urban and peri-urban areas in Tamale Metropolis, and the amount households are willing to pay for abatement.

Specifically, this study seeks to address the following objectives:
1. To estimate the quantity of waste generated by households in urban and peri-urban areas in the Tamale Metropolis
2. To estimate the abatement cost of waste disposal in the Tamale Metropolis
3. To identify the factors influencing households' willingness to abate waste in Tamale Metropolis

2. Literature Review

2.1 Waste

Numerous studies and analyses have explored the origins and features of waste along with the potential adverse effects of improper handling and global best practices. However, a precise definition of what constitutes waste remains elusive. The Longman Dictionary of Contemporary English describes waste as "the unwanted material or substance left after usage" (p.1612). The UN Statistics Division defines waste as "materials, not prime products, with no further use according to the generator's production, transformation, or consumption purposes, and intended for disposal' (Shah, 2007). The Organization for Economic Cooperation and Development (OECD) views waste as "unavoidable materials lacking near-future economic demand, necessitating treatment and/or disposal" (Mahrum & Jones, 2009). Synthesizing these perspectives, this study defines waste as any material or substance discarded or no longer serving a particular purpose.

2.2 Classification of Wastes

2.2.1 Classification of waste based on material composition

Waste originating from residential zones falls under the category of residential waste, whereas byproducts from plant cultivation and livestock rearing are termed agricultural waste (Obi, Ugwuishiwu, & Nwakaire, 2016). Similarly, the content composition of waste streams serves as the basis for categorizing waste into distinct types, including plastic, textiles, organic waste, cardboard and paper, glass, metal, and inert waste (Adeleke, Akinlabi, Jen, & Dunmade, 2021). Tchobanoglous, Theisen, and Vigil (1993) elaborated on the classification of waste according to its material composition, as outlined in the table below

Table 1. Type of waste and their examples

Waste type	Examples
Paper	Cardboards, office waste paper, newspaper, magazine/glossy
Plastics	Expanded polystyrene, film plastics, bottles, and other rigid plastics

Glass	Green glass, amber glass, clear glass, non-recyclable glass
Metals	Aluminium cans, steel cans, other ferrous, other aluminium
Organics	Yard waste-grass, yard waste-other, wood, textiles, fines, diapers, other organics
Inorganics	Carpets, electronics, drywall, other construction and demolition, other inorganic

Source: Tchobanoglous et al. (1993)

2.2.2 Classification of waste based on its physical state

The physical characteristics of waste aid in its classification into various forms such as liquid, solid, gaseous, and radioactive waste. Solid waste, as described by Oyelola and Babatunde (2008), is defined as non-liquid waste originating from diverse sources, including commercial, domestic, industrial, and agricultural origins.

Table 2. Type of waste based on their physical state

Waste type	**Examples**
Solid waste	Food-related waste, paper, plastic, metal, debris Sewage
Liquid waste	Sewage sludge, wastewater from the bath house and kitchens Factory
Gaseous waste	Smoke from factories smoke from vehicles, smoke and fumes from waste burnt
Radioactive waste	Radiation, uranium, plutonium, excess energy

Source: Tchobanoglous et al. (1993)

2.2.3 Classification of waste based on decomposition

Solid waste comprises a diverse array of materials with various properties. Within this category, some materials, such as plastics, paper, food waste, wood, textiles, and other organic substances, are combustible and capable of burning. However, non-combustible materials, including metals, bones, glass, leather, and aluminum, do not possess the ability to burn (Puopiel, 2010). Additionally, the recyclability of waste materials differs, with some being suitable for recycling processes while others are not.

Table 3. Waste type based on decomposition

Waste type	**Examples**
Biodegradable waste	Green waste, food and kitchen waste, paper (can be recycled)
Recyclable waste	Paper, glass bottles, cans, metals, certain plastics,
Inert waste	Construction and demolition waste, dirt, rocks debris,
Composite waste	Waste closing, Tetra Packs, waste plastics such as toys
Domestic hazardous waste and toxic waste	Drugs, E-waste, paints, chemicals, light bulbs, spray cans, batteries, shoe polish materials

Source: Venkata rajeev, Prasad, and Rama (2014)

2.3 Differences between Urban and Peri-Urban Areas

The term "peri-urban" is widely used in the literature, yet its definition is context-specific, offering limited insight into what constitutes a peri-urban zone. Depending on context, peri-urban areas may refer to a location, process, or concept. In a location-based context, it represents the rural-urban fringe and transitional zone surrounding a city, characterized by intense interaction, flows, and linkages between rural and urban areas (Varkey & Manasi, 2019).

Defined as the most actively urbanizing zone influenced by the urban core, a peri-urban area serves as the interface between the urban and rural regions (Ravetz, Fertner, & Nielsen, 2012). This denotes a transition or interaction zone where urban and rural activities intertwine (Goswami, 2018). For this study, a unique definition was adopted: peri-urban areas are characterized by structures resulting from dispersed urban growth, incorporating landscape fragments of both urban and rural characteristics. Peri-urban areas occupy the intermediate space between urban and rural zones, tailored specifically for this study.

In contrast, an urban environment is broadly characterized by population density, concentrations of administrative bodies and services, and a spectrum of income-generating activities. Urban areas, as defined in this study, are human settlements marked by high population density and built environment facilities, distinguishing them from other areas (WVI, n.d.).

2.4 Solid Waste Management

Different authors have presented different definitions of solid waste management. Puopiel (2010) characterised it as "the administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of waste." Effective management of solid waste in Ghana is a substantial challenge for Metropolitan, Municipal, and District Assemblies (MMDAs). The escalating volume of solid waste, driven by urbanization and population growth, creates challenges for MMDAs. This situation is further complicated by the indiscriminate disposal of domestic waste, which results in littering and accumulation (Puopiel, 2010).

Godfrey et al. (2019) noted that in many low and middle-income countries, including Ghana, a substantial portion of solid waste remains uncollected. This uncollected waste often finds its way to illegal dumps in streets, wastelands, and open spaces. Adu-Boahen et al. (2014) argued that irregular services provided by Municipal Councils compel households to dispose waste in an unrestricted manner. In Ghana, Adu-Boahen et al. (2014) seem to hold true because the country’s waste management system is inefficient and ineffective (Volsuuri et al., 2023).

2.5 Challenges of Waste Management in Ghana

Puopiel (2010) highlights that solid waste management systems in developing countries are fraught with challenges, encompassing low collection coverage, irregular collection systems, unauthorized open dumping, and inadequate regulation of air and water pollution. Various studies including those conducted by Volsuuri et al. (2023); Baabereyir (2009); & Oduro-Kwarteng (2011)have identified factors impeding solid waste management (SWM) in Ghana. These factors are categorized as rapid urbanization, high population growth, resource constraints, inadequate implementation of regulations, and poor governance of SWMs.

2.5.1 Resource Constraints

Resource constraints in solid-waste management include human, financial, and equipment limitations. Inadequate financial resources stemming from low-cost recovery and insufficient funding pose challenges to local authorities and private contractors. In a study on the implementation of waste management policy in Timor Leste, Da Silva and Toda (2021) revealed inadequate waste management infrastructure and human resources affected the effective implementation of waste management policies in the country. Insufficient funding also hampers the ability of local authorities to develop the necessary solid waste infrastructure to meet the growing demand for waste-management services. This financial strain is exacerbated by the Communal Container Collection (CCC) system, which is responsible for 70% of solid waste disposal and is nearly free of charge. This places considerable financial pressure on authorities, making it difficult for private contractors to meet financial obligations promptly. The delayed payment by local authorities adversely impacts private contractors' capacity to deliver quality services to beneficiaries (Alhassan, Asante, Oteng-Ababio, & Bawakyillenuo, 2017).

Furthermore, a significant hurdle in solid waste management arises from a lack of technical expertise among waste management officers, particularly at the local level. Many officers lack technical know-how in the management of solid wastes and, thus, further complicate the effective execution of waste management initiatives (Puopiel, 2010).

2.5.2 Weak Implementation of Regulations and Poor Governance of SWMs

Inadequate enforcement of solid waste management by law contributes to a nonchalant attitude among the populace regarding illegal dumping. This lax behavior worsens the challenges associated with solid waste disposal and places additional burdens on Solid Waste Committees (SWC), transportation, and disposal efforts for local authorities already grappling with limited resources. Government regulation implementation is often subpar, possibly because of a lack of capability, resources, political will, and institutional setup issues (Oduro-Kwarteng, 2011). Poor enforcement of by-laws significantly hampers efforts to address the ongoing solid waste management issues in these cities (Ampofo, Soyelle, & Abanyie, 2016). Poor enforcement of waste regulations undermines efforts put in place to curb waste problems (Alim, 2023). Effective enforcement of waste regulations is a prerequisite for effective waste governance and management. In Biyanto, Fadlan, and Prasetiasari (2023) and Seneviratne and Kalpani (2020), effective enforcement of good industrial waste practices formed part of the strategies of industries and manufacturing companies to promote environmental management.

2.5.3 Rapid Urbanization and High Population Growth

Rapid urbanization poses a significant challenge to the management of urban solid waste. The swift and uncontrolled expansion and development of urban areas creates a scenario where the infrastructure for solid waste services struggles to keep pace with population growth. Accelerated and unregulated urbanization in developing countries presents substantial issues for urban authorities, particularly in sanitation and solid waste management (Oduro-Kwarteng, 2011). In developing nations, elevated levels of urbanization correspond to increased volumes of solid waste generated. In third-world countries, mitigating the numerous adverse impacts of rapid urbanization is crucial, and poor waste management is emerging as a notable challenge.

2.6 Factors Influencing Willingness to Pay

Socioeconomic factors play a crucial role in determining individuals' willingness to pay (WTP) for solid waste management (SWM) services, influencing economic assessments, and policy considerations. Maskey and Singh (2017) identified income, education, environmental awareness, and waste collection services as significant variables affecting households' WTP for SWM services in NepalMaskey and Singh (2017). Sizya (2015) study in Tanzania highlighted marital status, education, income, household type, and legal regulations as important factors explaining WTP for SWM among households in Mwanza City. Similarly, Manga, Oru, and Ngwabie (2019) found that gender, age, income level, location (residential area), type of employment, and house type are significant factors that influence WTP.

In Ghana, Alhassan et al. (2017) identified gender, education, income, occupation type, satisfaction with SWM services, attitude, subjective norms, and location as significant variables in explaining households' WTP for SWM services. However, Boateng et al. (2019) argued that educational level, marital status, area of occupation, and region of residence predicted households' willingness to pay for solid waste management services. Addai and Danso-Abbeam (2014) also reported that gender, age, education, and household characteristics were significant variables influencing households' WTP for SWM services. In contrast, Seth, Cobbina, Asare, and Duwiejuah (2014) found no strong linkage between WTP for SWM services and socio-economic characteristics such as age, education, income, and employment.

2.7 Determinants of Household Solid Waste Generation

Numerous studies have explored the intricate relationship between the quantity and composition of household solid waste and various social and economic variables. Tassie Wegedie (2018) a study on household waste management in Ethiopia, Tassie Wegedie (2018) adopted a multiple regression analysis utilizing socioeconomic factors such as monthly household income, household size, educational status, extra land area in the compound, availability of solid waste management services, and age of the household. In this study, the quantity of waste generated per household was the dependent variable for socioeconomic factors. The results indicate that both income and household size exhibit a highly positive and significant correlation.

Similarly, Trang, Dong, Toan, Hanh, and Thu (2017) examined income, environmental concern, education, and household size as independent variables of household solid waste generation in Vietnam. This study found a positive and significant relationship between household size and solid waste generation, indicating that larger households tend to generate more waste. Additionally, the study revealed a negative but significant relationship between environmental concerns and household solid-waste generation. Moreover, income showed a negative but significant association with household solid waste generation, suggesting that higher income levels were linked to lower solid waste generation.

2.8 Contingent Valuation Method (CVM)

The Contingent Valuation Method (CVM) is a widely used survey-based approach to estimate the economic value of goods not typically traded in markets. This involves assessing individuals' willingness to pay (WTP) for certain goods or services through hypothetical scenarios. The flexibility and simplicity of the CVM make it popular in cost-benefit analyses and environmental impact assessments (Venkatachalam, 2004). Researchers emphasize its application in appraising societal benefits derived from public goods, with CVM surveys serving as a key tool for estimating these values (Antony & Rao, 2010). This is undertaken by asking a respondent a question or a series of questions about how much they value a good or a service. Individuals or households were asked to directly state or reveal how much they were willing to pay for an environmental good or service. Alternatively, they may be asked if they are willing to accept the good (Parajuli & Kanel, 2016).

The theoretical groundwork for the Contingent Valuation Method (CVM) can be traced back to S.V. In 1947, Ciriacy-Wantrup explored the elicitation of market valuations of non-market goods (Mitchell & Carson, 2013). However, the formalization and widespread adoption of CVM as a survey-based approach to valuing non-market goods occurred in later decades. In 1963, Davis pioneered the practical use of the method by employing surveys to assess the value assigned by hunters and tourists to a specific wilderness area (Davis, 1963). By juxtaposing survey outcomes with a value estimate derived from travel expenses, he identified a noteworthy correlation with his findings. This method gained prominence in the late 20th century, particularly in the field of environmental economics (Carson, 2012).

3. Methodology

The study adopted quantitative approaches for the collection and analysis of data. This study incorporated data from both the primary and secondary sources. Primary data collection involved the use of a structured questionnaire administered through face-to-face interviews with selected households. This approach aimed to minimize non-response and incomplete data by directly engaging with the participants. Data from secondary sources were collected from published articles and from other relevant organizations. In the data analysis, STATA v15 was used to conduct all descriptive and inferential analyses.

3.1 Sample Size Determination

Based on data from the Ghana Statistical Service (GSS), Tamale Metropolis has a total number of 219,971 households. Using these data with a 92% confidence interval, the sample size of the study was determined using the following formula:

$$n = \frac{N}{1 + N(\alpha)^2}$$

where *n* is the sample size, N is the sample frame, and α is the error margin.
Substituting into the formulae

$$n = \frac{219{,}971}{1 + 219{,}971(0.08)^2}$$

$$n = 156.1390911$$

$$n = 156$$

Therefore, the sample size in this study was 156.

3.2 Sampling Technique

This study adopted a mixed sampling technique to select participants for the study. Firstly, the cluster sampling technique was used to subdivide the Tamale Metropolis into three (3) clusters or groups namely; Tamale South, Tamale North, and Tamale Central. Four (4) communities were selected randomly from each cluster. Simple random sampling was used to select thirteen (13) households from each of the twelve (12) communities. A total of 156 households participated in the study.

3.3 Method of Data Analysis

3.3.1 Amount of Waste Generated by Urban and Peri-Urban Households

The amount of waste generated by households in urban and peri-urban areas was estimated, and the difference between locations was tested using Welch's t-test. Welch's t-test is an inferential statistic which was used to test the hypothesis that urban areas generate more waste than peri-urban areas.

3.3.2 Determinants of Household Waste Generation

Multiple linear regression was employed to identify the factors influencing household waste generation in the Tamale Metropolis. This modelling choice was driven by the nature of the dependent variable, which involved continuous data representing the quantity of waste generated. The analysis focused on understanding the relationship between the amount of waste produced in households and various socioeconomic variables, including location (urban and peri-urban areas). The multiple linear regression model, utilizing Ordinary Least Squares (OLS) estimators, was designed as an average response model. It aims to establish the connection between the dependent variable (in this case, the quantity of waste generated) and socioeconomic variables. Through this statistical approach, the model can provide estimates of the magnitude of the effects of each explanatory variable on the quantity of waste generated by households. The multiple linear regression model has the following formula.

$$y_i = \beta_0 + \sum_{j=1}^{p} \beta_j x_{ij} + \varepsilon_i$$

i= (1, 2, 3…, n) where

y_i is the real-valued response for the i-th observation

β_0 is the regression intercept

β_j is the j-th predictor's regression slope

x_{ij} is the j-th predictor for the i-th observation

Several studies have pointed out that the quantity of waste generated by households is largely influenced by monthly income, household size, educational status, extra land area in the compound of the selected household, age of the household head, waste management services available to the household, and many others. Following this, the empirical model is given as

$$Q_i = \beta_0 + \beta_1 IHH_i + \beta_2 HHS_i + \beta_3 EL_i + \beta_4 ELA_i + \beta_5 WMS_i + \beta_6 AHH_i + \varepsilon_i$$

Where:

Q=Quantity of waste generated per household (kg)

IHH=Monthly income of the household
HHS=Household size
EL=Educational level of household
ELA=Extra land area in the compound of the selected household
WMS=Waste management services available to household
AHH=Age of the household head or respondent
ε = the error term or random error

3.3.3 Estimate the Abatement Cost of Waste Disposal

According to the Food and Agriculture Organization (FAO), contingent valuation (CV) is a method of estimating the value that a person places on a good. This approach requires people to report their willingness to pay (WTP) to obtain a specific good. Willingness to pay is the maximum amount an individual is willing to hand over to obtain a good.

Contingent valuation was used to estimate the abatement cost of waste disposal. Individuals within households were asked about the current situation of waste management compared to an alternative state of the said situation. This is usually performed in the form of a hypothetical market scenario. Therefore, individuals were expected to state their willingness to pay, if any, for the alternative situation presented. This method involved face-to-face interviews with individuals within the household. A questionnaire valuation technique was used to directly obtain respondents' WTP by asking households how much they were willing to pay for abatement.

3.3.4 Identify Factors Influencing Households' Willingness to Abate

Households have varying decisions concerning their willingness to pay for the abatement of waste generation; hence, there is a need to determine the determinants of willingness to pay. There is a need to regress certain socio-economic variables on willingness to pay to estimate how these variables influence the amount households are willing to pay for abatement. Willingness to pay is a continuous variable and hence multiple linear regression was used to investigate the socio-economic factors influencing it.

The empirical multiple linear regressions for the factors influencing households' willingness to abate are given as

$$WTP_i = \beta_0 + \beta_1 AHH_i + \beta_2 GEN_i + \beta_3 EL_i + \beta_4 MS_i + \beta_5 EMP_i + \beta_6 IHH_i + \beta_7 RES_i + \beta_8 WMS_i + \varepsilon_i$$

3.4 Study area

Tamale is the capital city of the Northern Region of Ghana. Tamale is a metropolitan area with a growing population, similar to other metropolitan areas, such as Kumasi and Accra. As urbanization is increasing in Tamale, there is an environmental problem of how the waste generated is managed effectively. It has a population of 374,744, which represents the greatest number in the region (9.4 %). The majority of the population lived in urban localities, accounting for 80.8%, and those living in rural localities accounted for 19.1%. The total number of households in the Tamale Metropolis was 219,971, with 19,387 houses. The metropolis has an average household of 6.3 individuals per household (GSS, 2014).

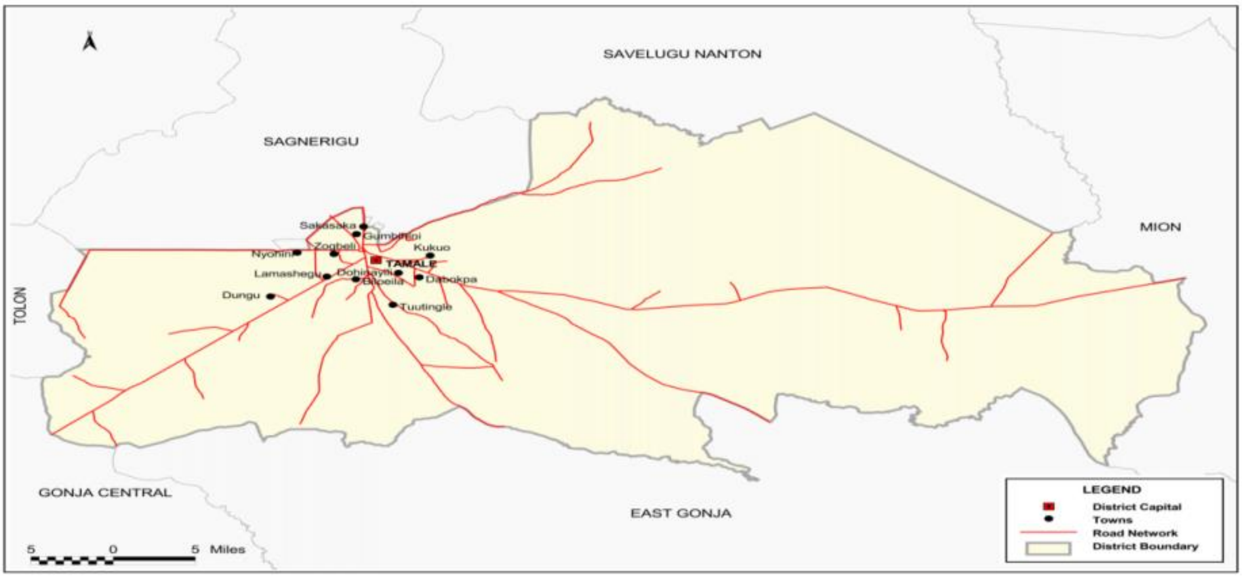

Figure 1. Map of Tamale Metropolis
Source: GSS (2014)

4. Results and Discussions

4.1 Socio-Economic Characteristics of Population

Predominantly, the households had more males as household heads, with approximately 89.4% of them being males and the remaining 10.6% females. This finding is typical of most households in Ghana, as it has cultural underpinnings, which explains why most household heads are male and, hence, decisions regarding household management, including waste management, are influenced by these heads. The Ghana Statistical Service (2022) of the 2022 Demographic and Health Survey revealed that more than 50% of households in the country are headed by males. In addition, 92.5% of household heads were married, 2.5% were single, 0.6% divorced, and 4.4% windowed. The lowest and highest household sizes were 1 and 25 respectively with 7.0 being an average household size.

In a study of household solid waste management in Tamale, Denteh et al. (2018) revealed a significant relationship between household size and waste generation rate, implying that household size is likely to influence the amount of waste generated by the household. In terms of education, the study revealed that the majority of the respondents (60.6%) had access to formal education while the remaining 39.4% had no access to formal education. This is consistent with the findings of Ontoaneyin (2015), who found that the majority of respondents (more than 90%) had attained some level of formal education in a study of solid waste management services in a metropolis. Moreover, while 6.9 % of the household heads were unemployed, a greater proportion representing 93.1% were employed. The average income of the household heads was (US$ 180) GHS 1,042.69 per month with minimum and maximum income made by a household head being (US$ 17.2) GHS 100 and (US$ 862) GHS 5,000, respectively. The average age of a household head is 43 years, while the youngest and oldest household head's ages are 21 and 89 years, respectively. The age category of 18-36 represented 31.2% of the sampled household heads, the 36 to 65 age group category represented 62.5% of the population, and the above 65 age group represented 6.3% of the respondents.

Table 4.Socio-Economic Characteristics of Population

Variables	**Frequency**	**Percentage**
Gender		
Males	139	89.4
Females	17	10.6
Marital status		
Married	144	92.5

Single	4	2.5
Divorced	1	0.6
Widowed	7	4.4
Educational status		
Formal	95	60.6
Non-formal	61	39.4
Age		
18-35	49	31.2
36-60	98	62.5
Above 60	10	6.3
Employment status		
Employed	145	93.1
Not employed	11	6.9
Income per month (GHS)		
Less than 1000	23	14.7
1000 - 2,500	79	50.6
2,500 - 4,000	30	19.2
4,000 Plus	24	15.4
	Mean = 1042.69	
Total	156	100

Source: field survey, 2020

4.2 Quantity of waste generated by households in urban and peri-urban areas in Tamale Metropolis

Per the data collected and analyzed from the urban and peri-urban areas from 12 residential areas in the Tamale metropolis, 1,584 kg of solid waste was generated by the households daily. This is far higher than Denteh et al. (2018) of 22.07 kg/day waste generated by respondents. Findings from the study further revealed that most of the waste (69%) was generated by households in urban areas, whereas 31% was generated by peri-urban areas. The average waste generated in an urban household was 6.83 kilograms while the average waste generated in a peri-urban household was 3.07 kilograms daily. This is a result of the fact that urbanization is on the rise, and hence, the consumption rate of people in these urban areas also increases. Thus, the amount of waste generated was relatively high in these areas. According to Puopiel (2010), the urbanized nature of the metropolis greatly influences the amount of waste generated and its disposal, and hence supports the finding that more waste is generated in the urban areas of the metropolis. The Welch's t-test was used to test the differences in the amount of waste generated at these two locations. The results show that the p-value for the alternative hypothesis test is 0.000, which is less than 0.05, implying that there is a statistically significant difference in the amount of waste generated between these two areas. The figure below also illustrates the quantity of waste generated in urban and peri-urban areas, measured in kilograms.

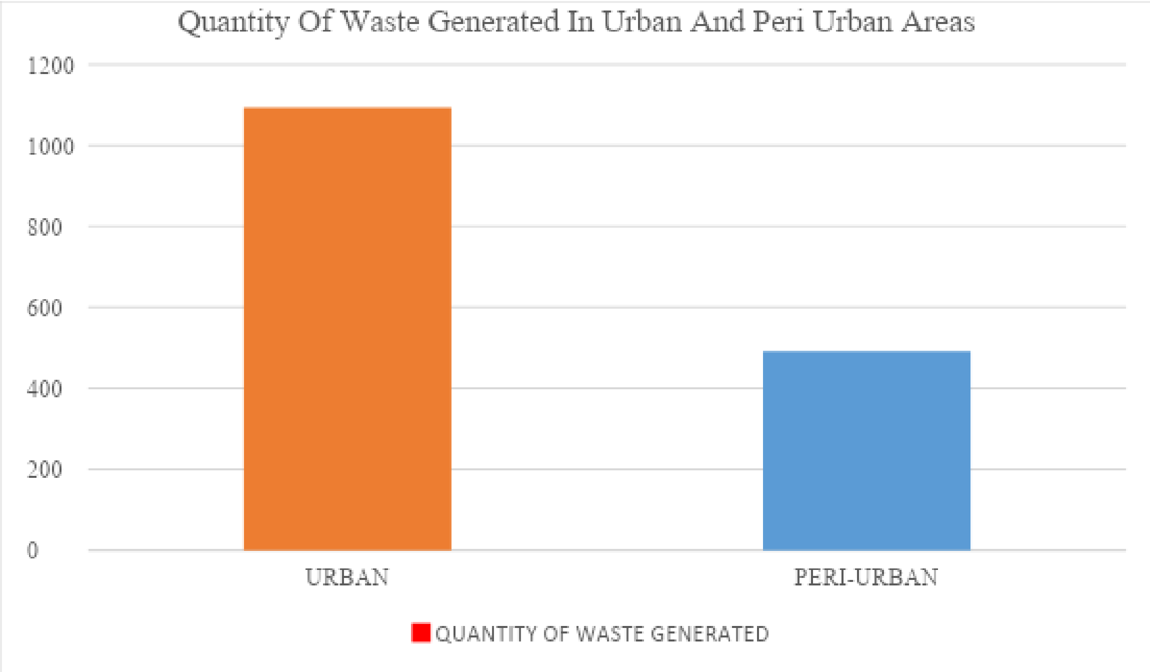

Figure 2. Quantity of waste generated by urban and peri-urban areas per day in Tamale metropolis.
Source: Field survey (2020)

Table 5. Welch's t-test results on the differences in waste generation between the two locations

Group	Mean	Standard error	Standard deviation
Urban	13.66	0.881	7.88
Peri-urban	6.14	0.571	5.10
Difference	-7.525	1.049	
H_0: diff=0			t = -7.1682
H_A: diff<0	H_A: diff!=0	H_A: diff>0	Welch's degree of freedom = 136.766
Pr (T<t)=0.000	Pr(|T|>|t|)=0.000	Pr (T>t)=1.000	

The figure below is a box and whisker plot that illustrates not only the difference in waste generation level in the community, but also the interquartile range, median and extremes, and outliers in the data gathered. From the figure below, there is an outlier in the data of the urban areas, which is marked around 48kilos therefore the maximum amount of waste was generated by a household in the urban areas. In the peri-urban section of the figure, the outlier is marked at 18kilos thus representing the maximum amount of waste generated by a household in peri-urban areas. This supports the findings of several studies that urbanization is an influencing factor on the quantity of waste produced globally.

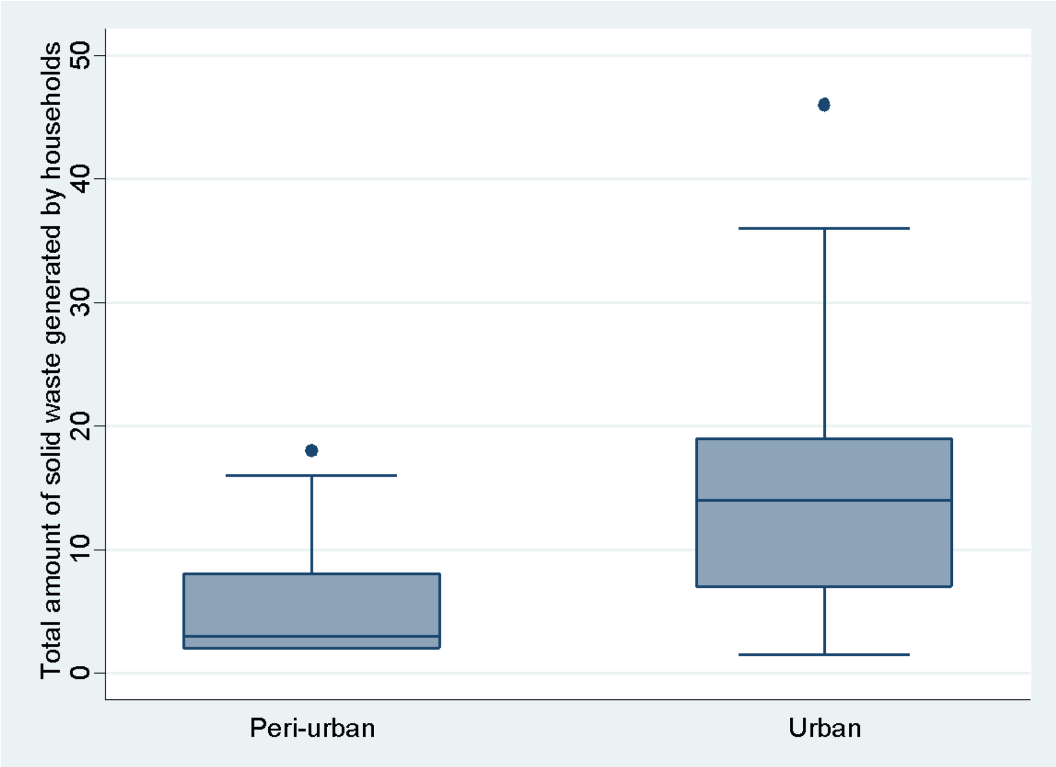

Figure 3. Box plot visualizing the distribution of waste generated between the two locations

4.3 Determinants of wastes generated by households in the metropolis

The multiple linear regression model indicated that at the urban level, the variables age, household size, and educational level were all positive and significant at the 1% level. Income is also positive and significant at the 5% level. Similarly, Denteh et al. (2018) found a positive relationship between household size and the quantity of waste generated in a metropolis. This is premised on the fact that the higher the number of people in a household, the higher the consumption rate, and thus, more waste is produced. The waste management services available were positive and significant at the 1% level. This implies that the availability of waste management services significantly influences the amount of waste generated by households in urban areas. In a study on waste management services in the metropolis, Ontoaneyin (2015) revealed that in the absence of waste management services, households tend to produce so much waste as there are no collection and disposal sites. The extra land area within the compound was negative and not statistically significant at any of the statistically accepted levels. In peri-urban areas, educational level and waste management services were negative and significant at the 1% level. This simply means that when more people are educated about the hazards of excess waste generation, they tend to reduce the amount of waste generated in their communities. Additionally, Age, household size, and income were negative and non-significant. The extra land area within the compound was positive and not statistically significant at any of the statistically accepted levels. Generally, in both localities, waste management services were positive and significant at the 1% level. Age and household size are positive and significant at the 5% level. Income was also positive and significant at the 10% level. This meets a priori expectations because when a household's income increases, they tend to spend more on goods and items, which generates more waste in the household. Additionally, the extra land area within the compound was negative and not statistically significant at any of the accepted levels. Educational level is positive but not significant

Table 6. Determinants of Waste Generated in Urban and Peri-urban Households

	Urban Households			**Peri-urban households**		
Variables	***Coefficients***	***Std. Err***	***p-values***	***Coef.***	***Std. Err***	***p-values***

Age	0.0983352	0.0335039	0.004***	-0.0173934	0.0290272	0.550
Educational level	0.2816717	0.0676098	0.000***	-0.1767876	0.058576	0.003***
Income	0.0011038	0.0004942	0.027**	-0.0000681	0.0004282	0.874
Household size	0.3043299	0.0980296	0.002***	-0.0671827	0.0849311	0.430
Waste Management Service	10.48959	1.245032	0.000***	-2.668263	1.078674	0.014***
Extra land area in the compound	-1.158943	1.00884	0.252	0.1781794	0.8740412	0.839
Constant	-5.137584	1.926433	0.008***	6.473908	1.669027	0.000***
	Number of Obs. = 158 Adj. R-squared = 0.6854 Prob. > F = 0.0000 R-squared = 0.6974			Number of Obs. = 158 R-squared = 0.2153 Prob. > F = 0.0000 Adj. R-squared = 0.1842		

***, **, and * at 1%, 5% and 10% significance level respectively.
Source: Processed data by STATA (2020)

4.4 Estimation of the Abatement Cost of Waste Disposal in Tamale Metropolis

In estimating the abatement cost of disposal in the Tamale metropolis, the study revealed that while 41.3% of the respondents were willing to pay for the disposal of their waste, a greater proportion representing 58.7% were reluctant to pay for their waste disposal. The average amount that a household is willing to pay is GHC 18.10. The minimum amount a household is willing to pay is GHC 0.00, whereas the maximum amount a household is willing to pay is GHC 35.00. Findings from the study suggest that the majority of the respondents were not willing to pay for the abatement cost of disposing of waste. In a study by Ontoaneyin (2015), the monthly charge for refuse disposal ranged from 15 to GHC 50 depending on the quantity of waste, implying that the average number of households willing to pay for abatement costs fell within this range. However, Puopiel (2010) revealed that some of these service charges were exorbitant, which explains the reluctance of households to pay abatement costs in the metropolis.

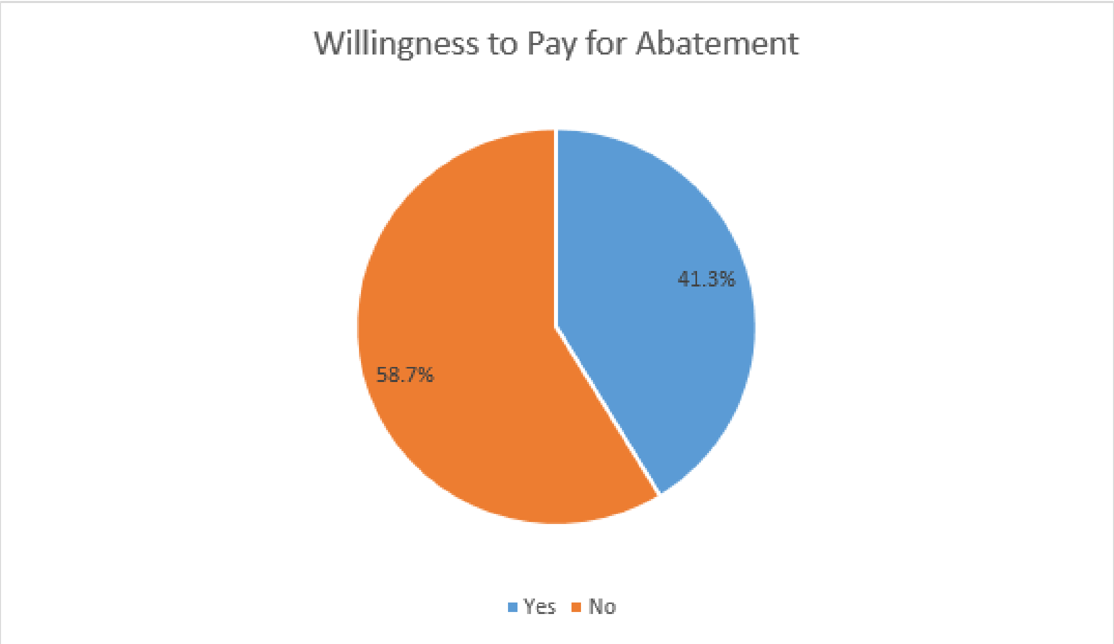

Figure 4. Willingness to pay for waste disposal
Source: field survey (2020)

4.5 Factors Influencing Households' Willingness to Abate waste in Tamale Metropolis

The findings revealed several significant factors that influence households' WTP for waste disposal. Age and residence type exhibited negative and significant associations at the 10% significance level. This indicates that, as an individual's age increases, they become less inclined to pay for waste disposal, holding other factors constant. Similarly, individuals residing in compound houses show lower willingness to pay than those in apartments or flats, all else being equal. This aligns with Manga et al. (2019), who emphasized the influence of residence type and age on households' WTP. Education level and income demonstrated positive and significant effects at the 1% level. This implies that an increase in educational level or income by one unit corresponds to an increase in willingness to pay by a margin equivalent to their respective coefficients. These results are consistent with those of Maskey and Singh (2017), highlighting the significant impact of education and income on households' willingness to pay for waste disposal. Household type and house ownership displayed negative and significant associations at the 1% level. This suggests that individuals in nuclear households and those who own their houses are less willing to pay for waste disposal than their counterparts in extended households or those living in rented apartments, all else being equal. Sizya (2015) also supported the impact of household type on households' willingness to pay for waste disposal by solid waste management (SWM).

Table 7. Factors influencing the willingness of households to pay for waste disposal

Variable	**Coefficient**	**Std. Err**	**t. stats**	**P. value**
Age	-0.0053755*	0.0031437	-1.71	0.089
Gender	-0.1049736	0.1110027	-0.95	0.346
Educational level	0.0148128***	0.0059254	2.50	0.014
Marital status	0.054641	0.0576737	0.95	0.345
Employment status	0.0299636	0.1482948	0.20	0.840
Income	0.0001357***	0.0000396	3.43	0.001
Location	0.1248355	0.0878898	1.42	0.158
Household type	-0.4000232***	0.1096913	-3.65	0.000
Dependency	0.0044282	0.0093252	0.47	0.636
Residence type	-0.1638396*	0.0949859	-1.72	0.087
Frequency of waste disposal	0.0244528	0.0329386	0.74	0.459
Awareness of health implications	-0.0929664	0.1434869	-0.65	0.518
Ownership of house	-0.2069275***	0.0753593	-2.75	0.007
Constant	0.9742164***	0.3189572	3.05	0.003
Number of obs. 156	Prob. > F = 0.0000	R-square= 0.5209	Adj. R-squared = 0.4776	

***, **, and * at 1%, 5% and 10% significance level respectively.
Source: Processed data by STATA (2020)

5. Conclusion

5.1 Conclusion

This research details the domestic waste generation and abatement costs in urban and peri-urban households, and the differences in waste generated in these areas in the Tamale metropolis. It outlined the amount of waste generated in both urban and peri-urban areas and tested for the statistical difference in waste generated between the two areas in the metropolis. It also details the factors that determine a household's waste generation and cost of abatement for waste disposal. The factors that influence a household's willingness to pay for waste disposal are also outlined. Data were obtained from a sample of 156 people from 12 communities in the metropolis and analyzed. The results showed that 1,584 kg of solid waste were generated in households per day. Additionally, 69 % of the waste is generated in the urban areas, while 31% of the total waste generated comes from the peri-urban areas. The results also showed statistically significant differences in the amount of waste generated between the two areas. At the urban level, the variables age, household size, educational level, income, and waste management services available influenced the amount of waste generated in the household. In peri-urban areas, educational level and waste management services had a negative influence on household waste generation. Collectively, the analysis of both locations showed that waste management services, income age, and household size had a positive influence on waste generation. In terms of abatement cost and willingness to pay for waste abatement, 41.3% of the respondents were willing to pay for the disposal of their waste, while 58.7% were not willing to pay for their waste disposal. The average amount that a household was willing to pay was GHC 18.10. The factors that influence household willingness to pay for waste abatement also include age, household type, educational level, income, ownership of house, and residence type. Based on these findings, the study suggests the following policy recommendations.

5.2 Recommendations

The findings of this research highlight the need for the policy recommendations outlined below. This will help ease the problems associated with waste disposal in the Tamale metropolitan area.

1. The government, especially the Metropolitan Assembly, should pass sanitation laws and by-laws to curb issues related to the improper disposal of waste. Measures should be put in place to deter people from the indiscriminate disposal of waste.
2. Government agents, including the Metropolitan Assembly, should collaborate with waste management service providers such as Zoomlion and Savanna waste management services to subsidize the cost of waste management services, such as collection and disposal services. This will help reduce the financial burden on household heads and encourage more households to patronize their services.
3. The Ministry of Sanitation and Water Resources should also ensure the equitable provision of waste management logistics and facilities in bigger cities and towns, including Tamale Metropolis, as the inadequacy of these essentials leads to the indiscriminate disposal of waste in the country.

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