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Prioritizing the Major Components of Municipal Solid Waste Based on Their Effects in Urban Centre Using Analytical Hierarchy Process

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Abstract: Municipal Solid Waste (MSW) is the waste generated by domestic, commercial, industrial, healthcare centres, agricultural, and mineral extraction activities, which accumulate in streets, drainages, and public places. These wastes produce toxic substances such as dioxins, polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), furans, etc, that are emitted into the environmental media such as air, soil, and water, and are considered harmful to the human system and the environment. These substances affect human organs such as the liver, lungs, kidneys, etc. Environmental issues such as ozone layer depletion and climate change are serious issues of concerns. This study considers the prioritization of the major components of solid waste based on their effects in Ganye Metropolis in Adamawa State, Nigeria. Analytical Hierarchy Process (AHP) was used to analyzed and prioritized the components of solid waste, which include: organic waste, plastics and polythene, paper and cardboard, metals, electronic waste, medical waste, and glass and ceramics. Five criteria were identified and considered to assess the major components of the solid waste. The criteria are: environmental, health, agricultural, economic, and social effects. Data were collected from environmental, health, agricultural, and economic experts, and community leaders in Ganye metropolis. Saaty's nine-point scale structured questionnaire was used. The Geometric Mean was used to aggregate the responses from the multiple respondents to drive the weights of the criteria. Based on the analysis, the result shows that plastics and polythene (PL) ranked first (1st), followed by organic waste (OR) which ranked second (2nd), paper and cardboard (PC) ranked third(3rd), glass and ceramic (GC) ranked fourth (4th), metals (MT) ranked fifth (5th), medical waste (MD) ranked sixth (6th) and electronic waste (EL) ranked last. Plastics and Polythene, which have the highest priority weight, should be given attention during solid waste management in Ganye Metropolis.

Keywords: AHP, Effects, Municipal solid waste, Prioritize, Urban center.

1. Introduction

Municipal solid wastes comprise organic and inorganic waste materials. It's generated from domestic, commercial, construction, and agricultural activities; hence, it is discarded as useless or unwanted material and collected and treated by municipalities [28]. These materials include foods, plastics and polythene, paper and cardboard, metals, electronic waste, medical waste, glass and ceramics, agricultural material, construction materials, disposed of without separation at the sources, particularly in developing countries as useless or unwanted material. Increase in population, rapid urbanization, economic growth, and improved living standards are the main factors contributing to the generation of MSW. The accumulation of these wastes has created growing concerns all over the world [9, 33].

Municipal solid waste components are also classified based on the nature of their breakdown as biodegradable and non-biodegradable solid waste. They are also classified by hazard properties as hazardous and non-hazardous waste [21]. The components of the municipal solid waste were associated with various toxic substances that affects humans and the environment, substances such as cadmium, arsenic, chromium, nickel, dioxin, furans polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), Lead, Carbon monoxide, Nitrogen oxides Sulphur oxides, Hydrochloric acid etc, were present in these wastes' materials [11, 15]. These substances were emitted into environmental media such as air, soil, and water during solid waste management activities. The effect of these substances from the MSW components is enormous and a serious issue of public concern. These substances have serious health effects on the communities and the environment. The communities and environments were exposed to these substances during MSW management activities directly or indirectly through various environmental media. Some of these substances are carcinogenic; their exposure

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affects the functioning of major organs of the body. For example, exposure to substances such as cadmium, mercury, lead, etc, affects the central nervous system, liver, kidneys, heart, lungs, skin, reproductive organs, etc [11]. Exposure to substances like carbon monoxide (CO) contributes to some of the major environmental problems, such as climate change, global warming, ozone layer depletion, etc [3].

Solid waste management is a process of controlling the generated solid waste, which involves collection, transportation, and proper disposal of the solid waste in a manner that is in accord with the best principles of public health and environmental considerations [7]. Municipal solid waste management (SWM) is largely limited to the collection and transportation of waste. It is estimated that less than 50% of the generated waste is collected in urban areas. And the waste is disposed of without any treatment [30]. Solid waste management affects every person in the world. By the year 2050, the world is expected to increase waste generation by 70%, that is, from 2.01 billion tons of waste in 2016 to 3.40 billion tons of waste per annum. Stakeholders make decisions about consumption and waste management that affect the daily health, productivity, and cleanliness of communities. Poor solid waste management process contaminates the atmosphere, the world's oceans, clogs drains, and causes flooding, transmitting diseases, increasing respiratory problems, harming animals that consume waste unknowingly, and affecting economic development [12]. Lack of limited resources, proper management, and control of these wastes has turned into a serious problem in most urban centers of the world. The situation is acute in developing countries, due to rapid urbanization, uncontrolled population growth rate, coupled with poor solid waste management practices and little financial commitment [9]. These wastes were dumped not evacuated for a long period, the hip of these waste not evacuated or not manage properly has serious social and physical problems, such as unpleasantness odor produce and serve as breeding grounds for insects and other small animals that harbor pathogens that are detrimental to human health and the environment [9, 14, 30]. Communities and the environment seriously grapple with the effects of this waste.

AHP is a multi-criteria decision-making approach that has good mathematical properties appropriate for incorporating value judgments of decision makers in modeling for the selection of the best alternatives. It is equally appropriate for providing a numerical measure of ranking of a set of decision-making criteria. In addition to its usefulness for decision making, it is also a tool used for deriving information for planning. Thus, AHP is a decision support tool that can be used to solve complex decision problems. It is modeled in a tree-like multi-level hierarchy structure of objectives, criteria, sub-criteria, and alternatives. Pairwise comparison of the criteria and or sub-criteria is established to model the same as a pairwise matrix. The result of the evaluation of the matrix is the weights of importance of the decision criteria and the relative performance measures of the alternatives in terms of each decision criterion [23, 1, 4]. AHP is widely used due to its mathematical and methodological simplicity and its ability to handle both quantitative and qualitative data. AHP is used in many areas of decision making, such as construction, manufacturing, engineering, education, waste management, etc. [20, 15, 25]. [19] used the Analytical Hierarchy Process (AHP) model to rank different components of solid waste. The study revealed that organic waste was the most significant component of solid waste, followed by plastics and paper. [16, 17] also used the AHP model to assess the sustainability of solid waste management practices. The study found that waste reduction and recycling were the most sustainable practices, followed by composting and waste-to-energy. [31] study conceptualized solid waste management system components of generation, handling, and disposal for a sustainable solid waste service delivery in Nigerian cities. The study found movement of the waste from one location to another, it is devoid of sustainable practices of reduce, reuse, and recycle from generation, handling up to final disposal. [32] Quantifies and compares the cost of municipal solid waste (MSW) management systems under different scenarios using a life cycle cost (LCC) analysis approach. LCC analysis was performed for six integrated MSW management scenarios for Mumbai city, India, which generates over 9000 metric tons of MSW daily and disposes of most of it in open dumps.

Most of the studies focus on cost and options of solid waste management, rank different components of solid waste, assess the sustainability of solid waste management practices, etc. None of the studies consider assessing and prioritizing the effects of substances emanating from major components of solid waste in urban centers of developing countries. There is considerable public concern about the issues of substance emanating from solid waste in urban centers. The objective of this study is to prioritize the major components of solid waste based on their effects on communities and the environment in Ganye metropolis, Adamawa State, Nigeria.

2. Materials And Methods

Ganye Municipal Council, in Adamawa State, Nigeria, was considered in this study. Ganye is located at 8° 26′ 0″ N, 12° 4′ 0″ E. It is a multi-ethnic community with a population of approximately 262,100 people and an area of 2,095 square kilometers. Farming is the predominant activity of the people in the community. The study considered five criteria, which include: environmental, health, agricultural, economic, and social effects, for assessing the components of solid waste based on their effects. A preliminary assessment was conducted to identify the major solid waste component in the community. These include: organic waste, plastics and polythene, paper, metals, electronic waste, medical waste, glass, and ceramics.

Various stakeholders in the community were considered, these include environmental experts, community health experts, agricultural experts, economic experts, and social experts, to assess the relative effects of these major components of the solid wastes. Primary data were collected from the stakeholders. A structured interview was conducted using a nine-point scale [24] questionnaire. Independent responses of these stakeholders were collected and aggregated. The AHP model of the problem was formulated. Excel Solver version 2.0 was used to solve the problem, and the priority weights were obtained. AHP is one of the multi-criteria decision-making (MCDA) approaches that supports an effective comparative analysis among alternatives based on determined criteria [27]. In the last two decades, AHP has gained significant popularity, and there are many reported real-life applications as mentioned earlier because of its flexibility, intuitive appeal to the decision makers, and its ability to check inconsistencies. Generally, users find the pairwise comparison form of data input straightforward and convenient. However, many researchers have observed some cases in which ranking irregularities can occur when the AHP or some of its variants are used [22]. The technique is gaining increasing importance in research and practice [2, 18]. AHP involves the following steps [8].

i. Define the problem and determine its goal

ii. Set up a decision hierarchy by breaking down the problem into a hierarchy of interrelated decision elements. The overall goal is placed at the top, with the main attributes on the level below. That is the structure of the hierarchy of the decision problem from the top (the objectives from a decision-maker's viewpoint), then the intermediate levels (criteria on which subsequent levels depend), to the lowest level, which usually contains the list of options or alternatives. This is shown in Figure 1 below.

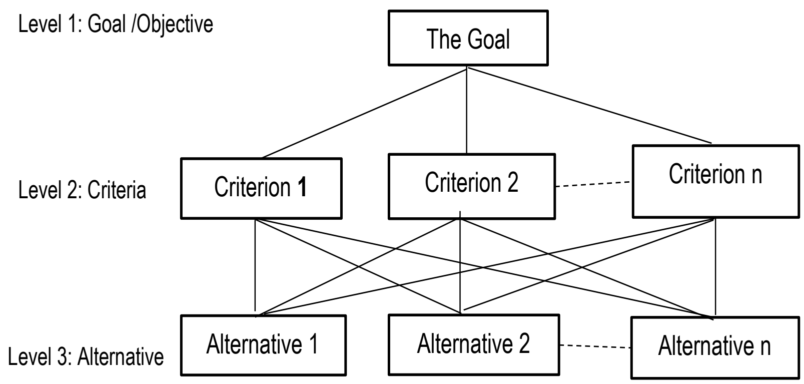

Fig. 1: Decision hierarchy of AHP

iii. Construct a set of pair-wise comparison matrix A of size n x n shown in equation (1) for the criteria (where n is the number of criteria). Another matrix A of size n x n (where n is the number of alternatives) will be developed for the alternatives for each of the criteria by using the relative scale of measurement shown in Table 1. The pair-wise comparisons are done in terms of which element dominates the other.

Table 1: AHP Pair-Wise Comparison Scale of Measurement

Numerical rating Scale	**Meaning (Verbal Judgments of Preferences)**
1	Equal importance of the two evaluated elements.
3	Moderate importance of one element over the other.
5	Strong importance of one element over the over.
7	Very strong importance of one element over the
9	Extreme importance of one element over the other
2,4,6,8	Compromise.

iv. There are n (n -1) judgments required to develop the set of matrices A in step 3, that is, for the criteria and the alternatives with respect to each criterion. In each case, reciprocals are automatically assigned in each pair-wise comparison to have the complete entries of matrices A (equation 1 below)

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{21}} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \dots & 1 \end{bmatrix} \quad (1)$$

a_{ij}: numerical comparison between criterion i and j or alternative i and j with respect to a particular criterion.

v. The relative weights of column A can be determined by dividing each element of the column by the sum of the elements of the same column (normalize matrix A). The desired relative weights W= ($w_1, w_2, w_3, ---, w_n$) of each row are computed as the row average of the resulting normalized matrix. The eigenvector is defined

$$AW = \lambda_{max} W, \quad \lambda_{max} \geq n$$

$$\lambda_{max} = \frac{\sum a_j w_{j-n}}{w_1} \qquad (2)$$

Where λ_{max} is the largest or principal eigenvalue of the comparison matrix, which can be shown to satisfy $\lambda_{max} \geq n$, (n is the order of the matrix), with equality holding only in the perfectly consistent case. Where λ_{max} is the maximum eigenvalue of A, and it should be noted that this eigenvector solution is normalized additively as seen in equation 2.

vi. Having made all the pair-wise comparisons, the consistency is determined by using the eigenvalue, $\lambda_{max,}$ to calculate the consistency index, CI, as follows: CI = $\frac{\lambda \max - n}{n-1}$, where n is the matrix size. Consistency of Judgment can be checked by taking the consistency ratio (CR) of CI with the appropriate value of random consistency index, RI in Table 2 [10]. The CR is calculated as: CR= $\frac{CI}{RI}$. The CR is acceptable if it does not exceed 0.10. If it is more, the judgment matrix (judgment of the respondent) is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

Table 2: Average Random Consistency Index (RI)

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

vii. Steps iii to vi are performed for all levels in the hierarchy.

viii. Obtaining an overall relative score for each option or alternative. In a final step, the option scores are combined with the criterion weights to produce an overall score for each option. The extent to which the options satisfy the criteria is weighed according to the relative importance of the criteria. This is done by simple weighted summation.

The two widely used approaches to handle the aggregation of individual judgments of pairwise comparison of the evaluating factor (criteria/alternatives) in AHP are the geometric mean and arithmetic mean. The responses of the experts' pairwise comparison judgement (score) are aggregated to arrive at the pairwise comparison matrix. Aggregation of individual judgments (AIJ) is usually performed using the geometric mean, while aggregation of the individual priorities (AIP) is usually performed using the arithmetic mean [2, 18, 29, 26]. [6] maintained that in aggregating individual judgments, each individual is regarded as independent and considered both geometric and arithmetic means as appropriate procedures for ratio scales. But of these

two methods, only the geometric mean satisfies the Pareto Principle (unanimity condition and homogeneity condition). Using the geometric mean in AHP for prioritizing decisions with diverse group members provides a range of benefits, including balancing perspectives, mitigating bias, promoting consensus, enhancing transparency, ensuring robustness to variability, and facilitating efficient and consistent decision-making. By leveraging the strengths of the geometric mean, groups can effectively navigate the complexities of decision-making in heterogeneous settings and arrive at informed and consensus-driven choices [13].

In this study geometric mean was adopted to aggregate the pairwise comparison judgements of the criteria of all the experts to obtain the aggregate pairwise comparison matrix for the criteria. Aggregating Expert scores by geometric mean is given in question 3 below [29, 26].

$$x_{ij}] = \begin{bmatrix} 1 & C_1 & C_2 & \cdots & C_n \\ C_1 & 1 & \sqrt[m]{\prod_{e=1}^{m} x_{12}^{(e)}} & \cdots & \sqrt[m]{\prod_{e=1}^{m} x_{1n}^{(e)}} \\ C_2 & \frac{1}{\sqrt[m]{\prod_{e=1}^{m} x_{21}^{(e)}}} & 1 & \cdots & \sqrt[m]{\prod_{e=1}^{m} x_{2n}^{(e)}} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ C_n & \frac{1}{\sqrt[m]{\prod_{e=1}^{m} x_{n1}^{(e)}}} & \frac{1}{\sqrt[m]{\prod_{e=1}^{m} x_{n2}^{(e)}}} & \cdots & 1 \end{bmatrix} \qquad (3)$$

Where:

x_{ij} = represents the verbal judgments of an expert; j= 1, 2, 3, … n

C = Represents the criteria i =1, 2, … n

e = 1, 2, … m represents the number of experts

3. Structure of the AHP Decision Problem Under Consideration

The decision structure required for our specific problem of prioritizing the major components of municipal solid waste based on their effects in urban centres is illustrated in Figure 2. The overall goal and the factors (criteria and alternatives) that affect this goal are defined. Table 3 shows the major components of the solid waste to be prioritized and the criteria used to assess the major components of the solid waste based on their effect on the community and environment. The structure of the aggregate pairwise comparison matrix for the criteria is shown in Matrix **B,** equation 4 below. The structure of the pairwise comparison matrix of the alternatives with respect to the five different criteria is shown in Matrix $\mathbf{C_j}$ equation 5 below (for j = 1, 2, 3, 4, 5).

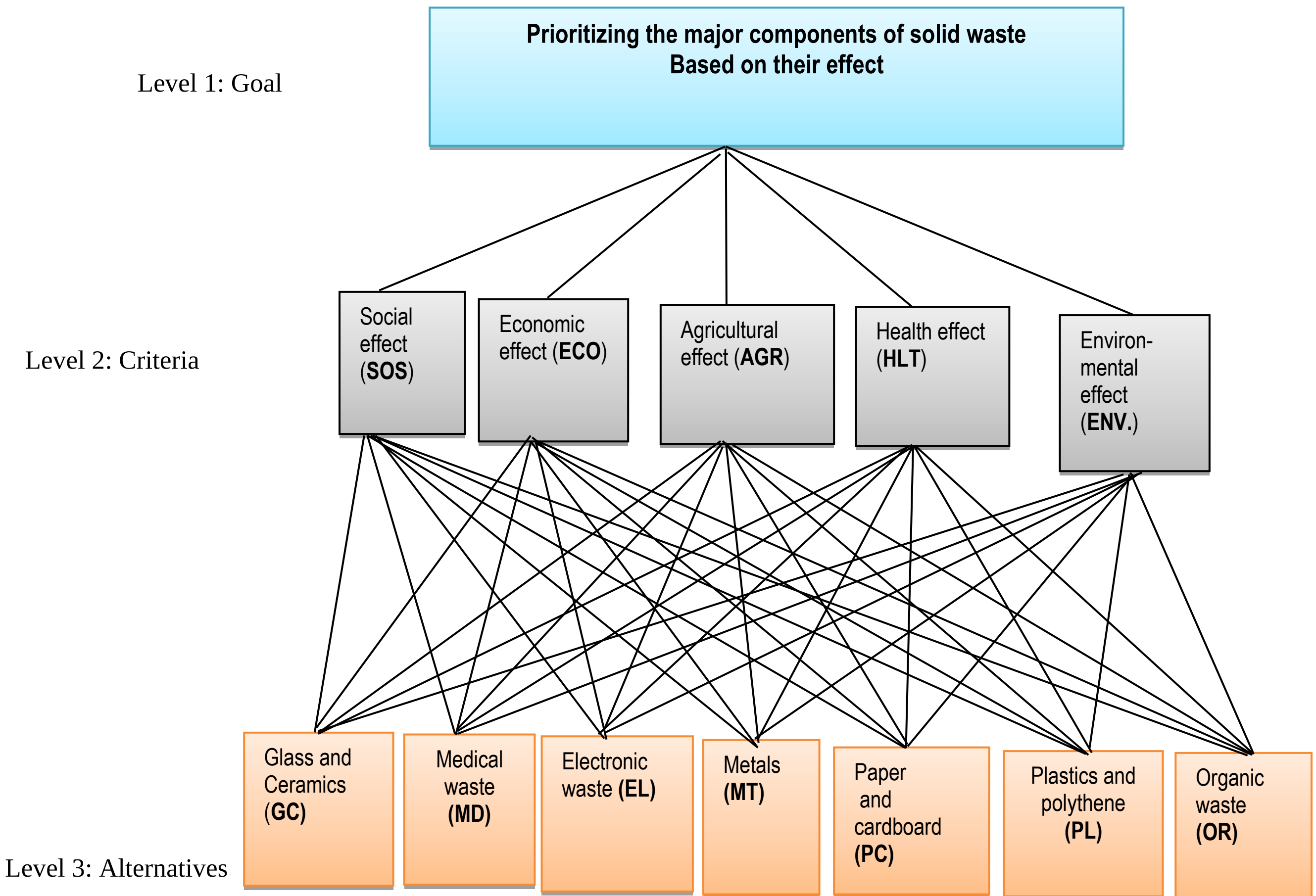

Fig. 2: AHP hierarchical structure of the problem

Table 3: Major Components of Solid Waste and Criteria for Assessment

S/N	Major Component of MSW		S/N	Criteria for Assessment
i.	Glass and Ceramics = **GC**		i.	Social effect = **SOS**
ii.	Medical waste = **MD**		ii.	Economic effect = **ECO**
iii.	Electronic waste =**EL**		iii.	Agricultural effect = **AGR**
iv.	Metals = **MT**		iv.	Health effect = **HLT**
v.	Paper and cardboard = **PC**		v.	Environmental effect = **ENV**
vi.	Plastics and Polythene = **PL**			
vii.	Organic waste = **OR**			

$$B = \begin{array}{c} \\ ENV \\ HLT \\ AGR \\ ECO \\ SOS \end{array} \begin{array}{c} \begin{array}{ccccc} ENV & HLT & AGR & ECO & SOS \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} \\ - & 1 & a_{23} & a_{24} & a_{25} \\ - & - & 1 & a_{34} & a_{35} \\ - & - & - & 1 & a_{35} \\ - & - & - & - & 1 \end{bmatrix} \end{array} \quad (4)$$

$$C_j = \begin{array}{c} \\ OR \\ PL \\ PC \\ EL \\ MT \\ MD \\ GC \end{array} \begin{array}{c} \begin{array}{ccccccc} OR & PL & PC & EL & MT & MD & GC \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} \\ - & 1 & a_{23} & a_{24} & a_{25} & a_{26} & a_{27} \\ - & - & 1 & a_{34} & a_{35} & a_{36} & a_{37} \\ - & - & - & 1 & a_{45} & a_{46} & a_{47} \\ - & - & - & - & 1 & a_{56} & a_{57} \\ - & - & - & - & - & 1 & a_{67} \\ - & - & - & - & - & - & 1 \end{bmatrix} \end{array} \quad (5)$$

For j = 1,2,3,4, **5**

4. Result and Discussion

The pairwise comparison judgements of the criteria by the five experts are shown in Table 4 below. From the table raw one, column A has numerical values entry of 1, indicating the preference of the pairwise comparison judgement of the experts I. The value indicates that expert I considered environmental (ENV) criterion equally important compared to health (HLT) criterion. That is, two of the factors (ENV and HLT) contribute equally to the objective of prioritizing the effect of the component of the solid waste (PECSW). In raw two (expert II), column A (ENV & HLT criterion), the numerical value of 2 entry indicates that the ENV criterion is equally moderately important as HLT criteria. That is ENV criteria slightly contribute more to the objective as compared to HLT criteria. Similarly, the other numerical values were obtained from the experts when making the pairwise comparison judgement of the other criteria in columns B, C, D, E, F, G, H, I, and J. All the other numerical values in the table were obtained similarly. The aggregated pairwise comparison matrix, the Synthesized matrix, and the priority vector of the criteria are shown in Table 5 below. The judgements of the experts were consistence as the value of the consistency ratio CR = 0.05 < 0.1.

Table 6 shows the pairwise comparison matrix judgements of the five alternatives with respect to the environmental criterion by the environmental expert. In the table, raw one, column one shows a numerical value of 1. This indicates that comparison of organic waste (OR) to organic waste (OR) with respect to environmental criteria is equally important. In the same table raw one (OR), column three (PC), which has a numerical value entry of 3, indicates that organic waste (OR) is moderately important than Paper and cardboard (PC) with respect to the ENV criteria. Organic waste has a greater effect on the environment than paper and cardboard. Similarly, the pairwise comparisons of the other alternatives with respect to the ENV criterion were carried out, and their respective numerical values are shown in Table 6 below. The Synthesized matrix and the priority vector of the pairwise comparison matrix of the alternatives with respect to the ENV criterion were also shown in Table 6 below. The judgement of the environmental expert was found to be consistence as shown by the value of the consistency ratio, $CR_{ENV} = 0.022 < 0.1$.

Similarly, the pairwise comparison matrix judgments of the alternatives with respect to the remaining criteria (HLT, AGR, ECO, and SOS) by the other experts (Health, Agricultural, Economic, and Social experts) were obtained in Tables 7, 8, 9, and 10, respectively. Their respective synthesized matrices and priority vectors were shown in Tables 7, 8, 9, and 10, respectively. Judgements of the experts were also consistent as shown by the consistency Ratios, $CR_{HLT} = 0.022 < 0.1$, $CR_{AGR} = 0.050 < 0.1$, $CR_{ECO} = 0.009 < 0.1$, and $CR_{SOS} = 0.034 < 0.1$, respectively.

Table 11 shows the overall priority matrix for prioritizing the major components of solid waste (alternatives) based on their effects. The overall priority vectors of the alternative with respect to the criteria were computed. And it shows that plastic and polyethene (PL) considered to be first priority, follow by organic waste (OR) second priority, paper and cardboard (PC) third priority, glass and ceramics (GC) fourth priority, Metals (MT) fifth priority, medical waste (MD) sixth priority and electronic waste (EL) seventh priority.

Table 4: Pairwise Comparison Judgments of Criteria by the Five Expects

Expert	***A***	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***
	ENV & HLT	**ENV & AGR**	**ENV & ECO**	**ENV & SOS**	**HLT & AGR**	**HLT & ECO**	**HLT & SOS**	**AGR & ECO**	**AGR & SOS**	**ECO & SOS**
I.	1	3	3	5	9	3	5	6	2	5
II.	2	3	4	8	2	4	5	3	5	3
III.	3	3	2	9	7	8	7	5	3	3
IV.	2	4	3	9	3	4	7	2	5	2
V.	2	3	3	6	2	2	7	1	7	7
Gmean	**2.35**	**3.18**	**3.25**	**8.11**	**3.02**	**4.18**	**6.35**	**2.27**	**4.83**	**3.99**

Table 5: Pairwise Comparison Matrix of the Criteria by the Five Experts and Synthesized Matrix with Priority Vector.

Pairwise Comparison Matrix Criteria							**Synthesized matrix of The Criteria**					
Criteria	**ENV**	**HLT**	**AGR.**	**ECO**	**SOS**		**ENV**	**HLT**	**AGR.**	**ECO**	**SOS**	**Priority Vector**
ENV.	1.00	2.35	3.18	3.25	8.11		0.46	0.58	0.41	0.30	0.33	**0.41**
HLT	0.43	1.00	3.02	4.18	6.35		0.20	0.25	0.38	0.38	0.26	**0.29**
AGR.	0.31	0.33	1.00	2.27	4.83		0.14	0.08	0.13	0.21	0.20	**0.15**
ECO.	0.31	0.24	0.44	1.00	3.99		0.14	0.06	0.06	0.09	0.16	**0.10**
SOS.	0.12	0.16	0.21	0.25	1.00		0.06	0.04	0.03	0.02	0.04	**0.04**
Total	2.17	4.08	7.85	10.95	24.28							**∑=1.00**

λ_{max} = 5.23, C.I = 0.056, RI = 1.12, $C.R_{CT}$ = 0.05 < 0.1, the judgment is consistent.

Table 6: Pair-Wise Comparison Matrix of the Alternatives with Respect to Environmental Criterion and Synthesized Matrix with Priority Vector.

Pairwise Comparison Matrix of the Alternatives with Respect to Health Effect									**Synthesized matrix**							
HLT	**OR**	**PL**	**PC**	**MT**	**EL**	**MD**	**GC**		**OR**	**PL**	**PC**	**MT**	**EL.**	**MD**	**GC**	**Priority Vector**
OR	1	2	2	4	3	2	3		0.29	0.32	0.32	0.24	0.26	0.32	0.23	**0.28**
PL	0.5	1	1	3	2	1	2		0.15	0.16	0.16	0.18	0.17	0.15	0.15	**0.16**
PC.	0.5	1	1	3	2	1	2		0.14	0.16	0.15	0.18	0.17	0.15	0.15	**0.16**
MT	0.25	0.33	0.33	1	0.5	0.33	2		0.07	0.05	0.05	0.06	0.04	0.05	0.15	**0.07**
EL	0.33	0.5	0.5	2	1	0.5	1		0.10	0.08	0.08	0.12	0.09	0.08	0.08	**0.09**
MD	0.5	1	1	3	2	1	2		0.14	0.16	0.15	0.18	0.17	0.16	0.15	**0.16**
GC	0.33	0.5	0.5	0.5	1	0.5	1		0.10	0.07	0.08	0.03	0.09	0.08	0.08	**0.08**
Total	3.41	6.33	6.33	16.5	11.5	6.33	13									**∑=1.00**

λ_{max} = 7.17, C.I = 0.029, RI = 1.32, $C.R_{ENV}$ = 0.022 < 0.1, the judgment is consistent

Table 7: Pair-Wise Comparison Matrix of the Alternatives with Respect to Health Effect and Synthesized Matrix with Priority Vector

Pairwise Comparison Matrix of the Alternatives with Respect to Health Effect									**Synthesized matrix**							
HLT	**OR**	**PL**	**PC**	**MT**	**EL**	**MD**	**GC**		**OR**	**PL**	**PC**	**MT**	**EL.**	**MD**	**GC**	**Priority Vector**
OR	1	2	2	4	3	2	3		0.29	0.32	0.32	0.24	0.26	0.32	0.23	**0.28**
PL	0.5	1	1	3	2	1	2		0.15	0.16	0.16	0.18	0.17	0.15	0.15	**0.16**
PC.	0.5	1	1	3	2	1	2		0.14	0.16	0.15	0.18	0.17	0.15	0.15	**0.16**
MT	0.25	0.33	0.33	1	0.5	0.33	2		0.07	0.05	0.05	0.06	0.04	0.05	0.15	**0.07**
EL	0.33	0.5	0.5	2	1	0.5	1		0.10	0.08	0.08	0.12	0.09	0.08	0.08	**0.09**
MD	0.5	1	1	3	2	1	2		0.14	0.16	0.15	0.18	0.17	0.16	0.15	**0.16**
GC	0.33	0.5	0.5	0.5	1	0.5	1		0.10	0.07	0.08	0.03	0.09	0.08	0.08	**0.08**
Total	3.41	6.33	6.33	16.5	11.5	6.33	13									**∑=1.00**

λ_{max} = 7.17, CI = 0.029, RI = 1.32, CR_{HLT} = 0.022 < 0.1, the judgment is consistent.

Table 8: Pair-Wise Comparison Matrix of the Alternatives with Respect to Agricultural Effect and Synthesized Matrix with Priority Vector

Pairwise Comparison Matrix of the Alternatives with Respect to Agricultural Effect									Synthesized matrix							
AGR	**OR**	**PL**	**PC**	**MT**	**EL**	**MD**	**GC**		**OR**	**PL**	**PC**	**MT**	**EL.**	**MD**	**GC**	**Priority Vector**
OR	1	3	5	7	9	1	5		0.34	0.38	0.32	0.27	0.22	0.34	0.32	**0.31**
PL	0.3	1	3	5	9	0.3	3		0.10	0.13	0.19	0.19	0.22	0.10	0.19	**0.16**
PC.	0.2	0.3	1	3	5	0.2	1		0.07	0.04	0.07	0.11	0.12	0.07	0.07	**0.08**
MT	0.14	0.2	0.3	1	3	0.14	0.3		0.05	0.03	0.02	0.04	0.07	0.05	0.08	**0.04**
EL	0.11	0.11	0.2	0.3	1	0.11	0.2		0.04	0.01	0.01	0.01	0.02	0.04	0.01	**0.02**
MD	1	3	5	7	9	1	5		0.33	0.38	0.32	0.27	0.22	0.34	0.32	**0.31**
GC	0.2	0.3	1	3	5	0.2	1		0.07	0.04	0.07	0.11	0.12	0.07	0.06	**0.08**
Total	2.95	7.91	15.5	26.3	41	2.95	15.5									**∑=1.00**

λ_{max} = 7.39, C.I = 0.066, R.I = 1.32, $C.R_{AGR}$ = 0.050 < 0.1, the judgment is consistent.

Table 9: Pair-Wise Comparison Matrix of the Alternatives with Respect to Economic Effect and Synthesized Matrix with Priority Vector

Pairwise Comparison Matrix of the Alternatives with Respect to Economic Effect									Synthesized matrix							
ECO	**OR**	**PL**	**PC**	**MT**	**EL**	**MD**	**GC**		**OR**	**PL**	**PC**	**MT**	**EL.**	**MD**	**GC**	**Priority Vector**
OR	1	9	5	2	1	1	0.5		0.17	0.19	0.20	0.21	0.19	0.12	0.18	**0.18**
PL	0.11	1	0.3	0.11	0.11	0.11	0.11		0.02	0.02	0.01	0.01	0.02	0.01	0.04	**0.02**
PC.	0.2	2	1	0.3	0.25	0.3	0.11		0.03	0.04	0.04	0.03	0.05	0.04	0.04	**0.04**
MT	0.5	9	3	1	0.5	1	0.3		0.09	0.19	0.12	0.11	0.09	0.12	0.11	**0.12**
EL	1	9	4	2	1	2	0.5		0.17	0.19	0.15	0.21	0.19	0.24	0.18	**0.19**
MD	1	9	3	1	0.5	1	0.3		0.17	0.19	0.12	0.11	0.09	0.12	0.11	**0.13**
GC	2	9	9	3	2	3	1		0.34	0.19	0.36	0.32	0.37	0.36	0.36	**0.33**
Total	5.81	48	25.3	9.41	5.36	8.41	2.82									**∑=1.00**

λ_{max} = 7.06, CI = 0.012, RI = 1.32, CR_{ECO} = 0.009 < 0.1, the judgment is consistent.

Table 10: Pair-Wise Comparison Matrix of the Alternatives with Respect to Social Effect and Synthesized Matrix

Pairwise Comparison Matrix of the Alternatives with Respect to Social Effect									Synthesized matrix							
SOS	**OR**	**PL**	**PC**	**MT**	**EL**	**MD**	**GC**		**OR**	**PL**	**PC**	**MT**	**EL.**	**MD**	**GC**	**Priority Vector**
OR	1	1	4	2	3	3	3		0.27	0.27	0.22	0.17	0.3	0.3	0.3	**0.26**
PL	1	1	4	2	3	3	3		0.27	0.27	0.22	0.17	0.3	0.3	0.3	**0.25**
PC.	0.25	0.25	1	0.33	0.5	0.5	0.5		0.07	0.07	0.06	0.30	0.05	0.05	0.05	**0.05**
MT	0.5	0.5	3	1	0.5	0.5	0.5		0.13	0.13	0.17	0.09	0.05	0.05	0.05	**0.09**
EL	0.33	0.33	2	2	1	1	1		0.09	0.09	0.11	0.17	0.1	0.1	0.1	**0.11**
MD	0.33	0.33	2	2	1	1	1		0.09	0.09	0.11	0.17	0.1	0.1	0.1	**0.10**
GC	0.33	0.33	2	2	1	1	1		0.08	0.08	0.11	0.17	0.1	0.1	0.1	**0.12**
Total	3.74	3.74	18	11.33	10	10	10									**∑=1.00**

λ_{max} = 7.26, CI = 0.045, RI = 1.32, CR_{SOS} =0.034 < 0.1, the judgment is consistent.

Table 11: Overall Priority Matrix for Prioritizing the Major Components of Solid Waste Based on their Effects

	ENV (0.41)	**HLT (0.29)**	**AGR (0.15)**	**ECO (0.10)**	**SOS (0.04)**	**Overall Priority vector**	**Priority**
OR	0.35	0.28	0.31	0.18	0.26	**0.30**	**2nd**
PL	0.24	0.16	0.16	0.02	0.25	**0.69**	**1st**
PC	0.16	0.16	0.08	0.04	0.05	**0.16**	**3rd**
MT	0.10	0.07	0.04	0.12	0.09	**0.08**	**5th**
EL	0.07	0.09	0.02	0.19	0.11	**0.06**	**7th**
MD	0.05	0.16	0.31	0.13	0.10	**0.07**	**6th**
GC	0.03	0.08	0.08	0.33	0.12	**0.10**	**4th**

5. Conclusion

Municipal solid waste management is a complex decision-making situation, particularly in developing countries, due to limited resources and a lack of sound solid waste management technology. A huge volume of solid waste dumped for a longer period, not evacuated, is visible in most urban centers of developing countries. Communities and the environment were exposed to the effects of the substances from the components of the solid waste, and physical assault from the solid waste was also visible. Stakeholders most of the time face serious decision-making situations during solid waste management, since the resources available for the management of the solid waste are limited. As such, all the solid waste cannot be evacuated at the same time. In this paper, major components of solid waste were identified, and criteria for assessing the components of solid waste based on their effect were also identified in Ganye Metropolitan, Adamawa State, Nigeria. Multi-criteria decision-making technique, AHP, was used to prioritize the components of the solid waste based on their effect during the solid waste management. The study shows that plastic and polyethylene (PL) will be first given attention, then followed by organic waste (OR), paper and cardboard (PC), glass and ceramics (GC), Metals (MT), medical waste (MD), and electronic waste (EL).

Due to the limited resources for solid waste management in most urban centers of developing countries, this study will assist stakeholders, concerned groups, and individuals in decision-making, giving attention to the component of solid waste that has the most devastating effect.

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