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Determinants of Household Solid Waste Generation Rate in Gondar Town, North West Amhara, Ethiopia

Endeshaw Assefa Derso*, Mequanent Wale

Department of Statistics, University of Gondar, Gondar, Ethiopia

Email address:
enduass@gmail.com (Endeshaw Assefa Derso)
*Corresponding author

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Abstract: Most developed countries recognized that household waste is very crucial for survival in addition to securing the safety of the environment and human health. However, developing countries like Ethiopia, let alone use its economic benefits, because of various reasons are dumping wastes in unauthorized sites, which easily expose to harsh hazards, like environmental pollution and health problem. The purpose of this study was to identify factors affecting the waste generation rate of households in Gondar town of Maraki sub-city from October 21, 2020 to December 2nd, 2020. Community-based cross-sectional was conducted. Data were collected from 196 households, which were selected through simple random sampling from five kebeles (stratum). The Obtained data were analyzed using SPSS Version 20. Multiple linear regression was done to identify the independent predictors of household-based waste generation rate. The results from the multiple linear regression models revealed that Age, marital status, occupation, ownership, sex, education level, and family size significantly ($p < 0.05$) contribute to the household generation rate. The average generation rate of households in Maraki sub-city was 3.94 kg/capita/week. In conclusion: The current study revealed that household waste generation was high in the study area. Age, marital status, occupation, ownership, sex, education level, and family size were found to be associated with household waste generation. Therefore, the town municipality must develop an appropriate waste management plan and implement it properly.

Keywords: Generation Rate, Households, Multiple Linear Regression Models, Ethiopia

1. Introduction

1.1. Background

Waste was an early problem of mankind and a growing one that is of major concern to every nation of the world [4]. Solid waste means any garbage, refuse, and other discarded solid materials, including solid waste materials resulting from community activities or as materials generated from the result of human daily activities resulting from areas such as households, public places, and city streets, shops, offices and hospitals and municipal solid waste is defined refuses from households, industrial, commercial and institutional establishments (including hospitals), market waste, yard waste and street sweepings [9]. Municipal solid waste management is a problem that is experienced by all counties in the world. Because of its nature, it has remained one of the major environmental problems man continues to face [11]. It is an issue mostly witnessed in urban areas as a result of a high surge in population growth rate and increase in per capita income thus posing a danger to environmental quality and human health [16].

Municipal solid waste management has thus become a major issue of concern for many underdeveloped nations, especially as populations increase [7]. The problem is compounded as many nations continue to urbanize rapidly. For instance, 30 to 50% of the population in most developing countries is urban [30] and in many African countries, the growth rate of urban areas exceeds 4% [27, 26]. When the governments of African countries were asked by the World Health Organization to prioritize their environmental health concerns, results revealed that solid waste was identified as the second most important problem (after water quality), less than 30% of urban populations have access to proper and regular garbage removal [27]. In 2012, the world's cities generated 1.3 billion tons of solid waste per year, amounting to a rate of 1.2 kg per person per day. With rapid population growth and urbanization, municipal waste generation is expected to rise to 2.2 billion tons by 2025.

In sub-Saharan Africa, waste generation is approximately 62 million tons per year ranging from 0.09 to 3.0 kg per person per day, with an average of 0.65 kg/ capita/day [15].

1.2. Solid Waste Composition

Different social economic groups may affect the solid waste generation rate and composition [20] The proportion of physical composition of wastes are: food and fruit waste 43.2%, hay, straw and leaves 22.2%, paper, and card board waste 11.1%, coal ash, fine earth dust 9.59%, plastics 5.72%, and garden trimming 3.06% were the main percentages of various physical components of the MSW in the city [21]. Sangamner city produces around 61% of organic waste, and the rest 39% is inorganic waste [29]. According to [31] organic waste represents 49.76% of the total mass quantity. It is followed by plastics and card board with their sub-categories 12% and 8% respectively; glass (5.44%), paper (5.34%), etc [31]. The high biodegradable fraction combined with the tropical climate warrants frequent collection and removal of refuse from the collection point [17] and the physical composition of solid waste consist of plastics (18.44%), metals (30.42%), paper (29.30%) and glass (21.82%) [25] The research conducted in Lahore (Pakistan), the finding showed that the Physical composition of wastes was food waste accounted for a major portion (39.38%-64.12%) while glass waste (0.53%-7.4%) was the least. Other components varied according to the area's social-economic stratum [14, 3].

As the findings showed in Jimma City, Eighty-seven percent (87%) of the solid waste was generated by households. But, only a negligible or very small fraction (0.1%) was generated by street sweepings [13]. As the research conducted in Addis Ababa, Lideta sub–city, the finding showed that the major households refuse includes, Organic wastes (64%) and recyclable wastes (18%), Combustible waste (12%), Hazardous waste (3%), and others (3%) which are responsible for an overwhelming portion of total solid wastes originated from lideta sub-city [28] The research conducted in Wolaita Sodo town indicated that the major source of municipal solid waste was residential, commercial and institutional sectors [14]. As the research conducted in Dessie City, the result revealed that the main sources of MSW in the City are residential, commercial areas, street sweeping, institutions and small-scale industries. However, a considerable amount of solid waste of the city (60%) is generated from residential areas [8]. The research done on Solid waste generation rates for 31 Nigerian cities was found to vary from 0.13 kg/capita/day in Ogbomosho to 0.71 kg/capita/day in Ado-Ekiti [25]. In Ethiopia, different findings showed that the solid waste generation rate varies between 0.21kg/cap/day and 0.55 kg/cap/day in Jimma City respectively [13].

In most cities and towns of the developing world, inappropriate handling and disposal of municipal solid waste is the most visible cause of environmental degradation, i.e., air pollution, soil contamination, surface and groundwater pollution, etc., resulting from improper disposal of municipal solid wastes [33]. According to [5] as the household income level increases, the amount of waste generated increases directly and the solid waste generation rate has increased owing to population growth along their socioeconomic activities or status [25].

Solid waste generation depends on the economy of the people and per capita generation increases with the level of income of the family or individual [32]. The amount of solid waste generated increases. The average per capita waste generation rate in the low-income area (0.49kg/cap/day) was lower than that of middle and high-income areas (0.72kg/capita/day and 0.82kg/capita/day respectively) [23] and there is the relationship between social standard of living and average ratio of daily waste generated by a person [28, 9, 12, 6]. Therefore; they have higher demands for goods to purchase and generate more waste [13].

Family size was positively correlated with the total waste generation rate per household, the household family size and the daily average per capita waste generation rate had direct relationship [13] As the integrated research conducted in Alberta and British Columbia, the finding was showed that Positive correlations existed in the residential waste generation rate with education level of the residents [5]. This indicates that as the educational status of the household increases the amount of solid waste generation rate in the households as well as per capita decreases. The highest (0.65 kg/capita/day) waste quantity was generated by illiterate people, and the lowest rate (0.47 kg/capita/day) was generated by those who were in grade 12 and above [12] Marital status of HHs and their family size had a direct relationship with solid waste generation. As the study showed, the majority of study participants HHs were married (93.4%) and the average family size of HHs was about 5.1, which is higher than that of the overall family size of the urban population of Ethiopia (i.e. 4.6). Married families usually have larger family sizes, and they generate more SWs [13].

Season affects the waste generation rate. The household waste generation rate was estimated at 0.22 kg per capita per day in the dry season and 0.42 kg per capita per day in the rainy season [10] During the rainy season, plumes of contaminants are transported to groundwater and surface water bodies and then polluting them [24, 18]. According to [20], SW generation rate and composition came from the reason high amount of ash contents was based on the city used coal and wood as the source of fuels for cooking in the lower socioeconomic groups and the residents whose houses are less than 200 meters from the dumpsite are victims malaria, chest pains, cholera and diarrhea [1].

The current understanding challenges in estimating municipal solid waste generation per capita in developing countries, including a lack of equipment, lower rates of MSW collection efficiency, and rural–urban migration, all of which may have negative effects on data reliability of clearly generated wastes and Many cities in developing countries face serious environmental degradation and health risks due to the weakly developed MSW management system (The negative impacts of wastes on the local environment (air, water, land, human health) are becoming more acute often resulting in public outcries and demands for action. The impacts of inadequate waste management are not just limited to local level but are now crossing boundaries [19].

Therefore, even though SWM is nowhere adequately executed and is a global problem, municipalities from the developing countries are highly faced with this problem and as long as life has existed in this world, the disposal of waste has been a problem, and it has argued that collection of solid waste in urban areas is difficult and a complex job because the generation of waste from different sources in a diffuse process complicates the collection task. Especially in underdeveloped countries, the problem of disposal of waste is both difficult and unsolved which further leads to several illnesses caused by infectious and parasitic diseases. The amount of solid waste produced in the fast-growing towns of Ethiopia has been increasing over time, while possible disposal areas for solid wastes are limited. As a result cities and towns are facing the challenge of managing municipal solid wastes [2, 25].

Although the prevalence of breast cancer is substantially increasing in Ethiopia as well as in the study area, as far as my knowledge there is no explanatory studies that documented on the area of the risk of time to death due to breast cancer among breast cancer patients after taking anti-cancer treatment by using survival analysis. The aim of this study is to assess the household solid waste generation rate and associated factors in Gondar town, North East Amhara, Ethiopia from October 21, 2020 to December 2nd, 2020. Specifically 1) To determine the average household solid waste generate rate in Maraki Subcity of Gondar Town and 2) To identify determinant factors associated with solid waste generation rate among households in the study area.

2. Methodology

2.1. Study Area

The study had been conducted in Gondar Town administrations. Gondar is the capital city of the Central Gondar Administrative Zone and is located at a distance of 185 km north from Bahir Dar which is the capital city of the Amhara National Regional State. According to a census conducted by the central statistical agency (CSA) in (2007) the total population of the town was 460,000. There are different religions worshiped by the people. Orthodox predominantly has high followers followed by Muslim and Protestant. Concerning the economic status of the town, the people engage in different types of activities of which considerable numbers of people are taking part in large businesses, micro activities and transportation areas. Concerning temperature, it has an average of 20 -22°C temperature.

2.2. Data Structure Data Sources

(1) Study Design

A community based cross-sectional study design will be conducted to assess the solid waste generation rates and to determine the covariates that affect the production of solid wastes among households in Gondar Town Maraki sub-city, North West Amhara, from October 21, 2020 to December 2nd, 2020.

(2) Source populations

Target (reference) population will be all populations or all households who live in Gondar Town Maraki sub-city.

(3) The study populations

Randomly selected households in Gondar Town Maraki sub-city administrator and the study unit were randomly selected households that lived in Gondar Town Maraki sub city those would give the actual informations for the purposes of this study.

(4) Inclusion and Exclusion criteria

(i). Inclusion criteria

Head of households who have lived in Gondar Town Maraki sub-city administration for at least six months and the age of the respondents will be 18 years and above.

(ii). Exclusion criteria:

Those heads of households who give additional Commercial services in or near their residents like hotels, restaurants, shops, cafes, etc, are unable to give a response due to critical sickness, the HHs left the kebeles for more than 6 months are excluded from samples in this study.

(iii). Operational definition

Solid waste generation rate means the amount of waste produces within one week and quantifies by measuring at the point of generation.

Household solid waste: is considered a type of waste (MSW) produces in individual houses.

Generation rate: the amount of solid waste produced by individuals throughout the day.

Waste is any unwanted leftover matters which intended to dispose of.

Solid waste: a type of waste that is neither liquid nor gases.

Municipal Solid Waste (MSW): any kind of wastes can be generated by everyday activities of households, schools, hotels, businesses and institutions that are collected and managed by municipalities.

Types of cooking fuel: Sources or types of fuels used for cooking purposes in the HHs.

Food habit: the types of food always eaten or cooked in the house (fruits, vegetable, cereals).

Study Variables

Outcome variables: Solid waste generation rate in kilo grams per individual per week.

Independent variables: Several clinical and demographic variables were considering in this study for Solid waste generation rate. These are mentioned below in the Conceptual Framework.

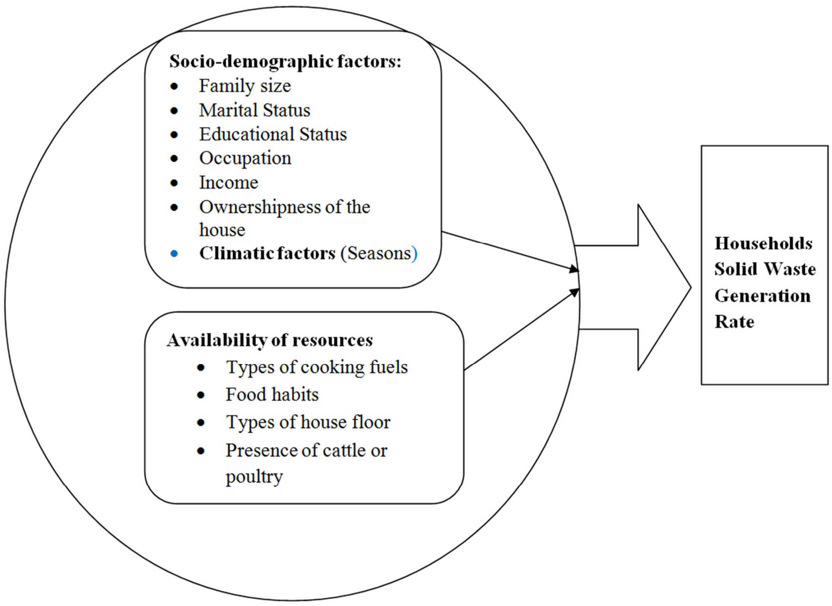

Figure 1. *Conceptual Framework Showing the Relationship of Dependent and Independent Variables of household solid waste generation rate.*

(5) Data sources

For the aim of accomplishing the objectives of this research, all required data were collected from primary and secondary data sources. The study was conducted by primary data sources from households by preparing a designed questionnaire and applying face-to-face interviews to reduce the nonresponse rate and incompleteness of data. Secondary data were collected from published and unpublished materials.

(6) Sampling technique

Stratified and simple random sampling techniques were used to determine the number of households, in order to collect primary data from these samples to obtain a reasonable and reliable result.

(7) Sample Size Determination

A critical component of sample size formulas is the estimation of variance in the primary variables of interest in the study (Cochran, 2007). The sample size is determined from the target population in this study by using the following formula:-

$$n_o = \frac{Z^{2}\frac{@}{2}PQ}{d^{2}} \text{ where } n = \frac{n_0}{1+\frac{n_0}{N}}$$

Where: n = sample size of housing units; P = residential housing unit variable; Q = 1-P: Q = housing units used for commercial activities, offices public; N = Total numbers of housing units centers, etc. Zα/2 = Standardized normal variable and valued that corresponds to 95% confidence interval equal to 1.96; d = Allowable error (0.05).

$$\text{If } {}^{n_0}\!/_{N} > 5\% \text{ ; } n = \frac{n_0}{1+{}^{n_0}\!/_{N}} \text{ and if } {}^{n_0}\!/_{N} < 5\% \text{ ; } n = n_0$$

According to data obtained from the city housing development office, there is a total of 12774 households headed in five kebele (N). Out of these more than 85% (P) are residential and the rest 15% (Q) are for commercial activities, offices, and for others. Therefore, the value of P =0.85 and q=0.15 from previous studies (Kassahun Tassie, 2018). Hence, based on the above-specified formula the required sample size becomes:

$$n_0 = \frac{1.96^2(.85)\,(.15)}{(.05)^{\,2}} = 195.9216 \approx 196$$

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then $\frac{n0}{N} = \frac{196}{12774} = 0.0154 < 0.05$; Therefore, $n = n_0$ (n=196).

The study area is divided into twenty administrative Kebelles and these Kebelles are arranged with a total of twelve sub-city. A researcher selected Maraki sub-city for the study area purposely having the information from officials of the city municipality office of the town. Based on geographical location, population density, and availability of different infrastructures, the Maraki sub-city is divided into five Stratification techniques and this is also suitable for administrative purposes. First, Maraki sub-city was divided into five strata namely Ayer Tena, shiromeda, Samuna Ber, Shewa Ber and Hidasie. Second, from five kebelles, samples were randomly from each stratum and the sample allocated to each stratum was proportional to the total number of units in the stratum. From all kebele, samples were selected random sampling by using the lottery method. In the last, 196 households were selected proportionally from the five kebelles based on their population size and Sample households are the main primary data sources of this study. The sample size in each stratum was proportionally grouped as follows using the formula for proportional allocations:

$$n_h = \frac{n}{N} * N_h$$

where n_h is sample size in stratum h (where h is the kebeles in Maraki subcities, h = 1, 2, 3, 4, 5); N_h is total population size in stratum h (N_h is total population size in kebele h); n is total sample size size; N is total population size.

For Ayer Tena (n_1) $= \frac{n}{N} * N_1 = \frac{196}{12774} * 2460 = 38$, N_1 is population size in Ayer Tena.

For Shiro Meda (n) $= \frac{n}{N} * N_2 = \frac{196}{12774} * 2890 = 44$, N_2 is population size in Shiro Meda.

For Samuna Ber (n_3) $= \frac{n}{N} * N_3 = \frac{196}{12774} * 2286 = 35$, N_3 is population size in Samuna Ber.

For Shewa Ber (n_4) $= \frac{n}{N} * N_4 = \frac{196}{12774} * 1988 = 31$, N_4 is population size in Shewa Ber.

For Hidasie (n_5) $= \frac{n}{N} * N_5 = \frac{196}{12774} * 32 = 12$, N_5 is population size in Shewa Ber.

Table 1: Representative elected kebeles of Maraki subcity of Gondar Town.

The following shows Schematic representation of sampling procedure.

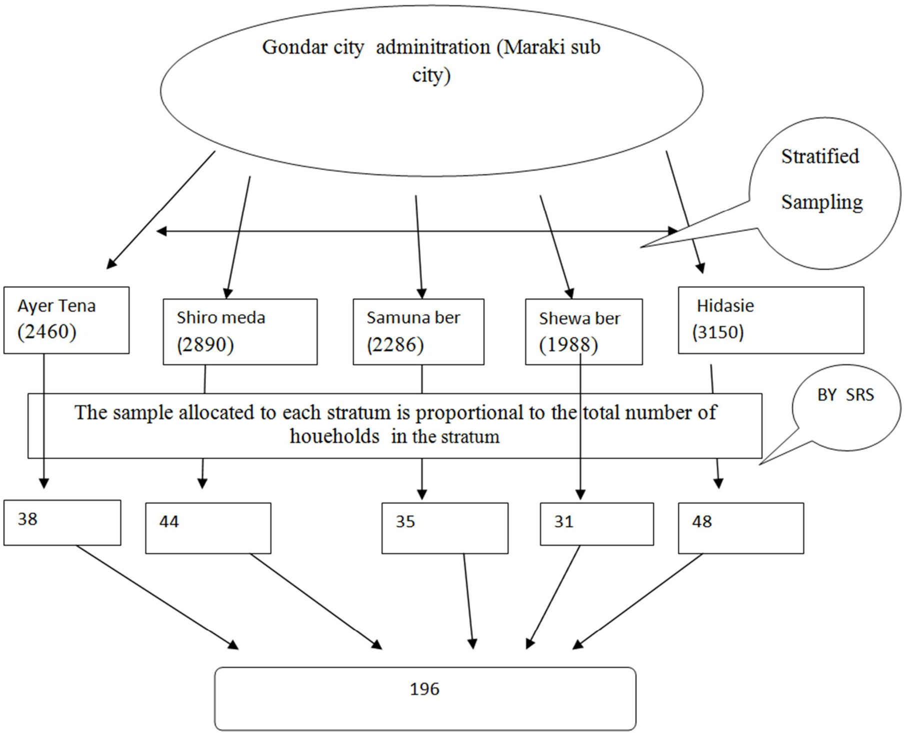

Figure 2. *Schematic representation of sampling procedure.*

Statistical models:

We use Multiple linear regressions model to explain the relation between one or more variables in a given population. The data were analyzed by using SPSS version 20.

3. Result and Discussion

3.1. Descriptive Statistics

By considering the descriptive statistics for categorical variables, a total Out of 196 household was included in this study. Description of the socio-demographic characteristics of the target households gives basic information about Age, Marital status, Occupation, Ownership, Religion Segregate, sex, Storage, Education level, Family size, and Common food. Socio-demographic characteristics of a given population have their own implication and relation with solid waste generation.

Among those sample respondents, about 114 (58.2%) of them are females while the remaining 82 (41.9%) of the respondents are males and considering the religion of the respondents 136 (69.9%) are Orthodox, 40 (20.4%) are Muslims and 20 (10.2%) of households are protestants. The descriptive statistics of this study showed that among respondents 8 (4.1%) who can't read and write properly account about, 35 (17.9%) are primary school (1-8 grade), 56 (28.6%) households were secondary (9-12 grade), 158 (31.5%) respondent households had certificate and diploma level of education and first degree and above accounts 116 (23.1%).

The number of which had solid waste storage facilities in their house was 156 (79.6%). Among the households in the study period, 14.3%, 67.3%, and 18.4% used collecting materials in plastic bags, baskets (sacks), and tins (cans) respectively. Only 20% of the households were segregate solid wastes in the household levels. 68.3% of the solid waste generated in residential was collected by MSSE (micro and small-scale enterprises). Thirty-nine percent of generated wastes were reused by households for different purposes like sales for 18.9%, 158 (31.5%) for cooking fuel, 1% used for animal feeding, 0.4% for composting, and 8.6% used for other purposes.

Among the sample taken, 22 (11.2%), of the head of households were single, 126 (64.3%) were married, 21 (10.7%) were divorced, 14 (7.1%) were widowed and 13 (6.6%) were separated. From all households accounted in this study, 121 (61.7%) were Civil servants, 38 (19.4%) were merchants, 24 (12.2%) were housewives, 11 (5.6%) were labor-based daily workers, and others 2 (1.0%). The minimum and maximum family size of the responded households was 1 and 9 years respectively and the average family size in the responded household was 5. The average Solid waste generation rate of a household in the study area was 3.94 kg/capita/week.

3.2. Multiple Linear Regression Analysis

Regression analysis is a diagnostics tools for checking regression assumption. Regression Analysis: the waste generation rate versus different covariates like Age, Marital status, Occupation, Ownership, Religion Segregate, sex, Storage, Education level, Family size and Common food.

The Model is given by:

$$Y=\beta_0 + \beta_1x_1+ \beta_2x_2 + \beta_3x_{3+} \beta_4x_{4+} \beta_5x_{5+} \beta_6x_{6+} \beta_7x_{7+} \beta_8x_{8+} \beta_9x_9 + \beta_{10}x_{10} + \beta_{11}x_{11}$$

where Y stands for waste generation rate, x1 is for Age, x2 is for marital status, x3 is for occupation, x4 is for ownership, x5 is for religion x6 is for segregate, x7 is for sex, x8 for Storage, x9 is for education level, x10 is for family size and x11 is for common food. Based on the multiple linear regression analysis results as shown in table 1, the significance variables are Age, Marital status, Occupation, Ownership, sex, Education level and Family size (p-value < 0.05). But the others independent variables Religion, Segregate, Storage and Common food are not significant (p-value is > 0.05).

Therefore, our model in given data by$Y = 1.761 +.009x_1+ 0.026x_2 + 0.128x_{3-} 0.404x_{4+} 0.093x_{7+} 0.151x_9 + 0.608x_{10}$

Table 1. *The parameter estimates, standard errors of fitting the multiple linear regression model for household waste generation rate (at Gondar town, during 2020).*

Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.716	.676		2.538	.011
Age	.009	.006	.051	1.443	.015
Marital status	.026	.067	.013	.393	.003
Occupation	.128	.040	.104	3.187	.002
Ownership	-.404	.100	-.142	-4.040	.000
Religion	-.069	.075	-.030	-.919	.358
Segregate	-.141	.110	-.043	-1.286	.199
Sex	.093	.105	.029	.881	.002
Storage	-.140	.182	.025	-.769	.442
Education level	.151	.043	.113	3.488	.001
Family size	.608	.035	-.614	17.330	.000
Common food	-.388	.211	-.058	-1.839	.066

a. Dependent Variable: waste generation rate.

3.3. Assessing of Model Adequacy

It is important to check the adequacy of the regression model before making any inferences based on the model undertaken. We can achieve this by using normal Probability plots and residual analysis, the points in this plot should generally from a straight line if the residuals are normally distributed. Thus the following p-p plot of regression standardized residual is normal since the points, in this plot from nearly straight line, the residuals are normally distributed. The normal plot shows an approximately linear pattern that is consistent with normal distribution. It shows that there is linear relationship.

In the Scatterplot of the standardized residuals (the plot displayed below) shows that the residuals will be roughly rectangularly distributed, with most of the scores concentrated in the center (along the 0 points) and no clear or systematic pattern of residuals in our study.

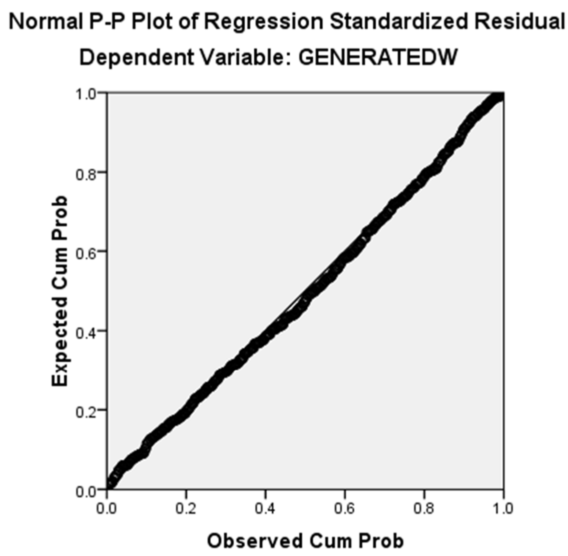

Figure 3. *Normal Probability plot.*

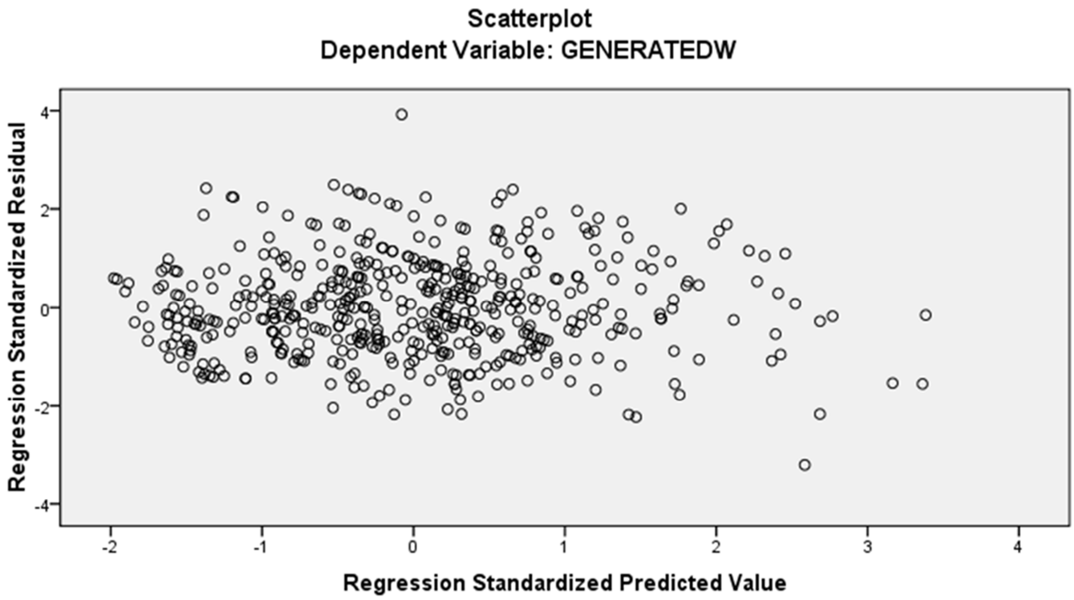

Figure 4. *The residual plot.*

The following histogram graph shows that the data was almost normal and indicates that the data in our study satisfy the normality assumption.

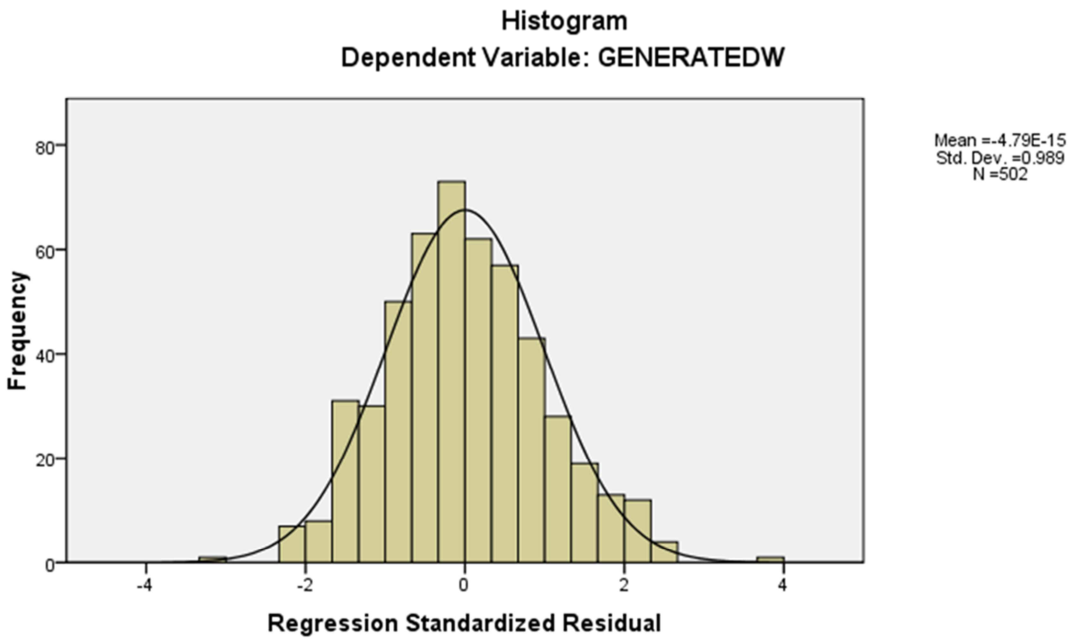

Figure 5. *Histogram for waste generation rate.*

3.4. Test of the Presence of Multicoliniarity

The following table shows the representations for the Test of the presence of multicollinearity in our study. Two values are given: Tolerance and VIF. If the Tolerance value is very small (less than 0.10) and VIF (Variance inflation factor) values above 10 would be a concern here, indicating multicollinearity. In this waste-generated study, the tolerance value for each independent variable is not less than 0.10; therefore, we have not violated the multicollinearity assumption. This is also supported by the VIF values, all are well below the cut-off of 10.

Table 2. *The multicollinearity test for household waste generation rate (at Gondar town, during 2020).*

Coefficients

Model	Collinearity Statistics	
	Tolerance	**VIF**
Age	.789	1.268
Marital status	.904	1.106
Occupation	.901	1.110

Model	Collinearity Statistics	
	Tolerance	VIF
Ownership	.784	1.276
Religion	.924	1.083
Segregate	.879	1.137
Sex	.873	1.146
Storage	.932	1.073
Education level	.930	1.075
Family size	.772	1.295
Common food	.976	1.025

a. Dependent Variable: GENERATEDW.

3.5. Evaluating the Model

In the Model Summary of table 3 and check the value given under the heading R Square. This tells you how much of the variance in the dependent variable (waste generation rate) is explained by the model (different covariates). In this case, the value is .625 means that this independent variable explains 62.5% of the dependant variable (waste generation rate) or 62.5% of the total variation in the waste generation rate is explained by explanatory variables.

Table 3. *The Model Summary for household waste generation rate (at Gondar town, during 2020).*

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.825	.625	.615	1.057

3.6. Statistical Test for the Overall Model

To assess the statistical significance of the result it is necessary to look in the table labelled ANOVA in table 4. This tests the null hypothes is:

Null hypothesis is H_0:

Factors do not have significant effect on the waste generation (multiple R in the population equals 0).

VS

Alternative hypothesis is H_A: factors have significant effect on the waste generation.

The Calculated F value (49.302), it is very larger than $F_{.05}$ (11, 184) and the corresponding p- value is 0.00 which is very small compared to the level of significance (α = 5%). Therefore, we reject the null hypothesis i.e. at least one of the independent variables is important for predicting the dependent variables (at least one of the parameters or coefficients of explanatory variables are different from zero). The model in our study reaches statistical significance (Sig = .000, this really means $p < .0005$).

Table 4. *The the overall model siginificancyfor household waste generation rate (at Gondar town, during 2020) (ANOVA table).*

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	605.382	11	55.035	49.302	.000[a]
Residual	546.973	184	1.116		
Total	1152.355	195			

a. Dependent Variable: waste generation rate

b. Predictors: (Constant), like Age, Marital status, Occupation, Ownership, Religion Segregate, sex, Storage, Education level, Family size and Common food.

4. Discussion

This study tries to estimate the average waste management rate and to determine major predictive factors on the waste management of households on the data of maraki sub-city of Gondar town. From the study using the multiple linear regression models, we found that the factors that significantly affect the waste generation rate of households are Age, Marital status, Occupation, Ownership, sex, Education level and Family. But covariates like Religion, Segregate, Storage, and Common food were not influential.

One of the factors that affect the Waste generation rate of households is the income of the family or individual. This result is in accordance with the study in Ghana [23, 13, 33]. The family size of households is an important predictor of the waste generation of households and the household family size and the daily average per capita waste generation rate had a direct relationship. These results confirm the result obtained from the previous study [12]. The educational status of the household is also a prognostic factor that significantly predicts the household-level waste generation rate.

5. Conclusion

The current study revealed that household waste generation was high in the study area. Age, marital status, occupation, ownership, sex, education level, and family size were found to be associated with household waste generation. The average generation rate of households in Maraki sub-city was 3.94 kg/capita/week. The result from this solid waste generation is used to design the appropriate solid waste management programs and is useful in areas where there is an urgent need for planning for solid waste management. This also leads to the development of strategies based on the quantity of waste that produces at the municipal level, used as baseline information to policymakers, planners, solid waste managers, and environmental protection agencies about the current household solid waste generation rate of GondarTown. Additionally, it creates inspiration for further investigators in this area and the findings can be used as initial references.

6. Recommendations

Based on our research findings, the following points are recommended:

1) Adequate supervision and management are imperative to ensure that wastes are collected properly and on time every day.
2) Since the amount of solid waste generated per household as well as per capita level per day increases when compared with other towns, so reducing, reusing, and recycling of generated wastes should be encouraged and enforced in the community.
3) Organizational strengthening and better management of the conservancy section would certainly help to change this gloomy condition of solid waste management and bring it to acceptable standards.
4) As the finding indicated, with the increasement of the family member, solid waste production is higher at the household level, so family planning should be recommended to households.
5) Personal protective equipment and cleaning materials should be full fill for MSSE members.
6) Encourage all the communities for reusing the generated solid wastes in their home.
7) The final municipal solid waste disposal site of Woldiya town is open, so it should be fenced by the concerned body to protect the safety of the environment, animals and children.

Abbreviations

CSA: Central Statistical Agency; ECSA: Ethiopian Central Statistical Agency; GHG: Green House Gas; HHs; Households; HSW; Household Solid Waste; KG; Kilo Gram; M^3; Meter Cube; MSSE; Micro and Small scale Enterprise; MSW; Municipal Solid Waste; MSWM; Municipal Solid Waste Management; SPSS; Statistical Package for Social Science; SW; Solid Waste; SWGR; Solid Waste Generation Rate; SWM; Solid Waste Management; WHO; World Health Organization.

Availability of Data and Materials

The datasets analyzed during the current study were available from the corresponding author on reasonable request.

Ethical Considerations

All procedures performed in studies involving human participants were in accordance with the ethical standards of University of Gondar institution and the University research committee declarations with comparable ethical standards for confidentiality.

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Competing Interests

The authors declare they have no competing interests.

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