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Composition, Preferences and Flow Pattern of Scrap Metal among Actors in Abia State, South Eastern, Nigeria

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ABSTRACT
management and resource conservation while providing financial and livelihood gains. This study therefore investigated the flow of scrap metals among the actors and the proportion of scrap metals sold to recyclers in Abia State, South Eastern Nigeria, within twelve months. A total of ninety-six scrap yards were selected and sampled using stratified sampling techniques. Site-specific/output approach that involves the vehicle load sampling of scrap metals from the scrap yards to recyclers was employed to determine the volume of scrap metal taken to recyclers monthly. The findings identified the scrap collectors as the value providers and primary stakeholders on which the entire scrap metal recovery chain depends. An average of 1026.49±471.35, 1258.38±577.85, and 4.65±3.31tonnes for ferrous, nonferrous and E-scrap are sold to recyclers reducing the volume sent to landfills. A higher volume of scrap metal was recovered and sold to recyclers during the wet season. Nonferrous scrap metal is the most preferred scrap metals and accounts for 54.9% of scrap metal sold to recyclers. Scrap recycling is a sustainable approach to its management.

KEYWORDS: scrap metals, scrap yards, ferrous metal, nonferrous metal, E-scrap.

INTRODUCTION

Waste is subject to commodification globally and is seen as a value-laden material whose exploitation provides significant socioeconomic benefits as they are often regarded as natural resources harvested for a livelihood (Nzeadibe, 2019). Dias (2012) reported that globally millions of less privileged urban residents make a living from unregulated collection, recycling, valorization, and waste disposal. Scrap metals are discarded metallic solid waste generated from human uses which could be reused, recycled, or landfilled. According to Aruna-Shantha (2019), scrap metals are recyclable metal remains from vehicles including aircraft and ships, metal from construction and demolition sites, machinery, household pieces of equipment, electrical and electronic equipment, and packaging. Shaw and Kelly (2006) noted that all metallic material types are susceptible to degradation. However, scrap metals retain all the qualities of metals even in their degraded state thus making scrap metal a prized material with significant monetary value, unlike other waste.

Scrap metals are classified into ferrous, nonferrous and e-scrap. ISRI (2019) defined ferrous scraps as metals that embed iron and, therefore, have a magnetic quality. They include steel, carbon steel, engineering steel, cast iron, and wrought iron. Nonferrous scrap metal does not contain any iron or magnetic properties

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and is usually more resistant to corrosion than ferrous metals (ISRI, 2019). They include aluminum, copper, lead, brass, nickel, and others. E-scraps are cast off valuable metals generated from electrical or electronic devices after the ferrous and non-ferrous parts have been recovered. These scrap metals become abandoned and littered in households, gutters, roadsides, auto-mechanic workshops, scrap vehicle markets, underdeveloped plots of land and public places. This uncoordinated scrap disposal has negative impacts on the environment as it has been linked to drainage and road blockage thereby causing flooding, poor aesthetics and breeding grounds for rodents which increase the prevalent rates of diseases. These improperly disposed scrap metals could also be buried in the soil thereby causing a barrier to the sprouting of seedlings, disruption of the vegetation and adverse environmental impacts through toxic leachates affecting local soil and triggering the bioaccumulation of toxic heavy metals in edible plants.

In recent years, there has been an increasing generation of scrap metals, thus, encouraging the involvement of the actors in its collection and recycling. The importance of the activities of these actors cannot be overemphasized as through their activities useful scrap metals such as iron, aluminum, lead, and copper are been recovered. These actors include the scrap collectors, the scrap dealers and the recyclers. The scrap collectors pick up scrap metal from a mixed solid waste stream or the first point of disposal whenever it may be temporarily accessible or disposed of or otherwise. They often utilize door-to-door visits (GSMD, 2014). The recovered scrap metals are predominantly generated in the investigated Locality as there is little or no inflow of scrap metal from other neighboring States. These collected scrap metals are sold to scrap dealers in the scrap yards. Scrap dealers manage the scrap metal yards which are holding facilities in the scrap metal recovery chain of activities. Scrapyards are spaces used for sorting, storing and processing scrap metals.

These actors garner a lot of financial gains while also performing an essential service in ensuring that scrap metals are taken to the recyclers who turn the scrap metals into reusable products. In the scrapyards, scrap metals are first identified by considering color, weight, hardness, magnetic properties, and the nature of sparks whenever metal is ground. They are further sorted into their categories by hand and thereafter compressed and bailed using sledgehammers and motor shafts used as flatteners. Thereafter they are stored in an enclosed or open space in the scrapyards to achieve the desired volume before transporting them to the recycling centers using vehicles such as trucks and freight containers.

Scrap metal is reprocessed into valuable materials like new railways and motor parts, electrical cables, beams, rebar used for bridges and buildings, structural steel, protectors, and nails. This earlier assertion aligns with Dawes (2015), who reported scrap metal as one of the materials that can be refashioned into many new uses. Scrap metal recycling helps to minimize waste landfills and reduce pollution as obsolete scrap that would have polluted the environment is recovered. It also reduces the monetary cost of waste management by reducing the volume of municipal solid waste due for collection and disposal (Gauffin and Pistorius, 2018). However, no work has been carried out on the flow pattern of scrap metals between actors involved in scrap metals activities or the volume of scrap metals sold to recyclers in South Eastern Nigeria. Against this backdrop, this study with a focus on Abia State determines the proportion and composition of scrap metals recycled and develops a flow map of the pattern of collection. This study aims to provide the background information to fill in the current gap in knowledge and could lead to improved scrap metal management practices.

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METHODOLOGY

Description of the study area

This study was carried out in the three major cities of Abia State, Nigeria. Abia State lies on Latitude $5^0$25'N and Longitude $7^0$30'E. The state is bounded in the North and North-East by Ebonyi state, bordered in the west by Imo State, to the east and southeast are Cross-River, and the Akwa Ibom States, and to the south is Rivers State. By the projection of the National Bureau of Statistics, established on the 2006 census and the National Population Commission Allocation 2006, Abia state has about 2,833,999 in population (NPC, 2011). The climate of Abia State falls within the equatorial climatic belts with alternating wet and dry seasons. The wet season begins in March and ends in October with a break in August, usually called the "August break", while the dry season extends between November and February each year (Abija and Nwankwoala, 2018). The economic activities which are primary in Abia State are agriculture and trading.

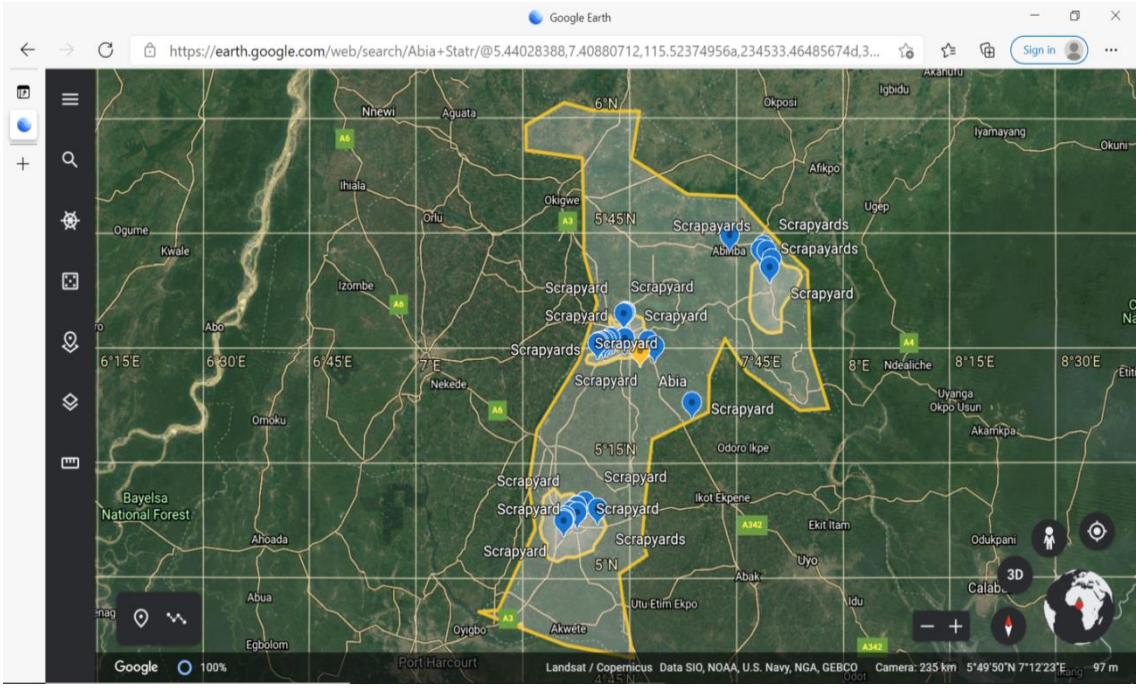

Fig. 1: Map of Abia State

Sample Size

The sample size was determined by first identifying the target population for the scrap collectors and scrap dealers and then determining a sample that reflects as closely as possible the whole population. The estimated population of scrap collectors in each of the towns is about 2550. A sample size calculator provided by Research Information (2008) was utilized to determine a suitable sample size. When this formula is applied to the 2550 scrap collectors we obtain 384 scrap collectors per town and 1152 for the entire population. Thirty-two scrapyards were also determined to be the sampling population for the scrapyards in each of the investigated locations (Aba, Ohafia, and Umuahia) using the earlier applied sample size calculator in the selection of sample size. These scrapyards were representative of the strata in the population. A total of 96 scrap yards were selected for the three towns. While a total of 128 scrap dealers were selected as a representative of the sample size which implies that 384 scrap dealers where selected for the study in the understudied towns.

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Research Design

A reconnaissance survey for familiarization of the studied scrap yards was initially conducted and the scrapyards were stratified before they were randomly selected for the study. Each of the selected scrap metal yards was visited weekly for twelve months to record the flow of scrap metals. Vehicle load sampling of scrap metals from the scrap yards to recyclers was employed in this study to determine the composition of scrap metals taken to recyclers as recommended by (ASTM, 2008, UNEP, 2009). This involved recording the number of vehicles loaded with sorted and categorized scrap metal leaving each scrap metal yard. These categories included ferrous, nonferrous, and e-scrap. These scrap metals were weighed twice and recorded in a logbook before loading into the vehicle. Their endpoint was also recorded. This provided the specific details of individual components of scrap metals taken to the recyclers and the generation trend. However, the final weights of the contents of the vehicles were determined at a weighing bridge at the recyclers' entrance, and tickets were issued to acknowledge the volume of scrap metals contained therein. The tickets were obtained from the scrap dealers and compared with the initial volume to obtain the accurate volume. This also served as a replicate. The quantity flows were determined monthly, and the inference was made at the end of the study.

Design of Survey Questionnaires

Semi-structured questionnaires were administered to twelve scrap collectors and four scrap dealers randomly selected from each scrap yard. A total of 1152 scrap metal collectors and 384 scrap metal dealers were interviewed using random sampling techniques. These questionnaires were similar in structure, but each was adapted to elicit the required responses from the target population. The questionnaires were validated through the standard process of pilot testing, checking for internal consistency, and reviewing the survey. Information from the primary sources was collated to provide the aggregate patterns and chains and determine the relationships between the identified actors, and the result was illustratively presented. The flow mapping of the collection pattern was achieved using the methodology described by Cousins (2021). Simple descriptive statistics such as tables, charts, and figures were used to analyze the data, and the results were displayed accordingly. These values were further subjected to basic descriptive statistical analyses such as mean and standard deviation using the software Statistical Package for Social Science (SPSS20) for Windows. A one-way analysis of variance (ANOVA) was performed to examine the significance level of the means as used by (Steel and Torrie, 1980). Fisher's least significant difference (F-LSD) test was used for comparison. The level of significance for mean comparison was $p<0.05$.

RESULTS AND DISCUSSION

Socio-demographic characteristics of scrap collectors

Table 1 shows the socio-demographic description of the scrap collectors. From the findings, 72.1% of the scrap collectors were itinerate collectors while 26.5 were scrap pickers. The itinerate collectors purchase a more significant percentage of scrap metals from private and public households, businesses, or institutions for a small amount before these metal waste fractions enter the formal waste management system. In contrast, the scrap pickers collect scrap metals freely from waste dumps, roadsides, and other options. The increasing number of itinerate collectors implies that people are becoming aware of the value of scrap metals and no longer dispose of them in the open waste dump, thus facilitating resource recovery and reducing scrap metal disposal at the waste dumping site. This finding is also in line with Agbeka (2016), which

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reported that scrap collectors pay for scrap metals due to increasing competition and awareness of the scrap metal trade.

One of the striking features of the gender distribution of persons involved in scrap activities is the overwhelming predominance of men's activity as only 11.45% were females and 88.51% were males as shown in Table 1. This low involvement of females in scrap activities could be attributed to the strenuous nature of the job. This corroborated Gugssa (2012) finding that female involvement in scrap metal activities was low but disagrees with Cointreau (2006), who reported scrap collectors in developing countries to comprise a significant proportion of women and children. The study established that 46.35% of the scrap collectors were in their youthful ages, while above 4% were older adults. This variation may be due to the nature of scrap activities requiring physical strength. This finding agrees with the assertions of Ngalim and Kila (2016) that scrap metal activity is dominated by those at a young age. Scrap collectors earned their livings from scrap activities, as 26.04, 33.33, 36 and 4.42% of the respondents indicated earning between ₦20,000 to ₦25,000, ₦25,000 to ₦30,000, ₦30,000 to ₦35,000 and ₦35,000 to ₦40,000 respectively as shown in Table 1. The analysis shows that income was earned whenever they conveyed the scrap metal to their endpoint. There were variations between their earnings as they depended on the number of hours they invested in the business, the composition of scrap metals traded, and trading margins. Despite all these, the majority of the scrap collectors earn more than the minimum wage, which aligns with the report by Omar (2019) that the scrap metal business offers income opportunities for poor people with an average monthly income greater than the minimum wage of workers in the formal employment sector without undermining the natural resource base. This implies that scrap collection is a significant source of income for most scrap collectors and should be encouraged to help alleviate the high rate of unemployment and poverty experienced in the State.

Table 1: Socio-demographic characteristics of the scrap metal collectors

Items	Aba(384)	Umuahia(384)	Ohafia(384)	Total(1152)
Categories of scrap collectors				
Scrap pickers	129 (33.59%)	174 (45.31%)	84 (21.88%)	387(33.60%)
Itinerant scrap buyers	255 (66.41%)	210 (54.69%)	300 (78.12%)	765 (66.40%)
Gender				
Male	318 (82.81%)	342 (89.06%)	360(93.75%)	1020(88.51%)
Female	66 (17.18%)	42 (10.94%)	24(6.25%)	132 (11.45%)
Age distribution/Category				
0 – 14 years /Children	105 (27.84%)	135 (29.69%)	138(35.94%)	378 (32.81%)
15 – 24 years/Youth	174(45.31%)	153(40.62%)	207(53.90%)	534 (46.35%)
25–49years/Young Adult	81 (21.09%)	72 (18.75%)	33(8.59%)	186(16.14%)
50–64 years/Older Adults	24 (6.25%)	24 (6.25%)	6(1.56%)	54 (4.68%)
65years and above/Elders	0	0	0	0 (0)
Educational Attainment				
No education	57 (14.84%)	48 (12.5%)	102(26.56%)	207 (17.96%)
Primary	219 (57.03%)	252 (65.62%)	258(67.18%)	729 (63.28%)
Secondary	87(22.65%)	69 (17.96%)	21(5.46%)	177(15.36%)
Tertiary	21 (5.46%)	15(3.90%)	3(0.78%)	39 (3.38%)

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Monthly income				
₦20,000 to ₦25,000	51 (13.28%)	78(20.31%)	171(44.53%)	300 (26.04%)
₦25,000 to ₦ 30,000	117 (30.46%)	135 (35.15%)	132(34.37%)	384 (33.33%)
₦30,000 to ₦35,000	165(42.96%)	171(44.53%)	81(21.10%)	417 (36.19%)
₦35,000 to ₦40,000	51(13.28%)	0	0	51(4.42%)

Source: Authors Fieldwork.

Pattern of scrap metal collection by the scrap collectors

Table 2 summarizes the pattern of scrap metal collection by the scrap collectors. From the result, a greater percentage of scrap metals are collected from the urban areas (41.66%), which implies that the urban areas generate more scrap metals than the suburbans(37.84%), and rural areas (20.46%). However, the findings also revealed that the itinerate collectors who consider scrap recovery solely as a business are ready to get to the remote areas to collect scrap metals and get to the rural areas where the municipal solid waste agencies do not have access. This helps in facilitating scrap metal recovery in rural areas. The consequential effect is that the absence of waste management agencies in rural areas may encourage rural dwellers to indiscriminate disposal of their scrap metal and may trigger environmental hazards.

Scrap metals are perceived as waste irrespective of their state, this encourages scrap collectors to collect all types of scrap metals as long as they are relatively accessible. Scrap metals are purchased without weighing them to know their actual worth. Instead, they rely on visual estimation of the weight of the scrap metal, which may be right or wrong in its estimation. They reported haggling the price of the scrap metals to the barest minimum as they feel they are worthless to the owner. These respondents listed ferrous, nonferrous, and e-scrap types of scrap metal they collect, and their preference was in this order (61.97, 30.72 and 7.29%) respectively. From the result, the most preferred category of scrap metals is nonferrous, of which copper is their most preferred nonferrous scrap. Although iron is collected in larger quantities, most scrap collectors prefer copper. This preference is linked to their monetary value from these classes of scrap metals and reflected in their purchases and volume sold to recyclers. The scrap collectors find it easier to convey nonferrous scrap metals, and a smaller volume of nonferrous scrap remits more money than a larger volume of ferrous scrap metals.

However, the most preferred ferrous scrap metal for scrap dealers is iron, which is always accepted by the recyclers and is reflected in their purchases and disposals. The scrap dealers prefer copper to other scrap metals, but due to its limited availability, aluminum, the most abundant of the nonferrous scrap metals, has taken over, so they had a better financial turnover. This was in line with Nkansah *et al.* (2015), who reported aluminum as Ghana's most common and preferred scrap metal.

The findings show a majority of the scrap collectors collect and sell scrap metals to scrap dealers on the same day thereby earning daily income. This shows that scrap collection and sundry activities formed a major means of livelihood for this population segment. Under these circumstances, the collectors cannot accumulate significant amounts of scrap to bargain for higher rates thereby implying that scrap collection is carried out on a subsistence scale.

The findings also revealed that 61.45% of the respondents use locally fabricated trucks, 30.46%, and 8% use wheelbarrows and sacks to transport the collected scrap to the point of sale despite the prevailing weather. This finding is consistent with the assertion by Nkansah *et al.* (2015) that scrap metals are usually picked into trucks and wheelbarrows. A majority (86.71%) claimed they could identify scrap metal by object recognition as they have spent years in the activity and become skilled in it, while 6.51% and 6.77%

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of the respondents identified scrap metals using chemical tests and others, respectively. Table 2 also shows the responses on the primary determinant of the endpoint of the collected scrap metals by the scrap collectors. The mode was seen in the offered price (63.57%), while nearness to the scrap yard had the least value(11.71%).

Table 2: Pattern of scrap metal collection by the scrap collectors

Item	Aba(384)	Umuahia(384)	Ohafia(384)	Total(1152)
Location of concentration				
Urban	212(55.20%)	234(60.93%)	34(8.85%)	480(41.66%)
Rural	73(19.01%)	83(21.61%)	280(72.91%)	436 (37.84%)
Suburb	99 (25.78%)	67(17.44%)	70(18.22%)	236 (20.46%)
Most preferred scrap metals				
Ferrous	105 (27.34%)	90 (23.43%)	159(41.40%)	354(30.72%)
Nonferrous	237 (61.71%)	264 (68.75%)	213(55.46%)	714 (61.97%)
E-scrap	42(10.93%)	30 (7.81%)	12(1.04%)	84 (7.29%)
Method of identification of the scrap metals				
Object recognition	342(89.06%)	309 (80.46%)	348(90.62%)	999 (86.71%)
Chemical test	-	45 (11.72%)	30(7.81%)	75 (6.51%)
Others	42 (10.94%)	30 (7.81%)	6(1.56%)	78 (6.77%)
Duration of time before disposal				
Daily	249 (64.84%)	261 (67.96%)	276(71.87%)	786 (68.22%)
Twice weekly	81 (21.09%)	69(17.96%)	33(8.59%)	183 (15.88%)
Weekly	27(7.03%)	30 (7.81%)	45(11.71%)	102(8.85%)
Monthly	27(7.03%)	24(6.25%)	30(7.81%)	81(7.03%)
Mode of transportation				
Wheelbarrows	81 (21.09%)	102 (26.56%)	168(43.75%)	351 (30.46%)
Trucks	270 (70.31%)	267 (69.53%)	171(44.53%)	708 (61.45%)
Sack bags	33 (8.59%)	15(3.90%)	45(11.71%)	93(8.07%)
Determinant of endpoint				
Offered price	237 (60.77%)	255 (66.40%)	333(86.71%)	825 (71.61%)
Familiarity and incentives	105 (28.46%)	54 (14.06%)	33(8.59%)	192(16.66%)
Nearness to scrap metal yards	42(10.77%)	75(19.53%)	18(4.68%)	135 (11.71%)

Source: Authors Fieldwork.

Socio-demographic characteristics of the scrap dealers

Table 3 shows the socio-demographic characteristics of the scrap dealer. Scrap dealers manage the scrap metal yards which are holding facilities for the scrap dealers in the scrap metal recovery chain of activities. The scrap dealers are legitimate as some are registered under the Corporate Affairs Commission (CAC) and are obligated to pay taxes and dues to the State Government. This makes them a revenue-generating sector for the State. As such, the scrap dealers constitute a crucial and secondary actor in that they exist as the primary benefactor of the scrap collectors.

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Most scrap collectors progress economically in the scrap industry to become scrapyard owners. This belief is in line with Akponah (2018), who believed that scrap workers' progression depends on the knowledge and mastery of the skills required to compete and succeed in the industry. Low involvement of females in the activity was recorded as 9.9% of scrap dealers were females against 90.10% of males. This could be attributed to the strenuous activities involved in scrap dealings.

From the results, the dominant age distribution of the scrap dealers was between 30 and 39 years, as the age distribution shows that under 20, 20 to 29, 30 to 39, 40 to 49, 50 to 59, and above 60years accounted for 16.14, 16.14, 30.72, 25, 10.93, and 1.04%, respectively. This varied with the findings by CHF (2011), who reported that the dominant age group for scrap yard workers was between 20 and 29 years.

The monthly income of the scrap metal dealers varied, with a majority (60.41%) earning between ₦35,000- ₦40,000. On the contrary, noticeable variations in the earnings of the scrap dealers were obvious. Scrap dealers experience fluctuations in their income depending on the volume of scrap metals sent to their endpoint. Since many earn from 50,000 and above, which is more than $2.5 a day, it implies that scrap dealerships are increasingly becoming a livelihood attraction in Nigeria, where a majority of the citizens earn below $2.5 per day. This finding is consistent with Amankwaa *et al.* (2016), who noted that the scrap dealers' income relates directly to the employment categories.

Table 3: Socio-demographic characteristics of scrap metal dealers

Items	Aba (128)	Umuahia (128)	Ohafia (128)	Total (384)
Categories of scrap metal dealers				
Gender				
Male	104 (81.25%)	114 (89.06%)	128(100%)	346 (90.10%)
Female	24(18.75%)	14 (10.94%)	0	38 (9.90%)
Age distribution				
Under 20	10 (7.81%)	20(15.62%)	32(25%)	62 (16.14%)
20-29	18(14.06%)	24 (18.75%)	20(15.6%)	62 (16.14%)
30-39	22 (17.18%)	32 (25%)	64(50%)	118 (30.72%)
40-49	48 (37.5%)	36 (28.12%)	12(9.37%)	98 (25%)
50-59	26 (20.31%)	16(12.5%)	0	42 (10.93%)
Above 60	22(3.12%)	0	0	24(1.04%)
Monthly income				
₦20,000 to ₦25,000	14 (10.93%)	22 (17.18%)	6(4.68%)	42(13.54%)
₦25,000 to ₦30,000	14(10.93%)	28 (21.87%)	14(10.93%)	56(14.58%)
₦30,000 to ₦35,000	22 (17.18%)	12(9.37%)	20(15.62%)	54(14.06%)
₦35,000 to ₦,40,000	78 (60.93%)	66 (51.56%)	88(68.75%)	232(60.41%)

Source: Authors Fieldwork.

Pattern of scrap metal management by the scrap dealers

Table 4 summarizes the trend of scrap management by scrap dealers. The result shows that the scrap collectors (93.75%) are the major supplier of scrap metals to the scrapyards. This further recognized the scrap collectors as the primary actors in the scrap metal industry, and the entire scrap metal recovery chain depends primarily on them. This categorization is in line with the earlier assertions by Nzeadibe (2019) report that scrap collectors are critical to the dynamic system of value reclamation from municipal solid

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waste in Nigerian cities. The study shows that 90.62% of scrap dealers identify the various types of scrap metals, irrespective of their state, through object identification, 7.29% use chemical tests, and 2.8% use other methods. This shows a lot of skill and expertise, especially in cases where the metals have degraded beyond the recognition they have acquired in handling scrap metals. However, scrap dealers are unaware of the latest trends or technology in scrap identification.

One hundred percent of the scrap dealers agreed that scrap metals were dismantled and sorted in the scrapyards before bailing. Other operational tools are gas torches or electrodes used to dismantle and cut materials of large sizes. They also use open burning to extract valuable fractions from cable wires. These scrap metals are manually sorted into various types: iron, lead, copper, aluminum, brass, and lead before weighing. The sorted scrap metals are baled and heaped in various compartments at the scrapyards. The scrap dealers stated that dismantling is a skill acquired through years of engaging in scrap metal activities. This outcome is in line with the report by Agbeka (2016), who reported that scrap metals are dismantled in an unskilled process and without the right equipment in the Ashman Scrapyard Ghana. These working conditions may have discouraged women's involvement, leaving the system only for men.

There were variations from the findings on the length of time scrap metals stay in the scrap metal yards before disposal, as 31.25%, 46.87%, 16.66%, and 5.20% disposed of their collected scrap metals weekly, bi-monthly, monthly, and other respectively. This turnover indicates that a high volume of scrap metals is recovered monthly. On the storage location of the collected scrap, all the scrap dealers store the collected scrap metal on bare ground. The dumping of scrap metals on bare ground for a more extended period poses great environmental hazards as it encourages uninhibited heavy metal leaching into the soil and subsequent uptake by the plant, which may, in turn, bioaccumulate in humans. Only precious scrap metals are stored in a large metal container built on the land to safeguard the metals if the scrap metal yards are not fenced. This finding is in line with Akpoveta *et al.* (2010), who stated that the collected scrap metal remains in the scrapyards for a more extended period for a considerable accumulation to be realized before they are evacuated and transported to recyclers. These scrap metal dealers stated they usually wait for a larger volume, preferably up to 30 tons of scrap metals, before disposing of the accumulated scrap. This helps them negotiate better prices as the recyclers prefer those with a larger volume of scrap metals and ensure that the entire transportation truck hired is filled up.

Price is the primary determinant of their preferred point of sale, as 83.33% of scrap dealers affirmed that. Familiarity and nearness to the Recyclers also determined the point of sale, as they accounted for 5.20 and 11.45% of the responses, respectively.

Table 4: Pattern of collection and disposal of scrap metals by scrap dealers

Item	Aba (128)	Umuahia (128)	Ohafia (128)	Total(384)
Provider of scrap metals				
Scrap collectors	108(84.37%)	124(96.87%)	128(100%)	360 (93.75%)
Industries	12(9.37%)	0	0	12(3.12%)
Institutions	8 (6.25%)	4 (3.12%)	0	12 (3.12%)
Storage location pending disposal				
In a container	0	0	0	0
Bare ground	128(100%)	128(100%)	128(100%)	384 (100%)
Inside a building	0	0	0	0

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Length of storage time before disposal				
Weekly	72(56.25%)	28(21.87%)	20(15.62%)	120(31.25%)
Bi-monthly	32(25%)	80(62.5%)	68(53.12%)	180(46.87%)
Monthly	20(15.62%)	12(9.37%)	32(25%)	64(16.66%)
Others	4(3.12%)	8(6.25%)	8(6.25%)	20(5.20%)
Method of identification of scrap metals				
Object recognition	108(84.37%)	120 (93.75%)	120(93.75%)	348 90.62%)
Chemical test	16(12.5%)	4 (3.12%)	8(6.25%)	28 (7.29%)
Others	4 (3.12%)	4(3.12%)	0	8 (2.08%)
Improvement done before disposal				
Dismantling and sorting	128 (100%)	128(100%)	128(100%)	384 (100%)
Chemical	0	0	0	0
Others	0	0	0	0
Equipment used for dismantling scrap metal				
Axe	6(4.68%)	12(9.37%)	4(3.12%)	22 (5.72%)
Sledgehammers	46(35.93%)	52(40.62%)	4(3.12%)	102 (26.56%)
Motor shaft	76(59.37%)	64(50%)	120(93.75%)	260 (67.70%)
Motorized equipment	0	0	0	0
Others	0	0	0	0
Extraction processes used				
Burning of cables	128(100%)	128(100%)	128(100%)	384(100%)
Use of chemicals	0	0	0	
Others	0	0	0	
Determinant of Endpoint				
Offered price	112 (87.5%)	108 (84.37%)	100(78.12%)	320 (83.33%)
Familiarity and incentives	0	12(9.37%)	8(6.25%)	20(5.20%)
Nearness to recyclers	16(12.5%)	8 (6.25%)	20(15.62%)	44(11.45%)
Others				
Loading of scrap metals				
Mechanical loading	0	0	0	0
Manual loading	32(100%)	32(100%)	32(100%)	96 (100%)
Others	0	0	0	0

Source: Authors Fieldwork.

End point of scrap metals

These reusers dismantle the scrap metals, and the valuable materials are used as spare parts for machines or other repairs. These scrap metals are manually loaded into open-top vehicles, making the stuffing of scrap metals possible. The initial weight is taken, however, the final weight of the scrap metals is determined at a weighing bridge at the recyclers' entrance, and tickets are issued to acknowledge the volume

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contained therein. This affirms scrap metals as valuable resources. From the findings, the endpoint of the scrap metals varies depending on the specified type, most of the recovered iron is taken to Inner Galaxy Recycling company located in Owaza, Abia State, and aluminum is to China and Sons in Aba. Other scrap metals are taken to the recycling centres in Onitsha, Lagos, and Benin.

Prices of scrap metal

Table 5 shows the varying mean prices of scrap metal in the investigated locations as of the time of this study. The price of copper was the highest as one kilogram was sold between ₦2,795.94 and ₦3,567 with a mean of ₦3,308 while iron accounted for the scrap metal with the lowest price as one kilogram was sold between ₦145.94 and ₦195 with a mean of ₦168. The respondents further noted that these prices fluctuate according to the Dollar exchange rate. The prices of e-scrap are constantly negotiated and rarely fixed. Leblanc (2018, 2021) reported that while the volume of nonferrous scrap metal recovered and recycled is greater than ferrous scrap, however, it is more valuable by monetary worth due to its properties, uses, and limited availability in nature. The location price differences resulting from competition and proximity to the recyclers prove a lack of standardization of scrap metal prices. This situation could be discouraging and may reduce their zeal in carrying out scrap metals activities. This is in line with the findings by Fofana (2009), who noted that the profit margin expected by scrap collectors is primarily influenced by the price per kilogram of scrap metal determined by the world metal market.

Table 5: Mean prices of scrap metals

Scrap metals (1kg)	**Aba(₦)** Mean+SE	**Umuahia(₦)** Mean+SE	**Ohafia(₦)** Mean+SE	**Mean(₦)**+SE
Iron	195.31±2.26	165.94±1.70	145.47±4.15	168.91±2.67
Nickel	646.25±4.91	460.94±3.89	447.81±4.59	518.33±9.64
Copper	3560.94±27.655	3567.19±30.42	2795.94±43.52	3308.02±42.07
Aluminium	443.75±6.02	449.69±4.93	341.25±5.15	4.11.56±5.96
Brass	1094.69±22.92	1454.38±39.48	849.69±6.82	1132.92±29.68
Batteries(Lead)	3456.25±47.16	3465.63±41.36	2298.44±30.90	3073.44±595.44
Motherboard	1522.19±33.18	1508.75±31.10	1418.75±65.71	1483.23±26.77

Source: Authors Fieldwork.

Mean Volume of Ferrous Scrap metal sold to Recyclers

Table 6 summarizes the mean volume (in tonnes) of ferrous scrap metal obtained from Aba, Umuahia, and Ohafia and sold to recyclers. Cast iron, wrought iron and steel are the main types of ferrous scrap metals sold to recyclers. The result shows that the maximum volume of ferrous scrap metal sold to recyclers was observed in Aba in the month of November (1,882.53tonnes) while the minimum volume (343.33tonnes) was observed in the month of August from the scrapyards in Ohafia. The overall monthly mean ranged between 767.91±369.07 to 1,280.80±683.06tonnes while the overall annual mean was 1026.494±471.352tonnes**.** These values were high and align with the study of Fenton (2001) who reported high deposits of metallic scraps in the environment. However, these values were higher than the values obtained from the study by Onesmo *et al* (2023), who reported a mean volume of 240 tonnes of ferrous scrap metal traded to recyclers monthly in Arusha City in Tanzania. This difference may be due to the higher population observed in the cities of Abia State when compared to Arusha City in Tanzania. The annual mean volume for ferrous scrap metals sold to recyclers from Aba, Umuahia, and Ohafia was high as it

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yielded 1403.71±321.80, 1216.05±227.41 and 459.71±82.25tonnes respectively. These results indicate that the volume of ferrous scrap metals in scrapyards in Aba and Umuahia was higher than their corresponding values in scrapyards in Ohafia all through the months of collection. The higher values of ferrous scrap metal recorded in Aba and Umuahia unlike Ohafia, could be attributed to Aba and Umuahia being densely populated and the industrial hubs of the State and implies that wealthy towns may generate more scrap metals than other towns. This finding aligns with Ogwueleka (2009), who reported that human population and industrial development are some factors influencing municipal waste generation. Cointreau (1982) also revealed that the types and volumes of waste generated vary according to economic development. Mobbs (2002) in his study also reported that recycling abandoned ferrous metal scrap is an alternative to the conventional ways of its production. This implies that a high volume of ferrous scrap metal is generated and sold to recyclers as it reflects the class of metallic materials primarily used in vehicle manufacturing, construction of houses, packaging, and foundries in the State.

Table 6: Mean volume (Tonnes) of ferrous metals sold to recycling centers

Month	**Aba(Tonnes)**	**Umuahia (Tonnes)**	**Ohafia(Tonnes)**	**Overall Mean ±SD(Tonnes)**
January	1,792.74	1,544.52	505.22	**1,280.80±683.06**
February	1,748.62	1,519.63	522.30	**1,263.52±652.04**
March	1,588.56	1,400.06	422.70	**1,137.10±625.82**
April	1,280.46	1,316.20	505.82	**1,034.16±457.90**
May	1,177.75	1,012.94	369.58	**853.42±427.04**
June	1,060.68	975.30	389.98	**808.65±365.08**
July	1,060.11	960.11	361.63	**793.95±377.72**
August	1,012.16	948.23	343.33	**767.91±369.07**
September	1,120.13	972.41	446.57	**846.37.354.03**
October	1,459.00	1,305.60	504.06	**1,089.53±512.85**
November	1,882.53	1,322.81	549.10	**1,251.48±669.57**
December	1,661.81	1,314.78	596**.32**	**1,190.97±543.42**
Annual Mean+SD	**1,403.71±321.80**	**1,216.05±227.41**	**459.71±82.25**	**1,026.49±471.35s**

Source: Authors Fieldwork.

The mean volume of nonferrous scrap metal sold to Recyclers

Table 7 shows the mean volume of nonferrous scrap metals recovered and taken to recyclers. The result shows that the range of the mean volume of nonferrous scrap metal taken to recyclers was between 907.153±557.598 and 1,623.004±823.203 with an annual mean of 1,254.388±577.851tonnes. The highest volume of Scrap metal was sold from Aba in February (2,220.45 tonnes) while the least was sold from Ohafia in the month of August(302.22 tonnes). The annual volume of nonferrous scrap metals sold to recyclers was in the order of magnitude Aba (1,765.33 ±258.38) > Umuahia(1,441.90±337.14) > Ohafia (555.92±163.27). These volumes of nonferrous scrap metals sent for recycling indicate the vast availability of these different classes of nonferrous scrap metals considered waste in the State and align with the findings by Ojonimi *et al.* (2018) that high economic value of scrap metals are hardly discarded or landfilled. Nonferrous is the highest sold category of scrap metal. This could be so because a large range of nonferrous scrap metals include aluminum, brass, lead, nickel, and copper and they are used in different applications

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ranging from construction and demolition, vehicles, food and drinks packaging are made up of Aluminium. This report aligns with Emery *et al*. (2002) that aluminum is the most abundant metal (by volume) found in domestic waste, mainly in drink cans. Used beverage cans (UBCs) made up of aluminum are gaining significant value with increasing market scrap prices. Leblanc (2018) reported that the percentage of recycled nonferrous scrap in the United States is smaller than that of ferrous scrap. The volume of scrap metal in the scrap yard was recovered by the scrap collectors thereby reducing the volume of waste that the municipal authorities have to grapple with and implying that scrap recycling will be an option to its management in Nigeria. This finding agrees with the work done by Asibor and Edjere (2017), who reported that scrap recycling is a viable means of waste management. This confirms that scrap recovery significantly contributes to reducing the challenges of solid waste management.

Table 7: Mean volume (Tonnes) of nonferrous metals sold to recycling centres

Month	**Aba**	**Umuahia**	**Ohafia**	**Mean ±SD**
	Mean ±SD			
January	1,950.32	1,400.44	680.57	**1,343.77±636.76**
February	2,220.45	1,964.56	684.00	**1,623.00±823.20**
March	2,160.97	1,950.82	634.98	**1,582.25±827.06**
April	1,768.66	1,792.11	650.22	**1,403.66±652.60**
May	1,724.66	1,357.00	460.97	**1,180.88±650.00**
June	1,588.62	1,678.00	484.99	**1,250.54±664.48**
July	1,665.50	1,111.00	398.04	**1,058.18±635.37**
August	1,400.56	1,018.68	302.22	**907.15±557.59**
September	1,384.88	1,002.30	356.23	**914.47±519.92**
October	1,670.99	1,228.81	470.00	**1,123.27±607.41**
November	1,824.06	1,398.59	768.06	**1,330.23±531.30**
December	1,824.33	1,400.50	780.78	**1,335.20±524.82**
Mean+SD	**1,765.33 ±258.38**	**1,441.90±337.14**	**555.92±163.27**	**1,254.38±577.85**

Source: Authors Fieldwork.

Mean Volume of E-scrap sold to Recyclers

Table 8 shows the mean volume of E-scraps taken to the recycling centres. The least volume sold to recyclers was from Ohafia(0.655tonnes) and the highest(9.72tonnes) was sold in Aba 9.72tonnes in January. The mean volume of e-scrap obtained from Aba (8.02±61.33tonnes) was higher than that obtained from Umuahia(4.94±2.45tonnes) and Ohafia(1.00±0.29onnes). The annual mean values of e-scrap (4.65±3.31tonnes**)** sold to recyclers were lower than the mean values obtained from ferrous (1,026.49±471.35tonnes) and nonferrous categories (1,254.38±577.85tonnes). This could have been because the majority of the E-scraps are dismantled into basic components of ferrous and nonferrous categories and sold off to scrap recycling companies. The residues after dismantling like hardboard drives and printed circuit boards are lower in volume but have very high commercial value because they contain precious metals which are expensive and rare. The residue with no financial value is landfilled, incinerated, or left on bare soil. According to Parajuly (2017), although e-scrap has attracted increasing attention worldwide as the 'fastest-growing waste stream' during the last two decades, in Nigeria, it is estimated that 461,300 tonnes of e-scrap were generated in 2019, and only 1,845kg were collected and recycled. This assertion aligns with the

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findings of this study as only a small fraction of E-scrap are taken to the recyclers despite the huge inflow of E-scrap.

Table 8: Mean volume of e-scrap sold to recyclers

Month	Aba(Tonnes)	Umuahia(Tonnes)	Ohafia(Tonnes)	Mean ±SD
January	9.72	7.89	1.396	**6.33±4.37**
February	9.33	8.050	1.020	**6.13±4.47**
March	9.03	7.88	1.001	**5.97±4.34**
April	7.99	4.11	0.877	**4.32±3.56**
May	7.02	4.01	0.761	**3.93±3.13**
June	6.86	3.020	0.655	**3.51±3.13**
July	4.92	1.002	0.700	**2.29±2.35**
August	7.44	2.010	0.800	**3.41±3.53**
September	8.11	2.745	0.990	**3.94±3.70**
October	8.02	5.80	1.65	**5.15±3.23**
November	8.900	6.50	1.11	**5.50±3.98**
December	8.91	6.33	1.12	**5.45±3.96**
Mean+SD	**8.02±1.33**	**4.94±2.45**	**1.00±0.29**	**4.65±3.31**

Source: Authors Fieldwork.

Seasonal variation in the volume of ferrous scrap metal sold to recyclers in Abia State

Fig. 2, shows the trend of scrap metals to recyclers in the months of study. The highest volume of scrap metal was sold during the dry season while the lowest volume was observed to have been sold during the wet season. This implies that there are seasonal variations in scrap generation and disposal as a higher volume was retrieved and sold to recyclers during the dry seasons. They further indicated the dry seasons as a season of abundance as it coincides with the festive periods as more ferrous scrap metals are generated. Akponah (2018) believes that seasonal cycles can dictate the economic performance of scrap metal collection. This finding also agrees with Ngalim and Kila (2016), who believe that the atmospheric condition is one of the prevailing determinants of the number of scrap metals collected.

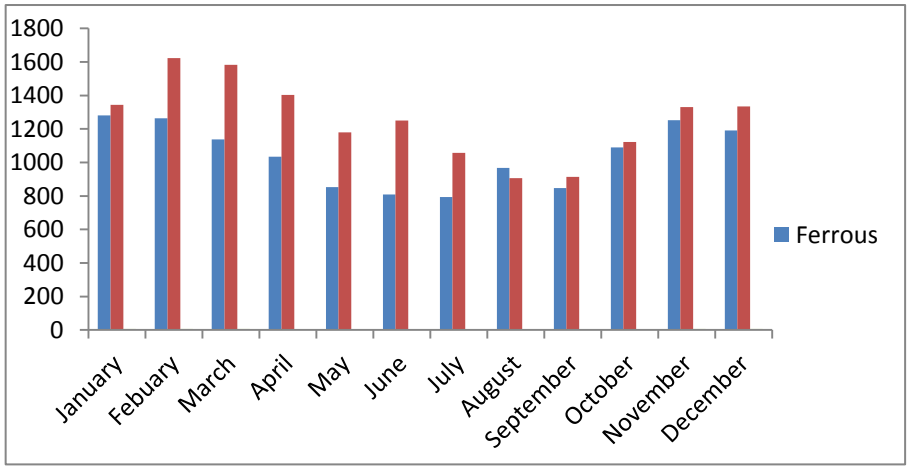

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Fig .2: Seasonal variation in the volume of scrap metals sold to recyclers in Abia State

The proportion of scrap metal sold to recyclers

Table 9 shows the proportion of scrap metals in the study areas. The highest volume of scrap metals was sold from Aba(1059.02±802.51) and the least from Ohafia(338.88±266.08) accounting for 46.3% and 14.8% respectively. Statistical differences were observed as the means of Aba and Umuahia were statistically higher than the mean obtained from Ohafia at ($P \leq 0.05$). This affirms the earlier results obtained from this study that Aba and Umuahia recovers and recycles more scrap metal than then suburban.

Table 9: Proportion of the sold scrap metals in the study areas

Study Areas	Mean±SD	Std. Error of Mean	% of Total Sum
Aba	1059.02 ±802.51[b]	133.752466	46.3%
Umuahia	887.63±679.28[b]	113.213605	38.8%
Ohafia	338.88±266.08[a]	44.347869	14.8%
Total	761.84±692.80	66.665546	100.0%

Source: Authors Fieldwork.

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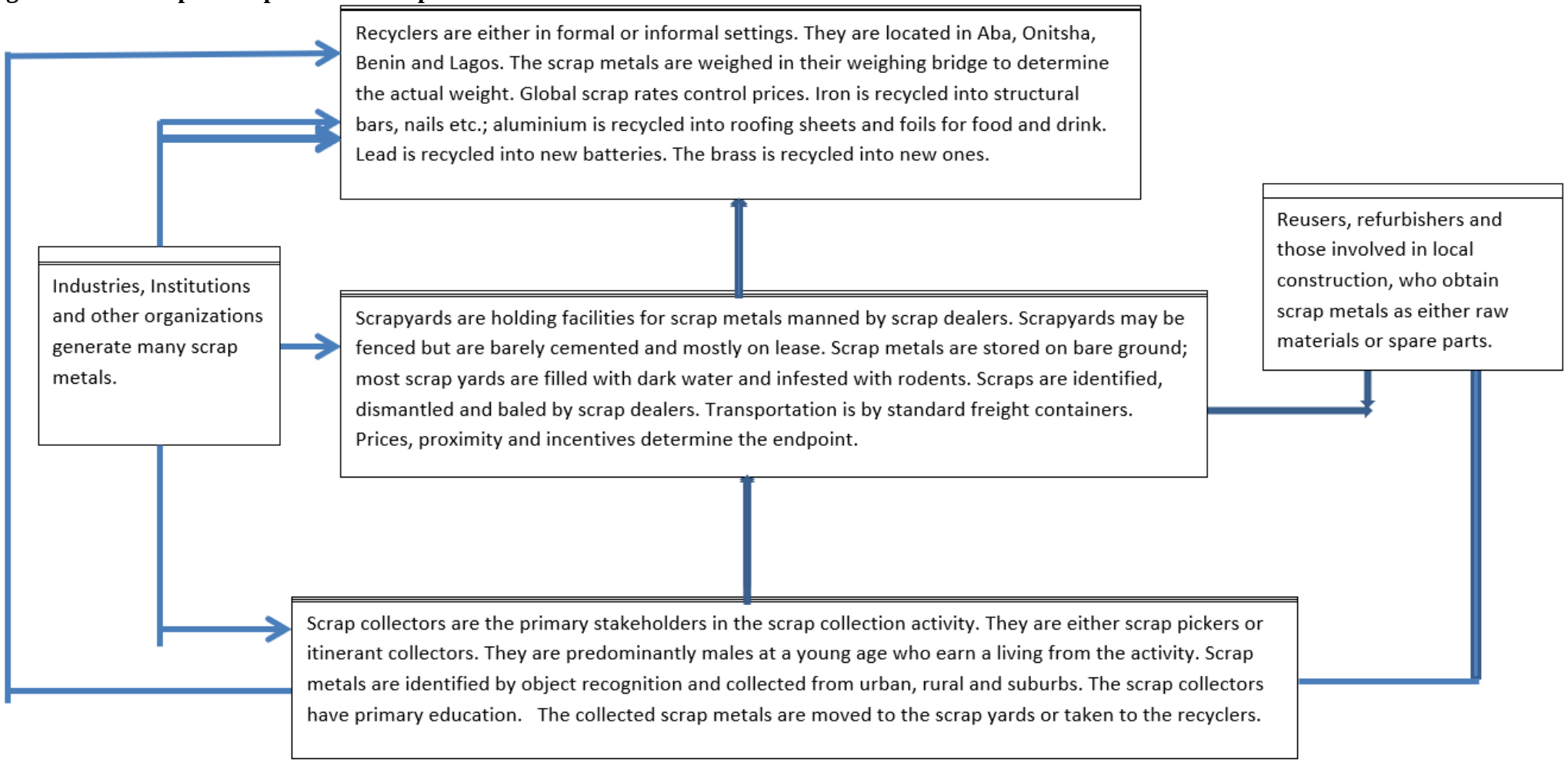
Figure 3: Flow map of the pattern of scrap metal in Abia State



Source: Authors Fieldwork

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CONCLUSION

This study investigated the composition and flow of scrap metal among actors in Abia State, southeastern Nigeria. The study had become necessary because of the challenges of scrap metal management and the resources that can be gained from using a more efficient system. This study also identified nonferrous scrap metals as the highest composition of the scrap metals recovered and recycled. The study revealed that a mean of 1026.494±471.352, 1258.388±577.851, and 13.014±9.614tonnes for ferrous, nonferrous, and e-scrap are sold to recyclers monthly. The volume of scrap metals collected was also influenced by seasonal variation as more scrap metals are collected during the dry than during the wet season. Scrap collectors are the primary actors in the scrap metal industry, and the entire scrap metal recovery chain depends primarily on them. Nevertheless, no legal or institutional frameworks promote the collaboration of scrap metal collectors with the Government to increase efficiency and minimize the volume of scrap metals ending in landfills. The result will help to provide valuable and current information to academia and other relevant agencies to develop appropriate policies to develop the scrap metals industry and increase the efficiency in scrap collection.

RECOMMENDATIONS

From the findings of this study, it is recommended that The Government should establish a sustainable scrap metal management strategy that recognizes the scrap collectors and scrap dealers involved in scrap metal collection and disposal. Scrap metal policies should be introduced and implemented by regulatory agencies. These policies should ensure that the local authorities duly register all scrap collectors and dealers and introduce innovations into the sector to enhance scrap metal recovery.

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