

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Focus in recent decade is the greening of the waste management sector, one that shifts emphasis from disposal based paradigm to integrated waste management of Reduce, Reuse and Recycle (3Rs) that could contribute to economic growth, address environmental issues in a pro-poor and equitable manner to achieve the economic, environmental and social objectives of sustainable development. Research has shown that waste is not only a challenge but also a largely untapped opportunity (UNEP,2012). However, generation of waste is an inevitable consequence of man's attempt to survive on the earth's surface through his productive and consumption processes (Miller, 2006). As more countries develop and population growth rates increase around the world, the amount of waste produced has become a major environmental issue. Man in every stage of development generates wastes, however, the rate of generation, quantity and disposal methods vary from individual to individual, source, season, geography and time (Robert, 1999). One of the challenges of the 21st century is how to achieve cost-effective and environmentally sound strategies to deal with the global waste crisis confronting mankind in both developed and developing countries. Rapid increase in volume and types of solid and hazardous waste as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for all tiers of government. The paradigm shift in waste management today is how waste can be converted to wealth. In most advanced countries of the world, such as United States of America, China and United Kingdom, waste management has become a big business because of the inherent resources potential it has (Enger and Smith, 2006). In the same vein, many organisations in Nigeria and other developing countries of the world are now advertising and selling waste which is a clear indication that the resources value of waste is on the increase.

The current trends in technological changes, population growth and pattern of consumption has largely underline the emergence of different wastes such as; industrial waste, electronic, health-care,

agricultural, domestic, construction and demolition waste among others. In 2006, the total amount of Municipal Solid Waste (MSW) generated globally was 2.02 billion tons, representing a 7% annual increase since 2003 (Global Waste Management Market Report, 2007). In the same vein, World Health Organization (2010) estimate of the total health-care waste per person per year in low income countries is between 0.5 kg to 3 kg. Similarly, the emergence of electronic waste in recent time and it has contributed significantly to the quantity of waste that is going to the waste stream. According to United Nations Environmental Programmes (UNEP, 2009), it is estimated that 20 to 50 million metric tons of e-waste are generated worldwide annually. Studies have shown that e-waste has steadily become a visible threat to the environment with the electronic industry fast becoming the world's largest manufacturing industry with the shortest life span products (Benedicta, 2012). Toxic ingredients such as lead, beryllium, flame retardants found in e-waste have been claimed to pose both occupational and environmental health threat (Puckett *et al.*, 2002)

Meanwhile, the core value of waste management can be attributed to its inherent resources potential in the society. The range of socio-economic activities associated with waste such as employment generation, poverty reduction and raw materials for industrial production of goods and services demands placing more emphasis on its management through 3Rs strategy. However, studies have shown that non-sustainable use of environmental resources have soared tremendously in recent time and evidence can be traced to huge amount of useful resources that is going into the waste stream (Ayuba, 2005).

According to UNEP (2012) an estimated global stockpile of 225 million metric tons of copper is estimated to sit in landfills. In the same vein, Food and Agricultural Organization of the United Nations (FAO, 2011) has pointed out that at least one third, or 1.3 billion tonnes of food produced is going to the waste stream, representing the superfluous use of 1.4 billion hectares of cropland which carries direct economic and environmental costs and depletes the natural resource base that underpins food production. Yet over 840 million people worldwide go hungry every day (UNEP, 2014). Besides,

UNEP (2012) have posited that the consumption of natural resources is increasing and will accelerate further if projected growth rates of the world economy are realized. These are clear evidences that the trends in waste generation, composition, types and its effects in the society are on the increase.

Similarly, the attendant problems of greenhouse gasses emission emanating from waste have been a global concern over the years. Studies have shown that waste, most especially those deposited at the landfills are major sources of greenhouse gasses; such as methane, carbon dioxide among others and the impact of these gases to ozone layer depletion cannot be over-emphasized. Pursuant to the International Framework Convention on Climate Change (IFCCC), which calls for an absolute 10 percent reduction (from 1990 levels) in GHG emissions, the practice of integrated waste management of Reduce, Reuse and Recycle (3Rs) was among the actions recommended to slow down global warming as a measures to reduce greenhouse gases emissions (Environmental International Plastic Council, 2002). To this end, it has necessitated different conventions such as Multilateral Environmental Agreements (MEAs) on wastes and chemicals in particular the Basel, Stockholm, and Rotterdam Conventions. Researchers have shown that greenhouse gases such as; methane, carbon dioxide among others takes a significant proportion of their sources from waste. According to Environmental International Plastic Council (2002), the modification of waste management practices in order to reduce the emissions of greenhouse gases is a complex procedure that involves the integration and coordination of a variety of treatment options. While waste may be land-filled or reprocessed for energy, other options like recycling and material recovery for subsequent reuse also present enormous opportunities for greenhouse gas reduction with economic and ecological benefits (Fred, 2010).

However, managing waste requires a substantial amount of capital. The United Nations Economic and Social Commission for Asia and the Pacific (2009) estimates show that in developing countries, municipalities spend 20-50 per cent of their available budget on solid waste management, yet, 30-60 percent of all the urban solid wastes remain uncollected and less than 50 percent of the

population are left unserved. Collection alone drains up 80-90 percent of municipal solid waste management budget (UNESCAP, 2009). Hence, developing countries are facing uphill challenges to properly manage their waste with rapid increase in volume and type, as a result of continuous economic growth, urbanization and industrialization. This is manifested by refuse heaps which some people call mountains of refuse that dots roads and disfigure landscape as one crisscross our urban centres (Ayuba, 2005).

Therefore, effective integrated waste management hierarchy used in an abbreviated version as a communication tool, referred to as the “3Rs” identify the choices, in order of preference, as “reduce, reuse, recycle”. The hierarchy captures the progression of materials or products through successive stages of waste management, and represents the latter part of the life-cycle for each product. This begins with design, proceeds through manufacture, distribution, use and the various options reflected in the lower stages of the hierarchy. This lower stage offers opportunities for policy intervention: to rethink the need for the product, to redesign it, minimize its waste potential, modify or extend its use so as to reduce its waste potential and recover the resources embodied in it. The resources that make up the product are the ultimate driver for better waste management policy aimed to optimize the use of the world’s limited material resources by avoiding the generation of waste.

Meanwhile, many researchers such as Ajibade (2007), Oguweleka (2009) and Clemetina (2014) among others have argued convincingly that waste is not a new thing in our society but its sophistication is advancing into the society in a new dimension. Therefore, effective integrated waste management strategy of 3Rs which can holistically address current sophistication and challenges facing waste management must be put in place so that resources can be recovered from waste in order to achieve the sustainable development envisaged globally.

1.2 Statement of Research Problem

The paradigm shift in waste management is how to attain zero waste all over the world through integrated waste management strategies of Reduce, Reuse and Recycle (3Rs). This has led to inclusion of sustainable waste management as one of the objectives of Millennium Development Goals (MDGs). Despite the world's attention to integrated waste management of 3Rs and its impact on greenhouse gas emission reduction, 3Rs is still downplayed and poorly embraced in Africa especially Nigeria. Consequently, the enormous potentials resources inherent in waste have not been fully tapped. This is evident by refuse heaps and proliferation of different landfills in our urban centres across the country.

In fact, it is an understatement that waste in Nigeria has constituted many problems over the years most especially, commercial, industrial, domestic and currently the emerging e-waste. Many floods have been reported which have wrecked great havoc, destroyed properties worth millions of Naira and in some cases claimed animal and human lives which are mainly caused by blockage of waterways by waste. Perhaps many of these disasters could have been averted if most of these wastes have been converted to useful resources through integrated 3Rs of waste management.

Studies on waste generation in major cities of Southwest Nigeria have shown that per/capita waste generation rate is between 0.4kg to 0.8 kg per day in rural and urban cities (Oguweleka, 2009). These tremendous waste generation rates are mostly caused by diverse economic activities such as urbanization, industrial development, population growth among others. As such, the land use patterns associated with these economic activities cannot cope with the enormous waste emerging from the region. Thus, the available land area to dump the waste is gradually diminishing annually.

At various occasions, Not in My Backyard (NIMBY) syndrome which is one of the major problems of landfill has caused untold crisis in many parts of the Southwest Nigeria primarily due to odours emanating from it and diseases infestation within the neighbourhood. Many landfill sites where most of the waste finally rest are major sources of methane and carbon emission which have contributed significantly to greenhouse gases. The impact of these gases on climate change cannot be

overemphasised most especially on agriculture, human health and other socio-economic activities. Besides, landfill has equally been observed as one of the major environmental concern that is posing problems on residential properties in major cities in Southwest Nigeria. In the same vein, the composition of waste stream as a result of innovations and changes in technology in the modern world of today has called for urgent intervention using 3Rs as a sustainable waste management strategy. In fact, the emergence of e-waste alone constitutes about 20% of the total waste stream generated worldwide (Benedicta, 2012). It contains many elements such as cadmium and arsenic which are hazardous and if allowed to have contact with soil, it will contaminate the groundwater and by extension have negative impact on the health of people.

Furthermore, resources exploitation as a result of poor waste management strategies is another area that deserves urgent attention. According to United Nation Centre for Regional Development (2011) the world minerals resource utilization between 1960 and 1995 rose 2.5-fold, metals use increased 2.1-fold, wood products 2.3-fold, and synthetics such as plastics 5.6-fold with annual mineral extraction of 100 billion tonnes expected in 2030. This has increased by 48% from 2002 and it has contributed significantly in eroding mineral resources base worldwide. Southwest Nigeria is a geopolitical zone of the region that is endowed with abundant natural resources and favourable climatic condition. However, the rate of unsustainable production and consumption of these resources has contributed to its diversion into the waste stream. The study area had 85 constituted forest reserves with a forest area cover of 842,499 ha (Agboola, 1979).

Today, most of the forest cover have been destroyed due to unsustainable production and consumption pattern. Through this, a sizable proportion of valuable woods and its bye-products are going into waste stream through lumbering activities. Currently, Nigerian's forest cover is less than 6% as against the FAO recommendation of 25% (Daily Trust, 2016). This shows that the total forest area cover in Southwest Nigeria is less than 50, 549.94ha. Yet, most of this forest resources like wood and paper are still going into the waste stream unchecked. Abeokuta alone generates 2288m³ of wood wastes

per day from saw mills activities (Aina, 2006). Consequently, if each state in southwest Nigeria will generates wood wastes at this magnitude, then 82,368 m³ of wood wastes will be generated in the region per day, and 30,064,320m³ annually. Thus, one could have imaging the enormous resource from wood-based industries that is getting eroded which could have serve as raw materials for other industry like potash industry, since African wood species have been studied to have potentials for generating good amount of potash (Adewuyi *et al.*, 2008).

In a related dimension, the amount of capital invested on waste management is another issue of great concern. According to fluorine (2012), government in all the six states of southwest Nigeria spend significant amount of money on waste collection and disposal, to some extent, they have created waste management agencies and engage private waste managers which have yielded little or no significant effect. Thus, this endeavour has made them to pay huge amount of money that is draining the little resource of the states without adequate consideration on resource saving measures and their economic return from the waste. To this end, the study addressed the following research questions:

- i. what are the determinant factors of 3Rs of waste management strategy in the study area?
- ii. what is the estimated utilization index of Solid waste through 3Rs in the study area?
- iii. what is the trends on practice of waste utilization of 3Rs in the study area?
- iv. is there any significant difference on use of virgin resource and waste on GHGs emission reduction in the study area?;and
- v. What is the amount of greenhouse gases emission saving reduction through waste utilization in the study area?

1.3 Aim and Objectives of the Study

This study assessed the level of utilization of waste using 3Rs model and its impact on greenhouse gas reduction in southwest Nigeria. In order to achieve this aim, the following specific objectives were pursued:

- i. identification of factors that affect waste utilization using 3Rs strategy;
- ii. estimation of the utilization index of solid waste through 3Rs in the study area;
- iii. estimation of trends on practice of waste utilization of 3Rs in the study area;
- iv. identification of any significant difference on use of virgin resource and waste on GHGs emission reduction in the study area; and
- v. estimation of the amount of greenhouse gas (carbon) emission saving reduction through 3Rs.

1.4 Justification of the Study

Southwest Nigeria has been known for her economic activities over the years such as; farming, industrial production and construction work. It has been the pacesetter for technological development of the country most especially states like Lagos, Oyo and Ogun, thereby attracting large proportion of the country's population. Population distribution, degree of production and rate of consumption have been linked with waste generation from time immemorial, of which developing countries like Nigeria is not an exception. The growth patterns of these factors contribute greatly to the waste generation in developed and developing nations of the world. Sequel to this, different waste management strategies have been adopted in the study area such as the use of incinerator, landfills and burning method coupled with efforts of different researchers across Southwest geographical zone of Nigeria but none of these efforts have holistically addressed waste problem. Hence, there is need for adequate understanding of past, present and future waste management trends in the study area to enable policy makers manage our changing and emerging waste stream and mainstream waste information into our national and global development plans.

Besides, the huge quantity of waste generated in Southwest Nigeria needs to be effectively converted to resources. The paradigm shift in waste management is how waste can be turned to resources and attained zero waste society. Over the years, many studies have been conducted on waste generation in different parts of the Southwest Nigeria such as Oguweleka (2009), Salami *et al.* (2011) and Samuel (2012) without concomitant insight on the amount of waste that is being utilized. Apart from the fact that waste disfigure the general landscape and aesthetic outlook of the major State capitals in Southwest geo-political zone, the resources depletion has called for urgent attention in the region due to changes in population, urbanization, industrialization, consumption rate and technological innovations.

The problem of land and water contamination, environmental pollution and greenhouse gases emission coupled with the proliferation of different dumpsites in Southwest Nigeria deserve urgent attention. Studies have shown that municipal solid waste disposal sites worldwide account for up to 20% of global emissions of methane, the second most significant contributor to greenhouse gas (World Resource Institute, 2012). Apart from the fact that most of the greenhouse gases from waste sector come from landfills, it is impacting negatively on residential properties in major cities because people are not ready to live in dirty environment thereby necessitating waste utilization as a prefer option. The usefulness of the energy content in waste cannot be underscored; the large volume of waste that is going into waste stream can be converted to energy. Waste generated from agricultural residue primarily in rural areas amounting to 140 billion tonnes globally has been reported to have an energy potential equivalent to 50 billion tonnes of oil and this is expected to result in a reduction of GHG emissions (UNEP, 2009). As such, the energy content in waste can be utilized to complement erratic power supply while biofuel from waste can equally be used to meet industrial energy demand in Southwest Nigeria even the country as a whole. When discarded materials (waste) are reused, they provide industries with alternate source of raw materials. This results in lower demand for virgin materials whose extraction, transport, and processing are major sources of GHG emissions. The effect of reduction in greenhouse

gasses through this means cannot be overemphasized most especially in the area of human health, reduction in desertification encroachment and general improvement in agricultural productivity. Recycling thus reduces emissions in virtually all extractive industries. Recycling of paper and wood products has a notable double impact. Not only does it reduce the demand for virgin wood fibre, but less the emissions from deforestation and enhance forest carbon sink capacity.

Utilization of wastes and their conversion into useful materials through 3Rs management strategy is another method of improving Southwest Nigeria economy. Studies conducted by Agunwamba (2003) has shown that thousands of people earn their living from waste especially scavengers. In the same vein Kofoworola (2016) posited that every 150,000 tons of waste recycled has a potential to creates nine jobs. As such, if waste is properly harnessed and used, it will create job opportunities to a substantial number of applicants thereby improving their income generation. Consequently, this will increase the Gross Domestic Product (GDP) of Southwest states and Nigeria at large.

1.5 Significance of the Study

Southwest is part of the global community and therefore not immune to the impacts of waste. As such, this study is expected to reveal the index of waste utilization in the region thereby create more awareness to step-up action and reduce the amount of resources that is going to the waste stream. The study will stimulate stakeholders in waste management to key into the strategy of reduce, reuse and recycle (3Rs) and explore its economic potential, such as employment generation, raw materials for industrial use and energy supply for socio-economic development.

In the same vein, the study will sensitise waste managers and planners to quantify the amount of waste going into the waste streams most especially iron metals, aluminium, copper and plastics and the amount of waste utilised so that the variation will form a basis to formulate policies on how to attain zero waste status in Southwest Nigeria. This implies that waste risk information derived from analyses of Southwest waste data will be integrated into the national planning and decision-making. The

integration will reveal both the challenges that waste pose and the opportunities waste presents, especially those associated with the green economy, and enhance pathway for sustainable development.

Furthermore, the study equally reveals the major factors that hinder effective utilization of waste so that government, individual and Non-Governmental Organizations (NGOs) can easily address them. Finally, this study has revealed the extent to which effective waste management strategy of 3Rs can mitigate greenhouse gas emission in the study area thereby create a platform to address problem of climate change with its attendant problems.

1.6 Scope of the Study

The study is on the assessment of Municipal Solid Waste (MSW) utilization and its effect on greenhouse gas reduction using 3Rs model in Southwest Nigeria. The study is restricted to four (4) states which are Lagos, Ogun, Oyo, and Osun in Southwest Nigeria. These states were chosen because of their large concentration of recycling industries which is the focus of this study. In the selected states, industries that utilize waste were covered. Besides, these industries are in position to provide relevant information on reduce, reuse and recycling on waste management strategy to the study. The wastes focused on include; iron metals, aluminium, copper, steel and plastics. The choice of iron metal, aluminium and copper and steel for the study was as a result of its unsustainable exploitation and consumption. They are majorly use in construction and packaging industries thereby leading to their higher consumption rate. In the same vein, the choice of plastic wastes is because it has dominated the major packaging materials for most of our consumer and industrial goods. Besides, studies have shown that plastic can stay more than three decades before it decays. Consequently, unsustainable usage of metals and non-biodegradable nature of plastics will translate to more waste generation in the study area; these factors inform their choice for this study.

The study equally examined the amount of these wastes that is reuse and recycle and the level of reduction carried out during industrial production processes. The study evaluates the amount of greenhouse gases reduction by utilising these wastes instead of using virgin resources as raw materials

for their production. Besides, the research also highlights the major factors that affect the utilization of these wastes in the study area

1.7 The Study Area

1.7.1 Location and extent

The study area is the Southwestern part of Nigeria (figure 1 & 2) which is made up of Lagos, Ogun, Oyo, Osun, Ondo and Ekiti state. It is otherwise known as southwest geographical zone of Nigeria. The area lies between Latitudes $6^{\circ}21'N$ and $8^{\circ}37'N$ of the Equator and Longitudes $2^{\circ}31'E$ and $6^{\circ}00'E$ of the Greenwich meridian with a total land area of $77,818 \text{ km}^2$ (Agboola, 1979). The study area is bounded in the East by Edo and Delta States, in the North by Kwara and Kogi States, in the West by the Republic of Benin, and in the South by the Gulf of Guinea.

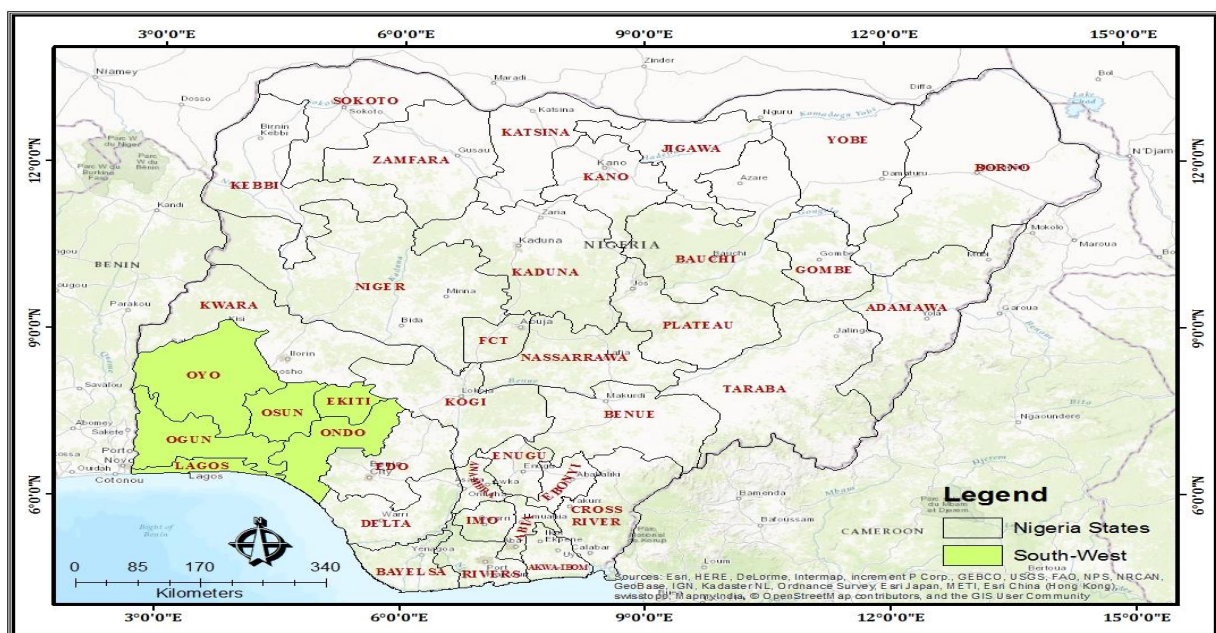


Figure 1: Map of Nigeria Showing the Southwest Geopolitical zone.

Source: National Space Research Development Agency, (2015).

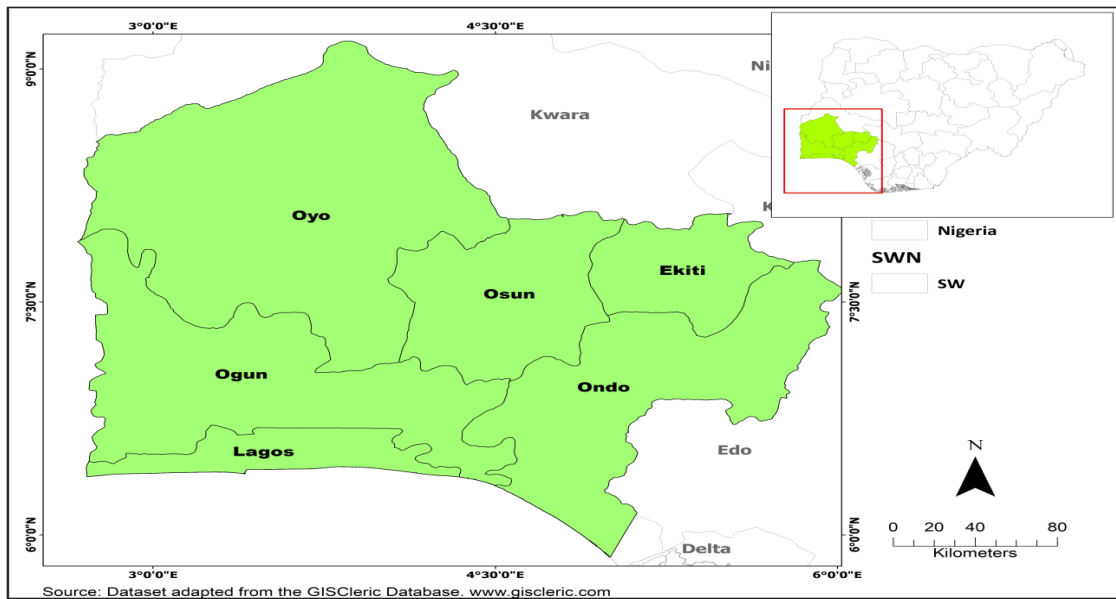


Figure 2: Map of Southwest Nigeria

Source: Dataset Adapted from the GIS Cleric Database www.giscleric.com

1.7.2 Climate

The climate of South-western Nigeria is tropical in nature and it is characterized by wet and dry seasons. The temperature ranges between 21° and 34°C (Table 1) while the annual rainfall ranges between 150 and 3000 mm (Table 2). The region experiences a rainfall regime of double maxima and last for a period of 7 to 8 months. Adejuwon *et al.* (1990) and Odekunle (1997) in their studies on various rainfall characteristics in southwest reported that the highly variable nature of the rainfall cannot be compared with the relatively stable nature of the temperature. The wet season is associated with the Southwest monsoon wind from the Atlantic Ocean. The long wet season starts in mid-March and lasts till July, is a season of heavy rains and high relative humidity of 70% (Iwena, 2008) in (Adeleke, 2016). Plants and pasture are fresh and green, grasses and weeds grow rapidly and look attractive which characterised the planting season. The short dry season is the August break and it starts from July to August and lasts for about one month. The short wet season follows the August break and lasts from September to October. During this period, rainfall is not usually heavy compared to the first wet season and the total amount of rainfall is less. The long dry season continues from November to mid-March. The average temperature of 27°C is fairly constant for the whole region (Iwena, 2008) in (Adeleke,

2016). The season is associated with the northeast trade wind from the Sahara desert. During this period, mornings are usually cool and misty, however the mist disappears after sunrise. The afternoons are full of haze due to dust in the air brought by winds from the north. At this period of the year, grasses die off and leaves of some trees turn brown and later fall (Oyenuga, 1967; Agboola, 1979; Iloeje, 2001)

Table 1: Ibadan (2000-2010) Temperature, Reflecting a Typical Southwest Temperature Data

Year	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
2000	25.46	26.03	26.05	26.00	25.90	25.22	24.17	24.11	24.49	24.79	24.81	24.98
2001	25.28	26.19	25.21	25.83	26.02	24.96	24.04	23.73	24.19	24.75	24.71	24.92
2002	25.81	25.82	25.59	25.74	25.65	24.99	24.31	23.81	24.22	24.72	24.73	24.86
2003	25.15	25.76	25.82	25.86	25.75	24.84	24.15	23.76	24.35	24.79	24.86	24.88
2004	25.75	25.72	25.90	25.46	25.36	24.46	23.70	23.63	24.33	24.34	24.73	25.24
2005	25.81	25.85	26.07	26.08	25.43	24.85	23.88	23.51	24.16	24.35	24.70	24.81
2006	25.19	25.41	25.52	25.84	25.37	24.79	23.80	23.26	23.84	24.75	25.02	25.45
2007	26.54	25.78	25.86	26.79	26.72	25.18	24.66	24.30	25.10	25.58	26.26	25.90
2008	24.51	25.73	25.98	26.17	25.60	25.10	24.05	23.78	24.23	24.92	25.77	25.58
2009	25.40	25.95	26.27	26.18	25.88	25.29	24.44	23.82	24.32	24.58	25.71	25.75
2010	25.94	26.92	26.96	27.18	26.61	25.24	24.50	24.65	24.95	25.36	25.74	26.09

Source: BBC Weather, (2016)

Table 2: Ibadan (2000-2010) Rainfall, Reflecting a Typical Southwest Rainfall Data

Year	January	February	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec
2000	5.72	0.6	66.11	122.38	126.61	184.93	158.38	194.07	252.71	118.79	2.44	0.52
2001	4.77	7.07	63.31	120.27	159.05	179.39	101.68	79.71	223.83	103.71	22.72	40.08
2002	9.29	17.39	90.46	134.02	125.52	204.35	258.83	133.21	126.53	184.11	25.94	2.56
2003	21.93	46.64	20.64	117.13	97.98	251.50	130.45	141.63	266.93	151.29	39.25	0.36
2004	70.25	31.13	73.66	93.92	140.65	94.96	184.87	110.21	219.24	178.21	20.77	2.76
2005	1.92	26.05	127.19	134.40	148.48	137.12	81.00	68.44	232.30	122.9	26.58	4.65
2006	22.13	30.09	92.52	89.26	176.91	112.65	92.30	164.31	297.30	143.99	41.24	3.21
2007	3.25	14.65	36.96	78.75	215.83	219.00	223.44	164.7	213.19	243.45	32.65	21.51
2008	13.29	15.46	91.74	75.11	183.31	256.81	239.27	152.51	244.82	156.54	13.60	21.4
2009	11.28	41.61	60.96	54.95	154.33	205.70	172.62	70.01	127.33	138.97	32.04	5.25
2010	11.65	76.83	86.94	84.04	158.72	174.92	141.68	193.16	241.83	222.69	88.82	29.13

Source: BBC Weather, (2016)

1.7.3 Relief

The southwestern Nigeria is dominated by the plain (Figure 3) which rises gently from the coast northwards to the area of crystalline rocks where inselbergs rise abruptly above the surrounding plains (Adebekun, 1978). The Idanre hill, the highest of these inselbergs, rises to about 981m above mean sea level. The plains have resulted from alternating denudational and aggradational activities. Generally, this area is referred to as the western plains and ranges. Due to the folding of the rocks, they tend mainly in a north-south direction and typical landforms are the structural ridges and inselbergs protruding from an almost flat plain consisting of pediments and sloping generally from the water divide between the Niger River and the Gulf of Guinea from about 183m to 106.5m (Adebekun, 1978). The plains extend into the western side of the Niger Delta - a swampy area of about 3,885Km² composed of the coastal plain sands and lignite series of Cainozoic age in its northern part and of alluvial mud in its southern part (Adebekun, 1978).

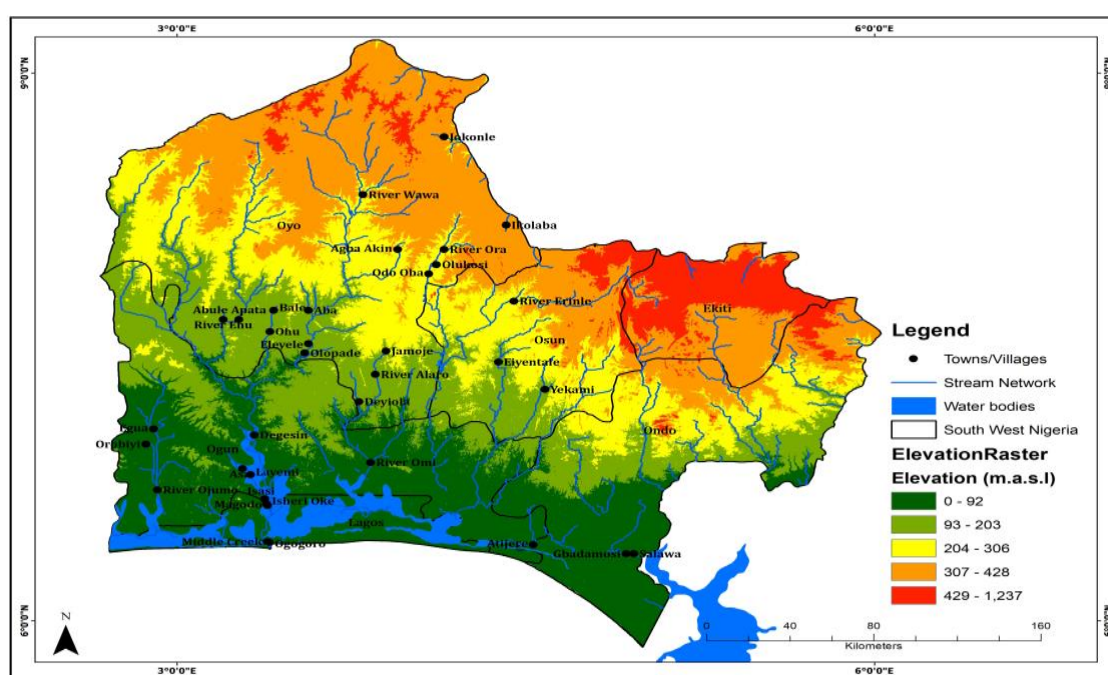


Figure 3: Relief of Southwest Nigeria

Source: Dataset Adapted from the GIS Cleric Database. (www.giscleric.com)

1.7.4 Drainage

The study area falls within the Atlantic system where most of the rivers are short, north-south coastal rivers which follow more or less regular courses (Adebekun, 1978). They drain into the sea. The western plains and ridges constitute the major divide between the rivers in a fairly simple line. On the basement complex of this unit, river directions are largely controlled by the trend of the foliated rocks and by jointing, particularly on the more resistant rocks. This structural control is well displayed by the rivers. Most of the rivers (e.g., *Ogbese*, *Ogun*, *Ogunpa*, *Oluwa*, *Ominla*, *Oni*, *Osun*, *Owena*, *Shasha*, etc.) are generally parallel but each river displays a dendritic pattern of drainage (Figure 4) with its tributaries. In the area of the coastal plains where the gradient of the river valleys is very low, the rivers deposit their load, thereby giving rise to the formation of braided channels (Oyinloye and Oloukoi, 2013)

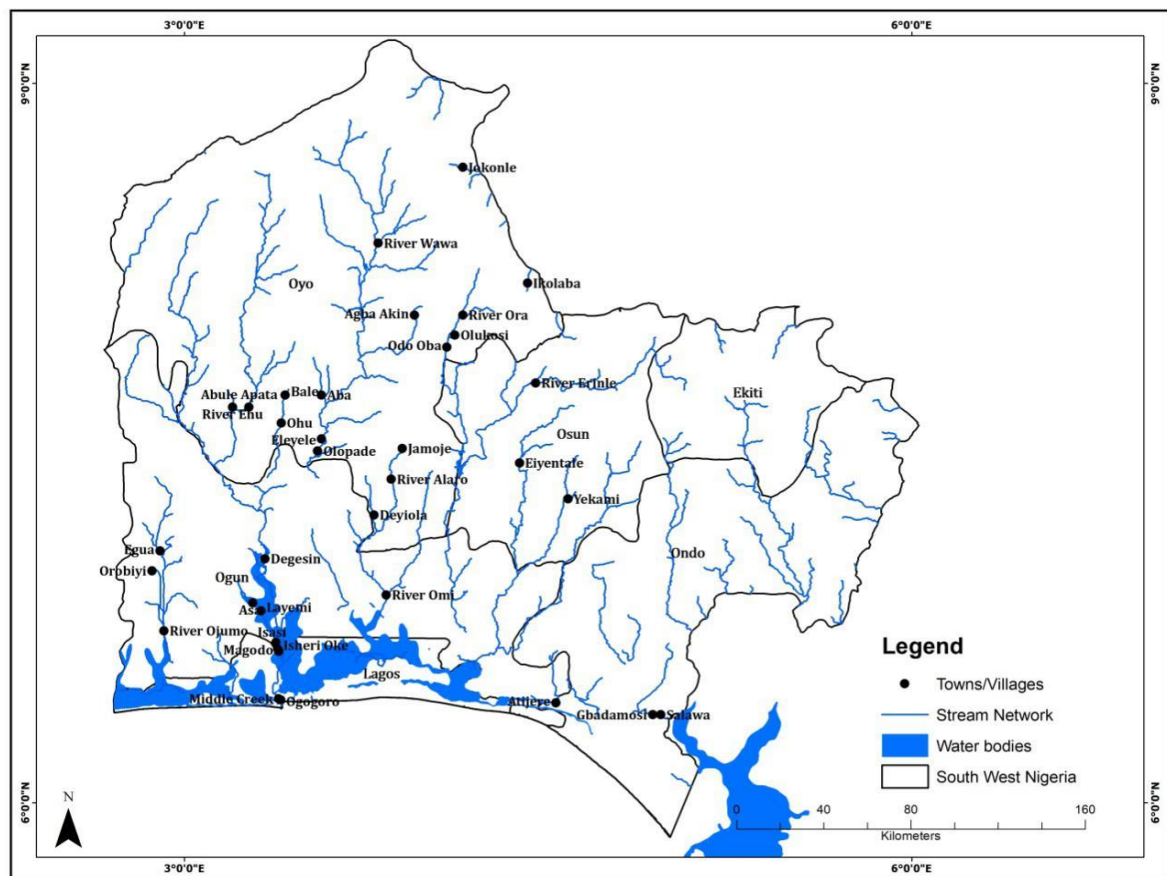


Figure 4: Drainage of Southwest Nigeria
Source: Dataset Adapted from the GIS Cleric Database. (www.giscleric.com)

1.7.5 Geology

Southwestern Nigeria overlies metamorphic rocks of the basement complex, the great majority of which are ancient being of pre-Cambrian age. These rocks show great variation in grain size and in mineral composition, ranging from very coarse grain pegmatite to fine-grained schist and from acid quartzite to basic rocks consisting largely of amphibolites (Smyth and Montgomery, 1962). The area of basement complex rocks has a number of inselbergs, hills and ridges (Figure 5) which are remnants of the African denudational surfaces. The inselbergs are generally bare domes, whale backs or less regular hills with onion-skins and tor-like cappings or boulders. Differential weathering and erosion due to rock lithology has resulted in such structural ranges of hills and ridges (Oyinloye and Oloukoi, 2013).

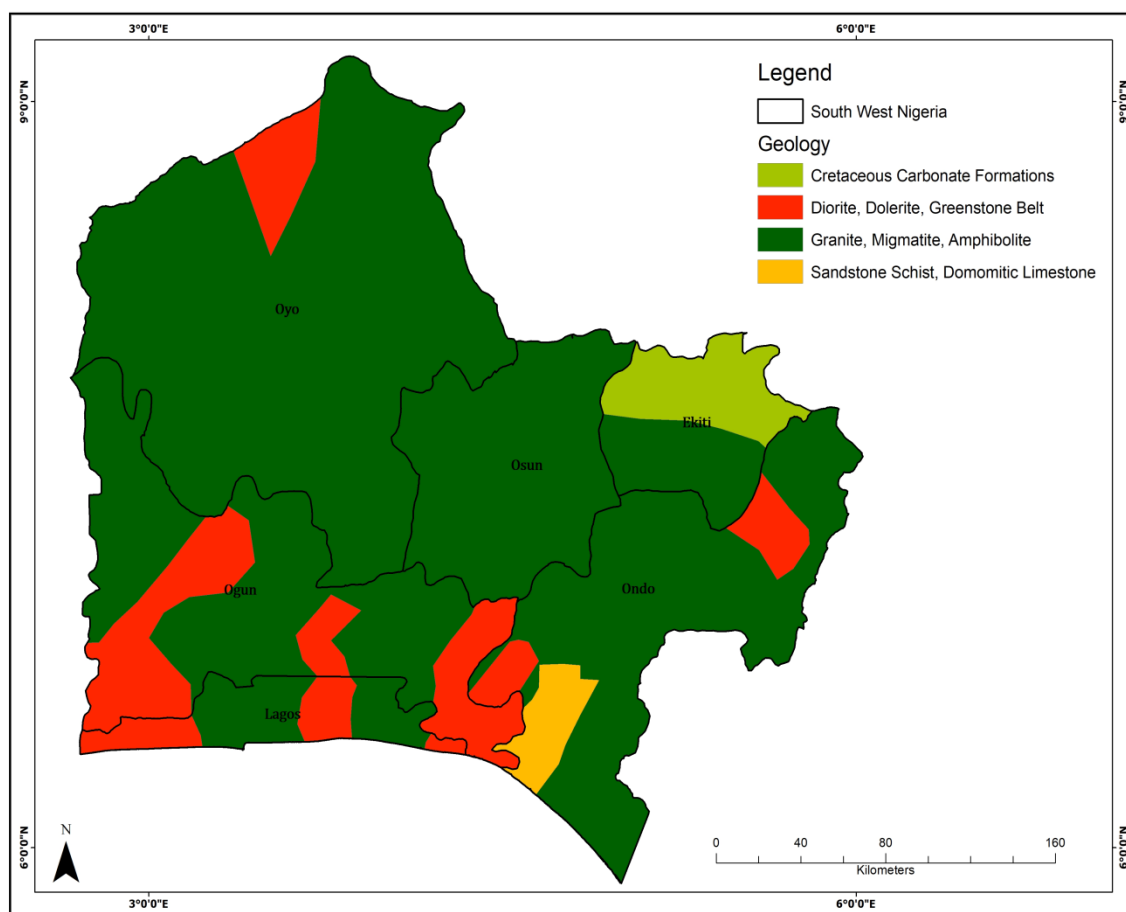


Figure 5: Geological Map of Southwest Nigeria

Source: Dataset Adapted from the GIS Cleric Database. (www.giscleric.com).

1.7.6 Vegetation

The vegetation in Southwest Nigeria is made up of forest and savannah. The forest zone comprises of saltwater and freshwater swamp located in the southernmost part of the region. The tropical rainforest or equatorial forest has three distinct layers of upper, middle and lower layer located immediately north of the salt water and fresh water swamp forest. The lowland in the forest stretches inland to Ogun and part of Ondo State, while secondary forest is towards the northern boundary where the derived southern Savannah exists (Agboola, 1979). The savannah regions, that is the Guinea and Sudan Savannah are found in the northern parts of the region particularly Oyo and Ekiti State. Human cultivation for agricultural purpose has led to emergence of a type of vegetation that can be described as Sudano-Savannah found in the northern part of southwest region.

1.7.7 Soil

The southwest belt is made of forest soils, the soil is clayey loamy and rich in minerals that support agricultural productivity (Eroarome, 2009). The soil is ferruginous and they are derived mainly from basement complex and old sediment rocks. Alluvial soil also occurs in the coaster area of Lagos and Ondo states and is poorly drained. Ferallitic or forest soil is found in area of mixed forest and savannah vegetation in parts of Ondo, Ogun, Oyo and Ekiti states. Ferallitic soil type is usually deeply weathered and heavily leached, the Ferruginous soil occurs in area where a wet season alternate with dry one. They are deeply weathered, heavily leached, reddish brown soil and are found in Osun states, parts of Oyo and Ekiti state.

These soils are developed on the sand-stone formation with red, red-yellow colours. The hydromorphic and alluvia soil characterized the type of soil found in Lagos state. Ferruginous soils are distinguished by marked differentiation horizons and abundance of free iron oxides usually deposited as red or yellow mottles or concretions. In the drier exposed sites, a distinct lateritic layer is present in the profile. The soil becomes increasingly clayey eluviation from above. The clay fraction is made up mostly of kaolin although there are small quantities of illite. The nutrient holding capacity is therefore

moderate. The ferruginous soils partly make up for their chemical deficiencies by having a strong stable structure arising from high kaolin contents and free oxides which aid particle aggregation (Adeleke,2016)

1.7.8 Landuse

Land use in southwest Nigeria varies from state to state; however, the bulk of land in the region is used for agricultural purpose particularly arable farming. Other recognized land uses include residential, educational institutions, road construction, commercial and industrial uses (Figure 6). Major industries are found in the state capitals and other major cities in the region while a number of local industries found in other towns and villages are scattered over the region. The major landuse associated with waste in Southwest Nigeria is the siting of recycling industries and landfills. Landfill has become the major techniques for waste disposal in the region, its proliferation across the major cities especially the state capitals cannot be over emphasized such as Olusosun landfill in Lagos state, Onibueja in Osun among others. Today, the declining availability of landfill space, particularly those that are close to urban areas, provides a strong incentive for waste reduction initiative. According to Gabriel and David (2014), many states in Southwest such as Ogun and Lagos state with their limited land spaces and increase in population are particularly sensitive to such space consumption issues.

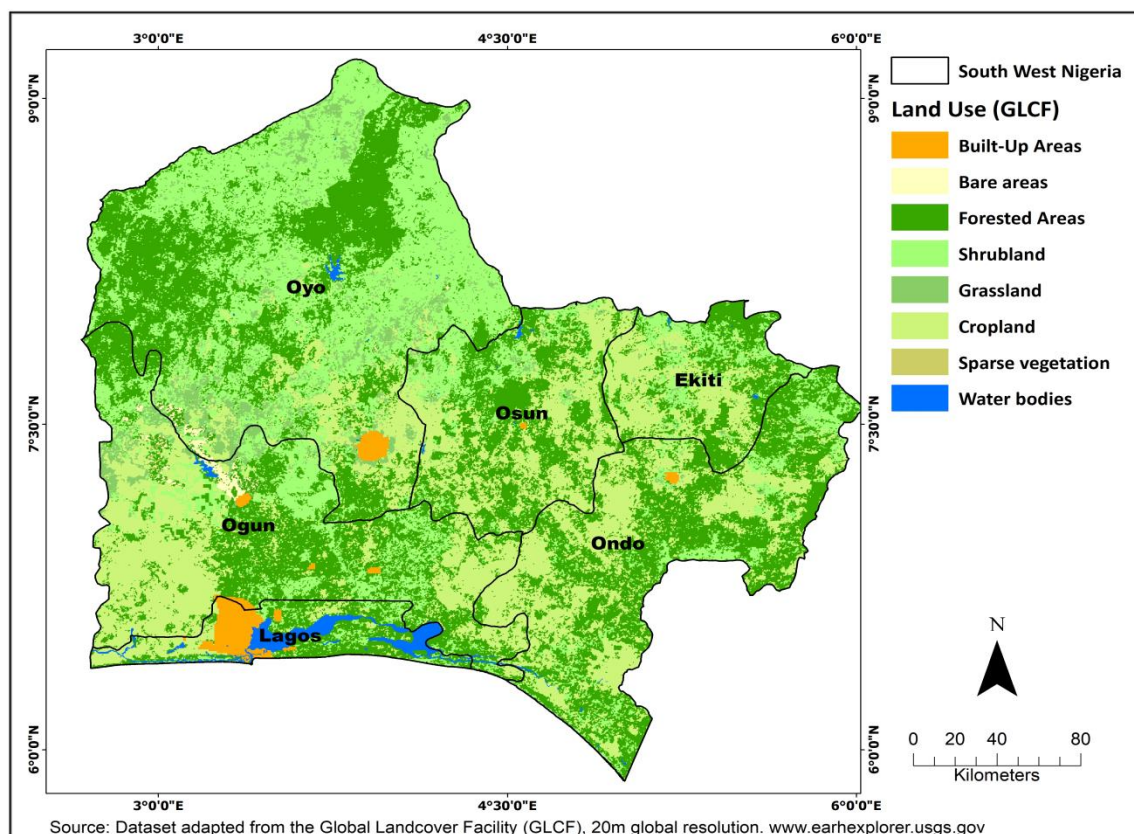


Figure 6: Vegetation of Southwest Nigeria

Source: Dataset Adapted from the Global Land Cover Facility(GLCF), 20m Global Resolution (www.earthexplorer.usgs.gov)

1.7.9 People and population

South-western part of Nigeria consists of six states; Lagos, Oyo, Ogun, Ondo, Osun and Ekiti. People in southwest are the Yoruba speaking area of Nigeria, although there are different dialects even within the same state. As such, different local languages exist in the area. Besides, the economic potential of the region has equally attracted other ethnic groups such as Hausa, Ibo and Fulani among others. People in the south-western part of Nigeria practice different religions; however, the dominant ones are Christianity, Islamic and Traditional religion. Their major occupation is farming, they engage in production of arable and cash crop. Economically, people in southwest Nigeria engage in petty trading and handwork.

The southwest have a total population of 27,581,911(NPC, 2006) as shown in (Table 3) while the population projection of the region is estimated at 41,678,162 million people at the growth rate of 3.5% as at 2018 which represent about 20% of the total population of the country

Table3: Population and Projected Population Distribution of Southwest Nigeria Using 2006 Census Figure

State	Population (2006)	Projected population (2018)
Lagos	9,013,534	13,620,069
Oyo	5, 591,507	8,449,151
Ogun	3,728,098	5,633,412
Ondo	3, 441,024	5,199,624
Osun	3, 423,536	5,173,198
Ekiti	2, 384,212	3,602,708
Total	27,581,911	41,678,162

Source: Researcher's Projection, (2018)

1.7. 10 Socio-economic activities

The people of Southwest Nigeria are endowed with favourable climatic condition with availability of fertile land that supports agricultural productivity. The people in the rural areas are purely farmers. Oyenuga (1967) reported that the humid, tropical forest zone of the Southwest that has longer rains is capable of supporting a number of plantation crops such as cocoa, oil palm, rubber, coffee, cotton and staple crops like, yam, cassava, cocoyam, sweet potatoes, melon, groundnut, rice, maize and cowpeas. In the urban cities, majority of the residents also engage in commercial activities such as trading and manufacturing which are also related to local agricultural products (Emielu, 2014). The manufacturing industries like tobacco company in Oyo and Ogun, pulp and wood industry in Ondo, food and drink industry in Oyo, Ogun and Lagos state; cement industry in Ewekoro and Shagamu in Ogun state; car assembly plant in Lagos state and saw mills in all the states. Marble is quarried in Igbeti

in Oyo north, gold is mined at Ilesha, Limestone at Ewekoro and Shagamu in Ogun state (Adeleke, 2016). Local cottage industries still feature prominently in the economy of south-western Nigeria such as weaving in Iseyin and Oyo, iron pot in Saki and Igboho, cloth dyeing *adire* in Abeokuta and Oshogbo, pottery, wood carving and calabash in Oyo. While at the same time, an appreciable proportion of the Southwest population are into civil-service jobs.

CHAPTER TWO

CONCEPTUAL CLARIFICATION AND LITERATURE REVIEW

2.1 Introduction

This chapter gives various perspectives on waste utilization of 3Rs with focus on Nigeria and other developing nations. It is divided into three parts; the first part sets out to examine important concepts pertinent to this research, while the second aspect presents available literature on waste utilization and importance of conversion of waste materials to useful resource. Finally, the third part investigates the empirical studies on waste utilization using 3Rs and related waste management studies carried out in Nigeria.

2.2 Conceptual Clarification

2.2.1 Sustainable waste utilization and management

Sustainable Waste Utilization and Management (SWUM) entail optimum use of waste as resources in the context of reduce, reuse and recycling. Today, the paradigm shift in waste management is how waste can be converted to wealth and attains zero waste society. It is a means to promote synergy between environmental resources usage and waste management. Thus to tackle the resource depletion problem, effort must be made in recovering, re-using and recycling of waste. One of the broad conditions of sustainability is built on the claim that waste should only be produced within the ability to process or assimilate them (Fred, 2010). Such a claim would under ideal consideration, imply zero waste state i.e. waste may be reprocessed to useful materials as well as energy or assimilated through reuse and recycling programs so that they can be returned to the economic mainstream. This idea was further promoted by integrated waste management hierarchy by providing a framework for moving beyond the disposal-based paradigm to a system elements of waste minimization, re-use and recycling (Olorunfemi and Raheem, 2010).

The economic approach to sustainability based on Hicks-Lindahi concept of maximum flow of income show that income could be generated while at least maintaining the stock of assets or capital

which yield these benefit (Solow, 1986; Maler, 1990; and Munasinghe, 1997) in Ivbijaro and Akintola (2012). Thus the approach focus on the optimality and efficient use of waste which is being generated from scarce resources while at the same time generate income for the populace and raw materials for industrial productivity. The concept of Reduce, Reuse and Recycle (3Rs) is a sustainable integrated waste management through which waste can be converted to useful resources. At the same time, sound and coherent waste management provide an opportunity to reap a range of material and other benefits.

Waste is not something to be abandoned or discarded, but rather a valuable resource. If waste is addressed through correct combination of policies, waste management can deliver economic, social and environmental benefits. Besides, when efficient practices are introduced into production and consumption, valuable materials are recovered (Figure 7) and people find jobs. This in turn will enhances business opportunities, communities are lifted out of poverty, health problems are solved and greenhouse gas emissions are reduced (UNEP, 2009).

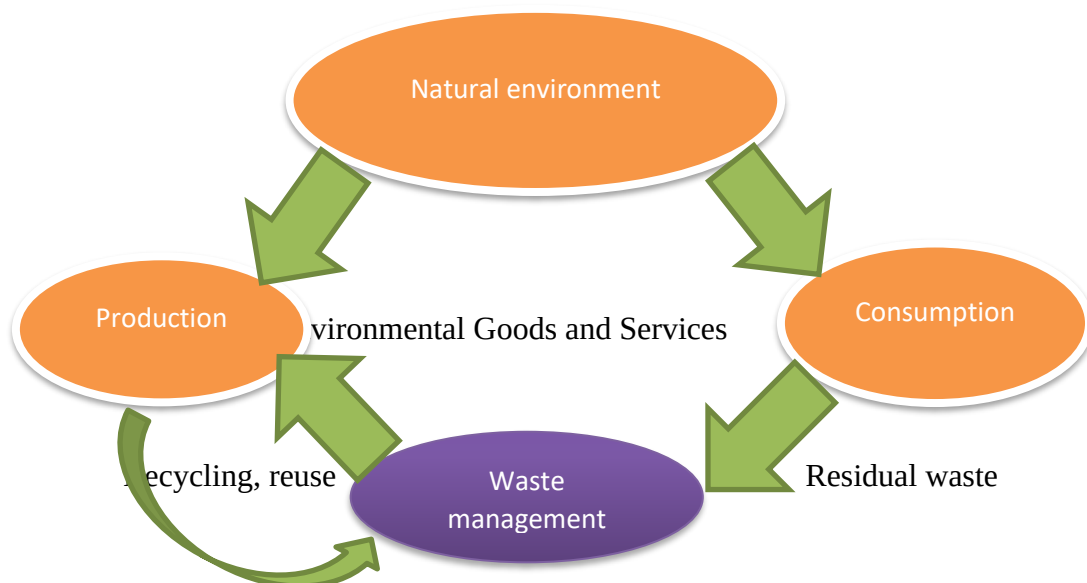


Figure 7: Framework of the Natural Environment and Human Economic Activities

Source: Adapted from Ivbijaro and Akintola (2012)

The figure 7 is a framework of natural environment through which environmental resources can be used for production of goods and services or consumption made directly from it. The residual waste generated through consumption processes can be used for further production through sustainable waste management strategies of reuse and recycling. Similarly, waste can also be generated during production

process. This indicates that the ability of the environment to continually (sustainability) perform the above function depends on production, consumption and the waste assimilator management strategy applied.

2.2.2 Concept of 3Rs

The 3R's is a vital and sustainable waste management option for reducing waste at a minimum level (Ahmedul *et al.*, 2014; Gary, 2011). "3Rs" refers to Reduce, Reuse and Recycle (Figure 8) particularly in the context of production and consumption. It calls for an increase in the ratio of recyclable materials, further reusing of raw materials and manufacturing wastes and overall reduction in resources and energy used. The introduction of 3R's became a necessity as waste generation rates risen, processing costs increased, and available landfill space decreased, the 3R's have become a central tenet in sustainable waste management efforts (El-Haggar, 2007; Seadon, 2006; Suttibak & Nitivattananon, 2008; Tudor *et al.*, 2011). The ideas are applied to the entire lifecycles of products and services, couple with all waste generation through human endeavour including agricultural sector.

The global 3Rs initiative aims to promote the (reduce, reuse and recycle) so as to build a sound material cycle society through effective use of resources and materials (Ahmedul *et al.*, 2014). Internationally recognized waste management hierarchy prescribes that the first priority should be given to waste minimization. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The impression of minimizing waste impacts in terms of extent or environmental effects is to reducing quantity of wastes, reusing the waste products with simple treatments and recycling the wastes by using it as resources to produce products (Ahmedul *et al.*, 2014). Therefore, figure 8 below is a model reflecting a continuous cyclical process through which environmental resources can be sustained.

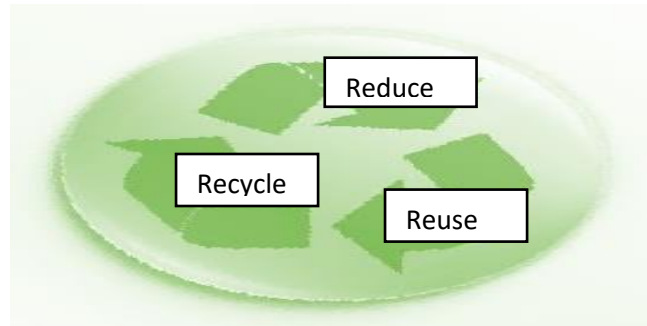


Figure 8: Integrated Waste Management of 3Rs

Source: StopWaste.Org (2008)

However, source reduction of waste have gained universal acceptance as a method of waste management which deals with the reduction in the amount of waste entering the waste stream, it is distinguished from recycling, composting, and other recovery practices, which all occur after generation of the waste, it is the highest ranking component of the solid waste management hierarchy because it represent the most effective means of reducing the economic cost and environmental impacts associated with handling waste (Henry and Gary, 1996). According to Tchobanoglous *et al.* (1993), three major factors are identified for implementing source reduction programme. These include:

- i. the adoption of industry standard product for manufacturing and packaging using less materials;
- ii. the passing of laws that minimize the use of virgin materials in consumer products; and
- iii. the adoption by communities of rates for waste management services that penalize generator for increasing waste quantities.

Various studies have shown that potential savings from source reduction are substantial; the cumulative avoided cost between 1992 and 2010 was between 700 to 800 million dollars (N.Y.C Dept. of Sanitation, 1992). This has added additional benefit to the society. Reducing waste at source, in simple terms, means reducing consumption or buying less by using products and packaging that we really need, and only buying the amount we need. This will unavoidably make people to throw away less waste. Reducing waste stops people from creating waste in the first place and is a better way to reduce waste than reusing or recycling and this has made reduction to be placed at the top of waste hierarchies

(USEPA, 2010). Economically, reducing waste generation from source has direct impact on the cost of its management.

Waste reuse is to use an item again after it has been used; it is a waste minimisation strategy which involves keeping waste out of the waste stream by passing it to others to use (USEPA, 1995; Enger and Smith, 2006; Davis, 2008). This includes conventional reuse where the item is used again for the same function and new-life reuse where it is used for a different function (Wikipedia, 2015). Reuse helps in saving money, energy and resources used in creation of new products. Waste reuse is an act of using the same item more than once instead of disposing it after a single use.

After source reduction, recycling is the most important practice within the solid waste management hierarchy (Henry and Gary, 1996). Recycling is the process of reclaiming a resource and reusing it for another or the same structure or purpose (Enger and Smith, 2006). Recycling is more than a waste-management strategy; it is also an important strategy for reducing the environmental effects of industrial production because it supplies industry with recycled materials, instead of “virgin” resources extracted from forests and mines (UNCRD, 2011). It is preferable because it saves energy, reduces dangerous air and water pollutants, such as greenhouse-gas emissions, and it conserves scarce natural resources. However, recycling requires energy and the input of some new materials, thus placing it lower on the waste hierarchy than reduction and reuse (Davis, 2008; USEPA, 2010).

The pressure of decreasing landfill capacity, environmental impacts, improving markets, economic incentives, and political support are contributing factors to the increase in recycling. Market development for recycling products depend on the quality of the materials, overall industry capacity and the cost of competing raw materials (Henry and Gary, 1996). However, contamination of the recovered materials and changes in chemical composition due to processing during recovery may lead to inferior inequality and thus lower the price of recycled materials. Similarly, recycling requires a collection and processing infrastructure so that a dependable and consistent supply of recovered materials are made available to manufacturer. This will facilitate treating and reconstituting materials

that would otherwise become solid waste to the economic mainstream in the form of raw materials for new, reused, or reconstituted products which meet the quality standard necessary to be used in the market place (CIWMB,1994) cited by (Olorunfemi and Raheem, 2010).

The economic potentials inherent in sustainable integrated waste management of 3Rs cannot be overemphasised. Recycling and reuse activities such as collection, sorting, and reprocessing generate employment. Moreover, raw materials for industrial use and reduction in the amount of Greenhouse gases which could have impacted more on climate change are wholesome benefits accrue to this system. In order to achieve optimal action plan for 3R's, the solid waste management (SWM) system must provide a reliable and sustainable waste separation system at source. This involves a house-to-house solid waste collection service, industrial and municipalities separation of waste that ensure all residual waste is transported and the remaining fraction disposed of in socially responsible manner in a safe environment. According to Ahmedul *et al.* (2014) he opines that effective 3Rs action plans (Figure 9) can achieve a recycling efficiency of at least 90 percent.

Many waste management frameworks seek to incorporate the 3R's in some capacity. In the UK, North America, throughout Europe and in parts of Asia, waste hierarchies are being incorporated which promote the adoption and use of "reduce, reuse and recycle" initiatives (Allwood *et al.*, 2010). In some instances, additional R's can be added to the basic three. Some organizations have chosen to add a fourth R (FNQLSDI, 2008; Davis, 2008). The fourth R can represent different words including rebuy (Davis, 2008), rethink (Concordia University, n.d), and recover (FNQLSDI, 2008). The concept of rebuy refers to consumer purchasing decisions. Consumers have the ability to take steps to improve waste management by helping to close the loop in waste management systems by purchasing products which have been recycled or used (Davis, 2008). Rethink is added to the three R's by some because changing our behavior and our actions can lead to improvements in waste management. Changing consumption patterns and considering the impacts of our actions can lead to decreased production of waste, and even a reduction in waste management and waste minimization efforts. Recover can refer to

methods which use and process waste so that it is used rather than disposed of (which would include reuse and recycling); however, it can also include recovering energy from waste before it is disposed. Waste can be processed into a fuel and used to produce a usable form of energy (FNQLSDI, 2008). Examples include incinerating waste to generate electricity, breaking waste down with (high temperature) pyrolysis to produce usable sources of fuel, or breaking down organic matter with anaerobic digestion to produce biogas. However, El-Haggar (2007) proposes that to achieve sustainable waste management, a 7R's methodology should be adopted: Reduce, Reuse, Recycle, Recover, Rethinking, Renovation, and Regulation. Renovation refers to taking action to develop innovative ways to process waste, while regulation is added in recognition that it is a driving force behind ensuring the implementation of responsible waste management practices (El-Haggar, 2007).

There are many key concepts which may be used to help structure a waste management plan. There are similarities and overlap between these different concepts, and each has their strengths and weaknesses, but the suitability of any given option must be assessed and determined by the responsible decision-makers.

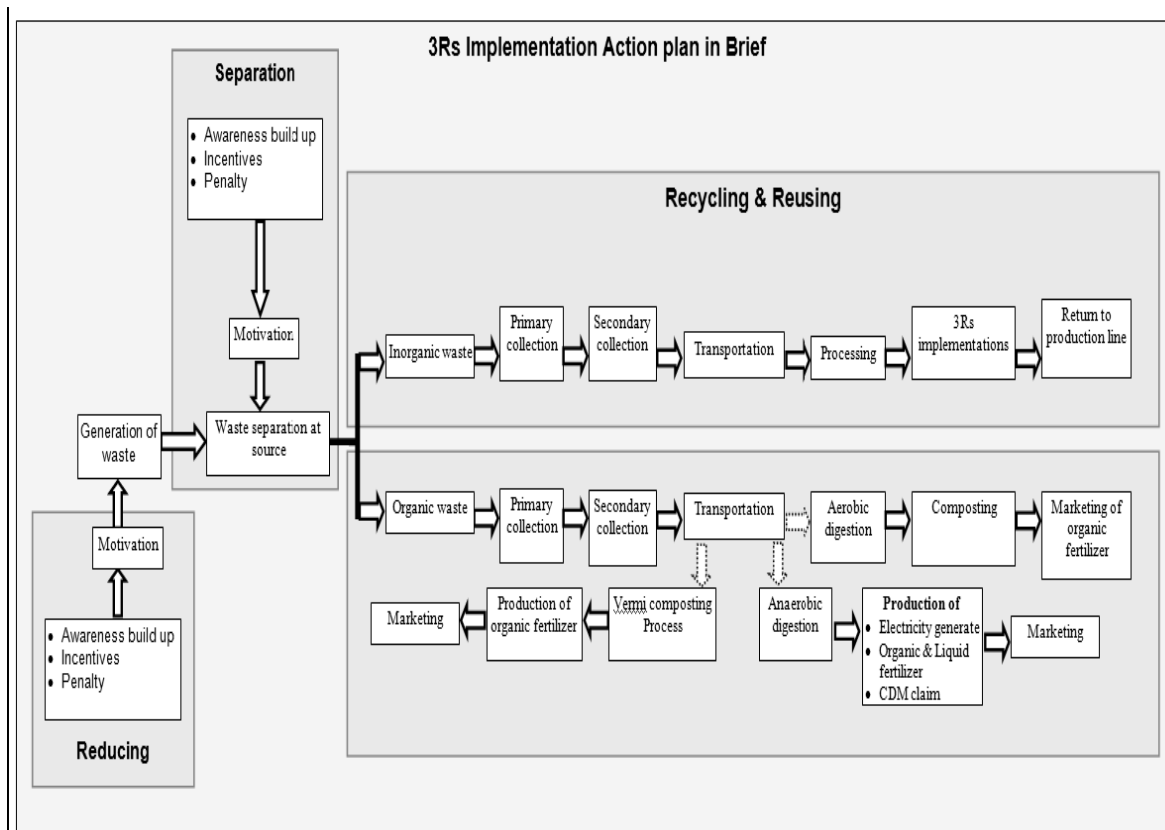


Figure 9: Effective 3Rs Action Plan.

Source: Ahmedul *et al.*, (2014).

2.2.3 Waste hierarchy

The original idea for the waste hierarchy was first borne out of the Dutch government's shortage of landfill sites (Wolsink, 2010), but the idea was propelled forward primarily by the environmental movement. The waste hierarchy is a model of waste management priorities based on the "Ladder of Lansink", a hierarchy of waste handling techniques going in order from prevention to reuse, reduction, recycling, energy recovery, treatment (such as incineration), and finally landfill disposal (Price and Joseph, 2000; Wilson, 2007; Wolsink, 2010). Thus, the availability of land and its value as a resource somewhat acted as a driver for the move away from landfilling, though land scarcity primarily led to new treatment options, such as incineration.

The waste hierarchy sparked a massive transition from end-of-pipe to preventative thinking, which emerged with a multitude of new terms and phrases – pollution prevention, source reduction, waste minimization, waste reduction, toxics use reduction, clean or cleaner technology among others,

to replace the old terms that focused on reaction and control instead of prevention (Hirschhorn *et al.*, 1993). However, Wilson (2007) points out that this is “often driven by statutory targets rather than by the resource value per se. recycling is practiced because it is the right thing to do, not because the value of the recovered materials covers the costs” Many governments, industry members, educators, environment groups, and programs have adopted and endorsed the waste management hierarchy (Gertsakis and Lewis, 2003; Seadon, 2006), which, along with what Seadon (2006) describes as “an almost mantra-like acceptance among waste professionals” and it has sparked a flurry of criticisms. According to Gertsakis and Lewis (2003), the hierarchy is difficult to implement because solid waste managers in industry and government have little control over production decisions that could influence higher-level priorities, such as waste prevention and minimization.

Additionally, McDougall *et al.* (2001) point out that the waste hierarchy does not make room for combinations of techniques, account for costs or specific constraints, lacks scientific or technical basis, and cannot provide what is fundamentally needed as an assessment of the context-specific system as a whole. The “waste hierarchy” (Figure 10) ranks waste management options according to what is best for the environment. It gives top priority to preventing waste in the first place. When waste is created, it gives priority to preparing it for re-use, recycling, recovery, and last of all disposal

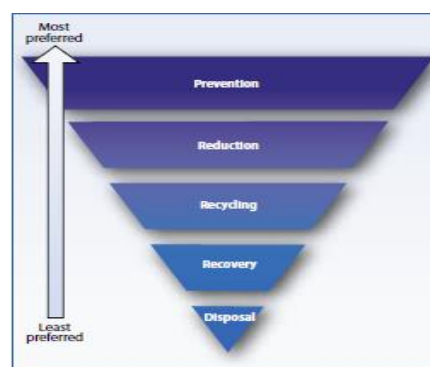


Figure 10: Waste hierarchy

Source: United Nations Environmental Programms (2011).

2.2.4 Waste collection

Waste collection is a critical component of integrated waste management of 3Rs most especially if the material is to be reused. Any wastes that are not properly managed in the collection process may finally end up in the landfill or down cycled before it can be brought back to the economic mainstream. Out of the billions of dollars expended each year for municipal solid waste management, about two third is needed to cover the cost of waste collection (Nathanson, 2006). Collection includes temporary storage or containerization, transfer to a collection vehicle and transport to a site where the waste undergoes processing and ultimate disposal.

Waste collection is the most expensive phase in waste management because it is labour intensive and proper collection techniques are important to protect public health, safety and environment quality. In developing countries, waste collection system can be categorized into six types namely: house-to-house collection, bin, block collection, curbside collection, communal collection, and the non-collection system (Adeyemi *et al.*, 2001). However, some of these methods may not be supportive for effective waste utilization of 3Rs if the wastes are not properly handled at the point of collection.

Therefore, the collection point is an interface where waste generators and waste collectors must be careful if effective and sustainable waste management of 3Rs is to be achieved (McDougall *et al.*, 2001; Davis, 2006). The old collection practice where wastes are comingled should be seen as a non-supportive system to sustainable integrated waste management of 3Rs. The collectors must be able to collect waste in a way and manner that is compatible with the planned treatment and processing methods and above all with minimal inconvenience. Collection equipment to be used must be structured in such a way as to meet the need of the end user (Plate 1: a, b, c, d,) where in most cases depend on a variety of factors such as: facility size, waste volume and weights, storage space available, characteristics of the waste being handled, and costs (CCME, 1996).



a. Roll of bins



b. Waste bins



c. Loading bins



d. Cats and tilts trucks

Plate 1: Waste collection equipment

Source: Adapted from Davis. (2006)

2.2.5 Waste characterization

Waste characterization simply means different compositions that form the waste stream. Developing effective and efficient waste management treatment is difficult in most of the developing countries because of lack of effective characterization and composition (Shimura *et al.*, 2001 and UN-HABITAT, 2010). Waste characterization plays an important role in any treatment of waste. The composition of solid waste must be known for economical collection, to design and operate an efficient recycling plant, to plan ahead for suitable reuse purposes and to forecast future demand which most of the recycling industries and other waste users are likely to meet (Salami *et al.*, 2011).

2.2.6 Waste processing/treatment

The primary objective of waste processing is to recover valuable materials from the waste stream and where possible convert some to other usable materials (Samuel, 2012). This is commonly known as resource recovery. Resource recovery is defined by Bartone (1990) as “the repairing, refurbishing, or remanufacturing of discarded goods; the separation, or reprocessing, and recycling of raw materials; and the processing of selected fraction of waste stream into new products such as compost and energy.” One of the objectives of waste treatment is to convert waste into safer material before heading to final resting place (Samuel, 2012). In the processing of waste, the equipment below (Plate2: a, b, c, d) can be used but some of them are lack in developing countries due to high cost of purchase, operation and maintenance.



a. Horizontal baler



b. Roll compactor



c. Crusher



d. Densifier

Plate 2: Waste Treatment Equipment

Source: Adapted from Davis (2006)

2. 2.7 Zero waste

Zero waste refers to waste management and planning approaches which emphasize waste prevention as opposed to end of pipe waste management (Snow & Dickinson, 2001; Spiegelman, 2006 and Gray, 2011). Zero waste encompasses more than eliminating waste through recycling and reuse; it focuses on restructuring production and distribution systems to reduce waste (Young *et al.*, 2010). An important consideration of the zero waste philosophy is that it is more of a goal, or ideal rather than a hard target. Even if it is not possible to completely eliminate waste due to physical constraints or

prohibitive costs, zero waste provides guiding principles for continually working towards eliminating wastes (Snow and Dickinson, 2001) and there are many successful cases around the world which resulted from the implementation of the zero waste philosophy (Townend, 2010).

The zero waste philosophy has been adopted as a guiding principle by several governmental organizations as well as industries (Snow and Dickinson, 2001; Townend, 2010). Because the focus of zero waste is on eliminating waste from the outset, it requires heavy involvement primarily from industry and government since they are presented with many advantages over individual citizens. In fact, zero waste will not be possible without significant efforts and actions from industry and government (Connett and Sheehan, 2001). Industry has control over product and packaging design, manufacturing processes, and material selection (Townend, 2010).

Meanwhile, governments have the ability to form policy and provide subsidies for better product manufacturing, design and sale; and the ability to develop and adopt comprehensive waste management strategies which seek to eliminate waste rather than manage it (Snow and Dickinson, 2001). Due to the heavy involvement of industry in eliminating waste, extended producer responsibility is often an essential component of zero waste strategies (Spiegelman, 2006). However, zero waste is now fashionable because it is more resource sustainable driven and a number of companies have successfully embraced the zero waste concept including Hewlett-Packard, Kimberly Clark, and The Body Shop (RCBC, 2002).

2.2.8 Extended product responsibility

The concept of Extended Producer Responsibility (EPR) was formally introduced by the Swedish Government in 1975 by the following official statement:

"The responsibility that the waste generated during the production processes could be taken care of in a proper way, from an environmental and resource saving point of view, should primarily be of the manufacturer. Before the manufacturing of a product is commenced it should be known how the

waste which is a result of the production process should be treated, as well as how the product should be taken care of when discarded."

It is generally described as a pollution prevention policy that focuses on whole product systems rather than individual production facilities. The responsibility for the product is therefore, broadened beyond the emissions and effluents generated by the extraction or manufacturing processes. It also includes the management of product once it is discarded.

Extended Product Responsibility (EPR) is based on the premise that the primary responsibility for waste generated during production process (including extraction of raw materials) and after the product is discarded, is that of the producer of the product (Haskell, 2004). The ultimate goal of Extended Product Responsibility (EPR) is sustainable development through environmentally responsible product development and product recovery. The theory is that by making producers pay to remediate the waste and pollution they create, they will have an incentive to include a broad range of environmental considerations into their product design, packaging and even choice of materials. The strategy is to reduce consumption of resources at all stages of the life-cycle of a product. Hence, the overall goals are cleaner production and waste prevention (Haskell, 2004).

2.2.9 Industrial symbiosis and by-product exchange

The concept of industrial symbiosis, a key field of study and practice of industrial ecology, is based on the process of exchange and collaboration between firms, where one facility's waste (energy, water or materials) becomes another facility's feedstock. Inherent in industrial symbiosis is a cooperative approach to competitive advantage among unrelated firms. The keys to industrial symbiosis are collaboration and synergistic possibilities offered by geographic proximity.

A by-product exchange is especially useful when a production company reach the limits of cleaner production and still have major unusable wastes. The concept of industrial symbiosis broadens the mission of such a network to sharing other resources, as well as by-products, especially energy,

water and a wide range of services. This is a waste management technique that is sustainable and has direct reduction bearing on consumption of virgin resources.

2.2.10 Life cycle assessment

Life Cycle Assessment (LCA) is a tool for the systematic evaluation of environmental aspects of a product or service system through all stages of its life cycle (Figure 10). According to Japan Global Environment Centre Foundation (2006), this can be used as a tool for evaluating the efficiency of various 3Rs activities. In nature and well-designed human systems, ‘waste streams’ become raw materials in other product cycles and this is termed, ‘cradle to cradle’. Life Cycle Assessment serves to compare different products and processes, to identify key environmental issues and optimize processes (Hellweg, 2003).

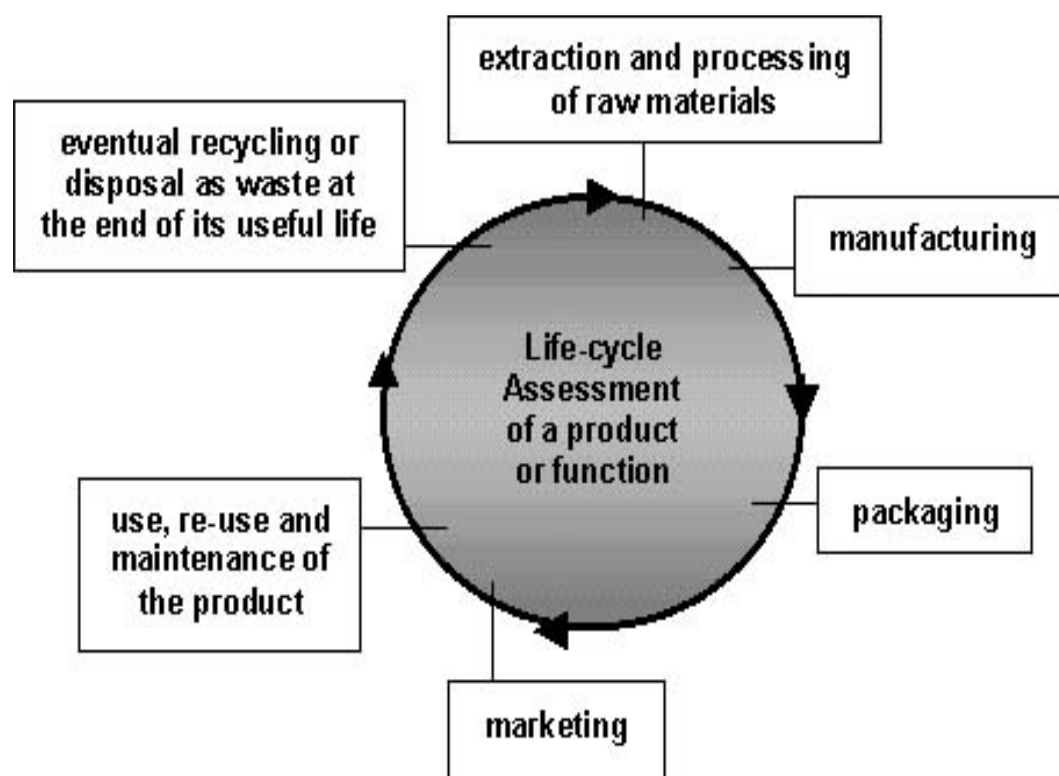


Figure 11: Life Cycle Assessment of Product

Source: Japan Global Environment Centre Foundation (2006)

2.3 Literature Review

2.3.1 Waste as resource

Resource recovery is the conversion of solid waste components to energy, fuels and other valuable products, as well as the recovery or salvage of existing materials. It has been x-rayed over the years that Nigeria government has no policy on waste reduction, reuse and recycling and no organized solid waste disposal. Therefore, most re-use, recycling and waste reduction strategies are only practised in Nigeria for economic gains. A survey of Enugu in Nigeria, an average waste picker earns N500-N700 daily and about N12, 000 - N16,000 monthly which is almost twice the minimum wage of some cities in Nigeria (Aremu and Sule, 2010).

Today in Nigeria, the federal and state government have initiated efforts to build formal resources recovery facilities including composting, and plastic recycling plants in Ibadan, the abattoir waste recycling plant in Port Harcourt, the organic waste recycling plant in Kaduna, the integrated waste management facilities in Aba and Ibadan, the material recovery recycling composting and sanitary landfill facility in Lagos, and the integrated waste recycling and treatment project (OSIWRTP) in Ondo state (Aremu and Sule, 2010). In the same vein, the reuse of materials in Nigeria is mostly practiced at household level though it is absolutely an informal technique. Items reused are (Plate 3, a, b and c) bottles, cans, plastics, bags, clothe, tyres and demolition waste such as corrugated iron sheets and planks among others.



a. Construction Materials for Reus



b. Cloth Materials for Reuse



c. Bottles for Reuse

Plate 3: Materials for Reuse

Source: Researcher's Fieldwork, (2016)

The report of the Urban Development Bank of Nigeria (UDBN, 1997) shows some items recovered from solid wastes and corresponding recycled products in Nigeria as shown in table 4.

Table 4: Some Items Recovered from Solid Wastes in Nigeria and their New Products

s/n	Items	New/ recycled products
1	Used newspapers, Magazines and waste papers	Toilet paper and packing materials
2	Plastics	Water containers, shoes, plates and pipes
3	Aluminium	Cooking pot, kettles, ladles and spoons
4	Scrap iron	Foundry products
5	Bottle and glasses	Ash trays , cups and bottles
6	Rubber	Sandals, swings and boat bumpers
7	Bones	Bones ornaments and feeds
8	Electronics	Electronics
9	Organic waste	Organo- mineral Fertilizer

Source: Adapted from Urban Development Bank of Nigeria (1997)

2.3.2 Waste management and public concern

Public concern and awareness have acted as one of the major factors that necessitated Waste Management (WM) in high-income countries. Poor practices in the past, such as burning dumps and polluting incinerators, have left the public with negative perceptions of new WM strategies (Wilson, 2007). Therefore, strategies that include more recycling, repair, reuse, home composting and sustainable consumption require behavioural change (Wilson, 2007). Jackson (2005) believes that public concern is becoming the ‘holy grail’ of any sustainable development strategy. Many people are unable to exercise deliberate choice because they find themselves locked into unsustainable patterns caused by habits, routines, and lack of knowledge, institutional structures, and inequalities in access, social expectations, and cultural values (McKenzie-Mohr and Smith, 1999; Jackson, 2005). Additionally, each form of sustainable behaviour has a unique and complex set of barriers that vary

amongst social groups (McKenzie-Mohr and Smith, 1999). Therefore, transferring initiatives that appear successful in a specific context is unlikely to be effective in another (Southerton *et al.*, 2011).

Overcoming public attitudes and unsustainable behaviour requires effective communication, a broad public understanding of the requirements of WM, and active participation of all relevant stakeholders throughout all project stages (Schübeler, 1996). Some of the top strategies identified for overcoming Not In My Backyard (NIMBY) opposition include building project supporters before implementation, developing a comprehensive understanding of causes of opposition, and acting to remove them through stakeholder consultation, correction of misinformation, and compromise. (Schübeler, 1996; Noto, 2010)

2.3.3 Waste management and environment

Solid waste has been a major environmental issue everywhere since the industrial revolution. Ever since, human's health and well-being is tied down to the quality of their environment, which is one of the determinants of the quality of life they enjoy. The term environment refers to the air, water and the land around us. These elements provide a variety of important services such as habitats in which to live and resources to produce goods and services (Sharp *et al.*, 2002). This implies that one cannot do away with the environment and therefore, there is the need to protect the environment. The primary purposes of waste management (WM) strategies are to address the health, environmental, aesthetic, land-use, resource, and economic concerns associated with the improper disposal of waste (Henry *et al.*, 2006; Wilson, 2007; Nemerow, 2009). These issues are an on-going concern for nations, municipalities, corporations, and individuals around the world (Nemerow, 2009), and the global community at large (Wilson, 2007).

In developing countries, the waste produced by growing cities is overwhelming local authorities and national governments alike (Yousif and Scott, 2007; Tacoli, 2012). Waste management is one of the major environmental problems in the society today most especially in developing countries (Wilson, 2007; Wolsink, 2010). This has created a significant shift in policymakers' perspectives on how to

approach WM (Wolsink, 2010). New legislations addressing water pollution and WM emerged, initially targeting the elimination of uncontrolled disposal. Subsequent WM legislations increasingly raised environmental standards to reduce the contamination of land, air, and water (Wilson, 2007; UN-HABITAT, 2010). Therefore, advocating for ever-increasing environmental protection was not enough; an integrative regulatory approach was needed that encompassed not only the technical and environmental but also the political, social, financial, economic, and institutional elements of waste management if environmental protection were to be realized (McDougall *et al.*, 2001; Vande Klundert and Anschutz, 2001 and Wilson, 2007)

2.3.4 Waste and greenhouse gases emissions

Treatment and disposal of municipal, industrial and other solid waste produces significant amounts of greenhouse gases. Majority of these gases such as methane (CH₄), biogenic carbon dioxide (CO₂), non-Methane Volatile Organic Compounds (NMVOCs) as well as small amounts of nitrous oxide (N₂O), nitrogen oxides (NO_x) and carbon monoxide (CO) take their sources from Solid Waste Disposal Sites (SWDS). According to (IPCC, 2001), greenhouse gases produced at SWDS contributes approximately 3 to 4 percent to the annual anthropogenic greenhouse gas emissions worldwide. In many industrialised countries, waste management has changed significantly over the last decade. Waste minimisation and recycling/reuse policies have been introduced to reduce the amount of waste generated. Also, landfill gas recovery has become more common as a measure to reduce greenhouse gases emissions from SWDS. Decomposition of organic material derived from biomass sources (e.g., crops, wood) is the primary source of CO₂ released from waste.

Reducing, reusing, recovering, and recycling municipal waste are effective and high-impact means of reducing greenhouse gas (GHG) emissions. When discarded materials (waste) are recycled, they provide industry with an alternate source of raw materials. This results in lower demand for virgin materials whose extraction, transport, and processing is a major source of GHG emissions. Recycling thus reduces emissions in virtually all extractive industries such as in mining, forestry, and agriculture

and petroleum extraction. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) states that “waste minimization, recycling and re-use represent an important and increasing potential for indirect reduction of GHG emissions through the conservation of raw materials, improved energy and resource efficiency and fossil fuel avoidance. According to UNEP (2010) report on waste and climate change, waste reduction is an important source of emission reductions through improved product design and cleaner production, increasing product durability and maximising the ease of product disassembly (for recycling). Additional energy and associated emissions is saved in the manufacturing process itself, as recycled materials generally require less energy to be turned back into products. This is particularly evident in products such as aluminium, where the direct energy required to recycle is 88% less than that required to produce primary aluminium. Recycling of paper and wood products has a notable double impact. Not only does it reduce the demand for virgin wood fibre, thus reducing emissions from deforestation, but it also preserves forests’ ability to continue to act as carbon sinks (removing carbon from the atmosphere).

2.3.5 Greenhouse gases and climate change

The greening of the waste sector offers promising opportunities to mitigate climate change. According to national estimates, the waste sector including waste water, produces an average of 2.8 per cent of national GHG emissions (IPCC, 2007). Climate change has been a waste management driver since the early 1990s, leading to a shift away from landfilling biodegradable waste, which is a major source of methane emissions, and a strengthened focus on energy recovery from waste (Wilson, 2007; UN-HABITAT, 2010). This has brought the global concern about climate change issues, which led to pressure and advocacy around the world. It has led to a policy stage that focused on waste prevention and target achievements, characterized by a series of preventive policy measures, including laws and targets for compost and recycling goals, diversion from landfill and reduce methane emissions which is one of the greenhouse gases that induce climate change (Wilson, 2007; UN-HABITAT, 2010).

2.3.6 Inventory of GHGs in Nigeria

Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC, 2005) requires each Party to periodically report the emissions of greenhouse gases (GHGs) including CO₂, CH₄, N₂O and Non-Methane Volatile Organic Compounds (NMVOC) in their National Communication. In fulfilment of the article, Nigeria's national communication based on emission per unit human population (based on gross population of 96.7 million for the year 1994) indicates a gross per capita CO₂ emission of 0.5 t C/cap. Per capita, non-CO₂ GHG and precursor gases are between 2 to 4 orders of magnitude lower than CO₂ per capita emissions.

An overview of gross carbon emissions by sources and removal by sinks indicates gas flaring, transportation, and electricity generation as the most significant energy consumption processes leading to GHG emissions. Energy and land use change sectors were the main contributors to CO₂ emissions, while energy, agriculture and solid waste are the main contributors to the total methane emission in Nigeria is 5.9 Tg CH₄. The energy production and consumption sector with a total emission of 1.48 Tg-CH₄ contributed 25% of gross national emissions with agriculture contributing the rest. Municipal solid wastes and waste water treatment contributed 0.21 and 1.88 Tg CH₄. These respectively represent 4 and 32% of gross national emissions. The gross emission of nitrous oxide was 11.95 Gg N₂O. The energy sector (principally petroleum refining, small combustion and transport sub-sectors generated 7.47 Gg N₂O representing 63% of gross national emissions for the year. This was closely followed by emissions from savannah burning (28%), field burning of agricultural wastes (6%), burning of solid wastes (2%) and on-site biomass burning from forest conversion (1%). The total CO₂ emission was 17.05 Tg CO₂. Out of these, the energy sector generated 13.1 Tg CO₂ with the following major energy sub-group emissions: transport 4.73 Tg CO₂ or 28% of the gross national emissions; small combustion sources and gas flaring each representing about 25% of the gross national CO₂ emissions. The agricultural sector emitted 3.59 Tg CO₂ or 28% of the gross national emissions for 1994, while the other energy sub-sectors, solid waste and land use change emitted 33.2 Gg CO₂, 171 Gg CO and 162 Gg CO₂.

The total generation of GHGs based on the current data for Nigeria is low when compared to emissions from the United States and other developed economies (Nabegu, 2011). However, Nigeria's gross emissions may approach those of these countries if its population continues to grow at the current rate of 3.5% per annum since per capita emissions is also likely to increase. The current population of Nigeria is put at 140 million, representing 20% of the entire population of Africa. The United Nations projected a population of 289 million for the Nigeria by 2050. Apart from population growth, Nigeria has been experiencing increased urbanization over the last five decades. The proportion of the population living in the urban centres has risen from 15% in 1960 to 43.3% in 2000 and is projected to rise to 60% by 2015 (NPC, 2006). Furthermore, current economic growth of 7% per annum since 2005 has been projected to continue and would invariably fuel increase in the generation of solid waste (Nabegu, 2011).

2.3.7 Nigeria enforcement framework on sanitation and solid waste control regulations

As a result of the weak enforcement structure in the management of MSW by FEPA a new regulatory body was constituted to see to the effective enforcement of sanitation and waste in Nigeria. This sector was vested in the hands of the National Environmental Standard Regulation Enforcement Agency (NESREA). According to Federal Republic of Nigeria Official Gazette, No.60/Vol.96/S.I.28/NER 2009 on sanitation and waste. The regulations are meant to address issues of sanitation and all categories of wastes in order to enhance adoption of sustainable environment, friendly practices in environmental sanitation and waste management to minimise pollution.

To this end, the global acclaimed 3Rs has been amplified in Nigeria waste management framework to 5Rs which include; Reduce, Reuse, Recycling, Repair and Recovery. The extended product responsibility was equally encapsulated in the recovery programme in which the manufacturers and importers of products shall be responsible for the management of the end-life waste of their products. The materials amenable to extended products responsibility programmes in schedule VIII of regulation 32 are; Plastic, used tyres, E-waste, newsprints and papers, batteries, metals, can or tins,

glass, refrigerators and asbestos waste. The schedule also mandated manufacturers and producers to individually or collectively submit a Product Stewardship Programme (PSP) of their products to the agency.

2.3.8 Nigeria enforcement framework on air pollutants and greenhouse gases

In spite of international framework conventions on climate change across the globe, which set standard for greenhouse gases emission, Nigeria also has standard on emission permissible for the release of most of the gases into the atmosphere. According to Federal Republic of Nigeria Officials Gazette No142/Vol.101/S. I No 64 of National Environmental (Air Quality) Regulation 2014, B827-850. The purpose of these regulations is to provide for improved control of the nation's air quality to such an extent that would enhance the protection of flora and fauna, human health and other resources affected by air quality deteriorations. These regulations shall apply to point, mobile and area sources of air pollution, as well as indoor and ambient air quality control. The National Environmental (Ozone Layer Protections, 2009) shall apply in the importation, handling, storage, sale and use of alternatives to Ozone Depleting Substances (ODS). Some of the permissible standard are shown in the table (5,6,7, 8).

Table 5: Point Source Maximum Emission Limit for Facilities and Process

Pollutants	Standard Applicable to Sources	Maximum Limits (mg/Nm ³)	Permissible Maximum Permissible Limits (ppm)
1. Antimony and its Compounds	Any source	10 as Sb	2.0
2. Arsenic and its Compounds	Any source	10 as As	3.0
3. Cadmium and its Compounds	Any source	10 as Cd	2.0
4. Carbon monoxide	Any industrial source	500 as CO	400
5. Copper and its Compounds	Any industrial source	100 Cu	36
6. Hydrofluoric acids and Fluoride Compounds	Any source other than the manufacture of Aluminium from alumina	50 as HF	56
7. Hydrogen Sulfide	i. Geothermal Power Plant ii. Any source other than i	7 as H ₂ S	5.0
8. Lead	Any trade, industry or process	10 as Pb	1.1
9. Mercury	Any sources	5 as elemental Hg	0.6
10. Nickel and its Compounds, except Nickel Carbonyl	Any source	20 as Ni	8
11. NO _x	Manufacture of Nitric Acid	2,000 as acid and NO _x and calculated as NO ₂	975
	Fuel burning steam generators		
	i. Coal-Fired	1,000 as NO ₂	487
	ii. Oil-Fired	500 as NO ₂	244
	iii. any source other than i and ii		
	Existing Sources	1000 as NO ₂	487
	New Sources	500 as NO ₂	244
12. Phosphorus Pentoxide	Any Source	200 as P ₂ O ₅	32

13. zinc and its compounds	Any Source	100 as Zn	34.2
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Source: Guidelines and Standard for Environmental Pollution Control in Nigeria, 2014

Table 6: Stack Emission from Point Sources Related to Combustion

Combustion process		Emission standard					
		Fuel Gas Concentration (kg TJ-Energy Consumed)					
		PM10	CH ₄	VOC	SO ₂	NON	CO
Public electricity generation							
Coal		350	-	8	550	300	15
Heavy Fuel Oil (HFO)		1	15	0.1	2	190	0.6
Light Fuel Oil (LFO)		0.3	2	-	5	70	0.6
Natural Gas		0.1	1	2	0.5	110	1.0
Industrial Electricity Generation							
Coal		500	2	20	500	350	150
HFO		40	3	8	800	190	10
LFO		5	3	5	200	70	10
Natural Gas		0.1	1.4	5	0.5	110	10
Industrial Generation		Boilers/heat					
Fuel-wood		200	-	400	-	10	4000
Charcoal		200	-	400	-	10	4000
Commercial/Institutional Electrical/Heat Generation							
Fuel-wood		200	150	600	10	94	9000
Charcoal		150	100	400	10	75	4000
Coal		100	23	31	500	100	625
Chemical process industry							
Charcoal kiln (kg/tonne)		1.24	-	2	-	0.112	1.6
Carbon black (stack) (kg/tonne)		6.7	-	77	0.045	6.2	123
Paint and varnish(kg-/tonne)		-	-	0.5	-	-	-
Plastic (kg/tonnes)		-	-	5.9	-	-	-
Printing ink(kg/tonnes)		-	-	213	-	-	-
Soap and detergent (kg/tonne)		7	-	-	-	-	-

Source: Guidelines and Standard for Environmental Pollution Control in Nigeria, (2014)

Table 7: Emission Standard for Air Pollutants from Industrial Sources /Operations

Pollutants 1	PPM	Averaging time(min)
Ammonia	0.28	30
Carbon Disulfide	0.01	30
Chlorine and chlorine Compound Expressed as Cl ₂	0.03	5
Formaldehyde	0.04	30
Hydrogen Chloride	0.13	30
Hydrogen Sulfide	0.07	30
Nitrogen Dioxide	0.20,0.14	30,60
Phenol	0.03	30
Sulphur Dioxide	0.18,0.13	30,60

Source: Guidelines and Standard for Environmental Pollution Control in Nigeria, (2014)

Table 8: Emission limits for specific metal pollutant from stationary sources

No	Substance	Limit(mg/m ³)
1	Antimony	20-100
2	Arsenic	20-100
3	Cadmium	1.0-40
4	Copper	20
5	Lead	10-100
6	Mercury	1.0-230
7	Zinc	11.72

Source: Guidelines and Standard for Environmental Pollution Control in Nigeria, 2014

2.3.9 Waste management authorities in Southwest Nigeria

There is no unified waste management authority in southwest Nigeria as at today. However, pursuant to the establishment of Federal Environmental Protection Agency in 1988, the six states in Southwest Nigeria take a cue from the Federal government and established their State Environmental Protection Agencies (SEPA's) in the mid-1990s (Table 3). These agencies were saddled with the

responsibility of keeping their environment clean and manage the generated waste. In extension of their responsibilities in some states, most of these agencies also created enforcement unit such as “OYES” in Osun to enhance compliance and standard. Besides, some of the agencies are now embracing integrated waste management of 3R’s by establishment of recycling facilities.

Table 9: State Waste Management Authorities in Southwest Nigeria

States	Management Authorities
Lagos	Lagos Waste Management Agency (LAWMA)
Oyo	Oyo State Solid Waste Management Authority (OYOSWMA)
Ogun	Ogun State Waste Management Authority (OSWMA)
Osun	Osun Waste Management Agency (OWMA)
Ondo	Ondo State Waste Management Agency (OSWMA)
Ekiti	Ekiti State Waste Management Agency (EKSWMA)

Source: Researcher’s Fieldwork (2016)

2.3.10 Waste management and health

The volume of waste generated is one of the challenges confronting human health and ecosystems, particularly the growing hazardous component of the waste streams. Unless action is taken to properly collect and segregate waste materials, many developing countries face the challenge of mixed and growing waste streams beyond what the current waste-management infrastructure can cope with. Investment in institutions and physical infrastructure to properly collect and segregate waste materials need to be put in place to avoid imminent and serious consequences to environmental quality and public health.

Uncontrolled dumpsites have been linked to many harmful health effects such as skin and eye infections, respiratory problems, vector-borne diseases like diarrhoea, dysentery, typhoid, hepatitis, cholera, malaria and yellow fever. Rodents and other stray animals have also been known to spread a variety of diseases including plague and flea-born fever (UNEP, 2011). In the Republic of Palau (an island nation in the Pacific Ocean) for example, the cost of waste-related health damage amounts to

US\$697,000 per year-about US\$32 per capita (Hajkowicz *et al.*, 2005). In Tonga, total economic cost of waste was estimated to be 5.6 million a year (about US\$2.8 million) of which US\$ 0.45 million was related to the health cost to private individuals (Lal and Takau, 2006). Lack of alternative livelihoods and the value of recovered materials entice many poor men, women, and even children to engage in dumpsite scavenging in low- and middle income countries. Scavengers are vulnerable to intestinal, parasitic and skin diseases. A UNEP (2007) study carried out at Dandora dumpsites in Kenya, found that about 50 per cent of the examined children and adolescents living close to the dumpsites (from a total of 328) had respiratory ailments and blood lead levels exceeding international threshold (10 micrograms per decilitre of blood). Further 30 per cent were confirmed to have high exposure to heavy metal poisoning detected by red blood cell abnormalities. Other severe effects observed in waste picker children in India include worm infestation, scabies, xerophthalmia and lymph-node enlargement (Hunt, 1996)

2.3.11 Solid waste reuse and recycling culture in Nigeria

Though waste problem has not been pronounced for long in the less developed countries like Nigeria, it is known that there have been some local methods by which solid wastes were being reused or recycled (Plate 4)



Plate 4: Recycled Plates made from Aluminium

Source: Researcher's Fieldwork,(2016)

Historically, it was a taboo to waste anything that cost money in Nigeria. There was reuse culture that have been planted into Nigerians traditionally (Ajibade, 2007). Every item used were structured for reuse. Even today, the sachet water that is hawked is used by horticulturist for flower nursery. The reuse tradition is what makes old newspaper useful for wrapping roasted groundnut and popcorn (guguru or akara), the popular fried bean cake. Apart from the fact that the reuse culture saves lots of money, it is highly conservative resulting in waste management (Ajibade, 2007).

This idea has helped in the emergence of biodegradable solid waste in the production of organic fertilizer and possible use in the production of biogas. Some researchers have studied the great potentials in Nigeria's municipal solid wastes to produce enormous amount of methane gas (Yusuf and Oyewumi, 2008). Mixtures of manure and ashes from burning of urban solid wastes have been used for soil amelioration to boost agricultural productions in Jos (Pasquini and Alexander, 2004).

In a similar manner, wood waste is use today in cooking across the country. In southwest Nigeria, Abeokuta alone generates 2288m³ of wood wastes per day from saw mills activities (Aina, 2006). The product which can be reused for generating good amount of potash (Adewuyi *et al.*, 2008).

2.3.12 Overview of 3Rs of waste management in Africa and developing countries

Despite the overwhelming benefits of integrated waste management of 3Rs which has consequently lead to its recommendation at different conventions across the globe, Africa and other developing countries are yet to take optimum advantages inherent in it. According to United Nations Industrial Development Organization (2009), the major drawback associated with 3Rs of waste management strategy in Africa has been linked with infrastructure, political, technical, social/economical, techniques and legal challenges. Environmental Legislations and Policies (ELP) do exist in the developing countries including Nigeria which have piece meal legislation on hazardous waste management as posited by Mwesigye, *et al.*(2009) in order to protect their natural resources and environment, but most of them are not revised or updated according to the need and prevailing situation. In most cases they are not clearly defined, creating complications for the implementing body,

resulting in duplication of task and negligence in other activities. In cases, where they do exist, its implementation fails. The possible reasons for poor implementation could be linked with a myriad combination of many factors such as social, technical, institutional and financial issues.

Developing countries urgently need infrastructural, institutional, legal reforms and changes in attitude. Adoption of Environmentally Sound Management (ESM) of wastes which should include initiatives such as: Waste Minimization, focusing on the promotion of the “3Rs” – Reduce, Reuse and Recycle; Waste to Wealth Initiatives (ILSR, 2012) towards poverty reduction and alleviation; Corporate Social Responsibility (CSR) by producers of wastes; and involvement of multiple stakeholders, for example, under the New Partnership for Africa's Development (NEPAD) initiative should be focused. Alternative options in waste management that could be explored include Public-Private Partnerships and Waste Exchange. Solid waste management through 3Rs management should focus on clearer monitoring and evaluation, particularly the use of suitable indicators in national legislation to harmonize the overall waste management activities which will further promote recycling and reuse of wastes (Gabriel and David, 2014).

2.3.13 Municipal solid waste generation and characteristics in southwest Nigeria

Waste generation encloses the activities where waste is produced. In recent year, waste situation has reached its threshold level, especially in developing countries such as countries in Asia (Pitchayanin and Pisit, 2013). According to the U.S. Environmental Protection Agency (2003), MSW generation has increased by 2.6 times from 1960. Waste generation is closely linked to population, urbanization and affluence. Estimates of total quantities of MSW generated in Nigeria are difficult to determine. However, estimates of waste generation per capita have been carried out in several investigations (Rushbrook and Pugh, 1999; John *et al.*, 2006; Igoni *et al.*, 2007; Kofoworola, 2007; Sha'Ato *et al.*, 2007). The output of solid waste per day in Nigeria is about 69,000 tons base on generation rate of 0.49kg/capital/day (Aremu and Sule, 2010). Continued population growth will increase the quantity of

waste. In south-western Nigeria, Oguneleka (2009) estimated the amount of waste generated in Lagos state to be 0.4-0.8 kg/ per capital.

In the same vein, Fakere *et al.* (2012) revealed the constituents and sources of municipal waste generation in some selected cities in Southwest Nigerian as shown in the Tables 10 and 11. The report revealed the major constituent is Garbage with mean composition of 60.5%, while glass has the least with a mean composition of 1.7%. The dominant source of municipal solid waste in the region is domestic waste with a mean rate of 76.42% while the least is industrial waste with a mean rate of 3.76%. (Fakere *et al.*,2012)

Table 10: Constituents of Municipal Solid Waste Generated from some Cities in Southwest Nigerian

Cities	Percentage (%)					
	Garbage	paper	sand grits	plastic	glass	metal scrap
Ile-ife	77.9	5.3	7.5	7.3	1.1	0.8
Oyo	62.1	18.5	4.3	10.6	1.4	3.1
Ijebu-ode	58.7	19.6	4.7	14.7	1.8	0.5
Akure	59.5	14.5	11.0	1.7	6.3	7.2
Ado-ekiti	60.4	21.4	11.5	4.3	2.2	0.2
Abeokuta	57.8	26.2	3.4	8.7	2.2	1.6
Ibadan	64.9	14.2	6.5	9.9	1.7	2.9
Osogbo	58.2	17.8	9.9	12.1	0.6	1.4
Iyin-ekiti	60.9	15.3	6	14.0	0.8	0.4
Igede-ekiti	58.1	19.3	17.7	3.6	1.1	0.2
Odeomu	47.8	37.7	12.3	1.2	0.4	1.4
Mean	60.5	19.1	9.8	7.1	1.7	1.8

Source: Fakere *et al.* (2012)

Table 11: Main Sources of Municipal Solid Waste from some Cities in Southwest Nigeria

City	Domestic	Commercial	Agricultural	Industrial
Abeokuta	73.90	17.50	8.20	0.50
Ado – Ekiti	78.90	14.30	4.10	2.70
Akure	70.30	18.60	6.30	4.80
Ibadan	66.10	20.30	2.20	11.40
IgedeEkiti	75.10	11.00	12.40	1.00
Ijebu Ode	79.50	14.00	3.50	3.00
Ile- Ife	67.40	28.40	1.0	1.10
Iyin –Ekiti	79.60	2.20	11.60	6.60
Ode- Omu	91.20	1.80	5.90	1.10
Oshogbo	68.20	23.50	2.10	6.20
Oyo	90.50	6.50	2.0	3.00
Mean	76.42	14.37	5.39	3.76

Source: Fakere *et al.* (2012)

2.3.14 Solid waste reduction as waste management strategy

Solid Waste Reduction is defined as any change in the design, manufacture, purchase, or use of materials products (including packaging) to reduce their volume and amount of toxicity before they become municipal solid waste (Plate, 5).



Plate 5: Some Packaging Items Reduced during Industrial Production to Minimize Waste.

Source: Researcher's Fieldwork (2016)

It is an attempt to reduce waste disposal and handling costs, because it avoids the costs of collection, transport, recycling, municipal composting, disposal sites and combustion. Source reduction conserves resources and reduces pollution, including greenhouse gases that contribute to global warming. According to Ikemike (2015) Coca Cola has reduced the weight of its can by 41% since 1963, by reducing its aluminium usage and also shaving off some part of the cans. Since 1977, the weight of a 2-litre plastic soft drink bottle has been reduced from 68 grams to 51 grams this relates to a 25% reduction in the gross weight of plastic in the municipal solid waste stream by this change in production technique alone. In 2005, there was 12,490,000 kg of municipal solid waste collected by Local Authorities. This amount could be source reduced by 8,743,000-11,241,000 kg or 70- 90% according to current waste characterization studies.

2.3.15 Waste reduction benefits

Saves natural resources: Waste is not just created when people throw items away, throughout the life cycle of a product or package - from extraction of raw materials, to transportation, processing and manufacturing facilities, to manufacture and use - waste is generated. Reusing items or making them with less material decreases waste dramatically. Ultimately, fewer materials will need to be recycled or collected and sent to disposal sites or waste combustion facilities.

Reduction in toxicity of waste: Selecting non-hazardous or less hazardous items is another important component of source reduction. Using less hazardous alternatives for certain items (e.g. cleaning products and pesticides), sharing products that contain hazardous chemicals instead of throwing out leftovers, reading label directions carefully, and using the smallest amount necessary are ways to reduce waste toxicity.

Reduction of costs: The benefits of preventing waste go beyond reducing reliance on other forms of waste disposal. Preventing waste can also mean economic savings for Local Authorities, businesses, schools and individual consumers. In most Local Authorities in Sri Lanka, it is estimated that 15-25 % of the annual budget is utilized for SWM, out of which 60-70 % is spent on collection and

transport of waste. By reducing the amount of waste to be collected, Local Authorities could use savings to expand or improve these services. Businesses Industry also has an economic incentive to practice source reduction. When businesses manufacture their products with less packaging, they are buying fewer raw materials. A decrease in manufacturing costs can mean a larger profit margin, with savings that can be passed on to the consumer. Consumers can also share in the economic benefits of source reduction. Buying products in bulk, with less packaging, or items that are reusable (not single-use) frequently means a cost saving. Local Authorities have the opportunity to see monetary, environmental and quality of life benefits by waste reduction. These opportunities will help to create a cleaner environment, create efficiencies for the constituents of the Local Authorities through the advantages provided by solid waste reduction.

2.3.16 Informal recycling sectors in Nigeria

As in other developing countries, recycling operations in Nigeria are highly labour intensive (Solomon, 2009) largely carried out by the informal sector known as “Scavengers” because there are no formal planned recycling facilities in many cities of Nigeria to carry out the recycling operations. Despite government’s apathy towards resource recovery, economic pressures often force many amongst the urban poor to scavenge waste dumps in Nigerian cities to earn a living (Roberts *et al.*, 2009). In a study on recovery and recycling practises in Lagos, Kofoworola (2007), found out that only materials with high market value such as paper, plastics, glass and metals were scavenged. In major cities in the South Eastern parts of the country (Nsukka, Onitsha and Port Harcourt), Agunwamba (2003) discovered that between 70%-83% of scavengers were unemployed or underemployed urban youths (mostly males) who scavenge and restrict their activities to open waste dumps and landfills, some prefer to go from house to house and from bin to bin, looking for discarded but useable materials. They are known by different names in different parts of the country: “Mai bottle” in the northern parts and “Baro boys” or “Ndi-ebulu” in the southern parts (Afon, 2007). In other part of the world, they also bear different names as shown in table 12.

Table 12: Local Names for Informal Recyclers in other Parts of the World

Country	Local names for informal sector
Costa Rica	Buzos
Colombia	Basuriegos, Cartoneros, Traperos and Chatarreros
Argentina	Cirjas
Ecuador	Chamberos
India	The Harijans are a caste of untouchables that collect and recycle waste
Mexico	Pepenadores, Catroneros and Buscabotes
Egypt	Zabbaleem and Ewaabisi

Source: Adapted from Samuel (2010)

In all cases however, materials recovered are either kept for personal use or sold to middle men who further sort them for sale to small scale industries around the city and beyond. According to Agunwamba (2003) the average daily earnings by the scavengers were as high as US \$10 in 2003 while middlemen made even much higher profits. In a country where over 60% of the population live on less than \$1 a day (World Bank, 2000), such activity poses good prospects for environmental as well as economic sustainability and poverty reduction (UNEP, 2007; UNCED, 2007).

2.3.17 Institutional and policy frameworks for MSW management in Nigeria

In 1988, the Federal Government of Nigeria (FGN) established the Federal Environmental Protection Agency (FEPA) in response to the serious challenges posed by environmental degradation, exemplified by the dumping of hazardous waste substances by an unidentified naval vessel around Koko port in the Niger Delta region. The Agency was mandated by the FGN decree 58 of 1988 to among other functions:

- (a) Advise the Federal government on national environmental policies and priorities and on scientific and technological activities affecting the environment.
- (b) Prepare periodic master plans for the development of environmental science and technology and advise the Federal government on the financial requirements for the implementation of such plans.

(c) Promote co-operation in environmental science and technology with similar bodies in other countries and with international bodies connected with the protection of the environment.

(d) Co-operate with Federal and state ministries, local government councils, Co-operate with Federal and state ministries, local government councils, statutory bodies and research agencies on matters and facilities relating to environmental protection.

(e) To carry out such other activities as are necessary or expedient for the full discharge of the functions of the agency under this decree (FGN, 1988). Taking a cue from the Federal government, each of the state governments in the country also established a State Environmental Protection Agency (SEPA) in the mid-1990s. At the local or municipal levels, environmental regulation and management functions were left as before to their individual environmental service departments. In essence, Nigeria like most Sub-Sahara Africa (SSA) countries has a three tiered environmental / waste management structure i.e. Federal, state and local environmental authorities. FEPA was upgraded to a fully-fledged environmental department with a cabinet minister at the Federal level in 2000 (Adeoti, 2001), following the coming of a new civilian administration and a result of the rise in profile of the environmental agenda globally. With these institutional reforms, the overall responsibility for environmental regulation and management in Nigeria is currently discharged by the Federal Ministry of Environment, Housing and Urban Development at the Federal level. Nigeria's premiere policy document on environmental management was launched in November 1989, enunciating guidelines for the achievement of sustainability in fourteen vital sectors including Municipal Solid Waste (NEEDS, 2004; UNEP, 2007). This policy document has been lauded by many as a pacesetter for other Sub-Sahara Africa (SSA) countries to copy. As laudable as this step was, the document soon attracted several criticisms mainly on account of its limited scope and deficiencies in practicality. The policy document was subsequently revised to address those concerns. With regards to the waste sector, a positive consequence of these developments was the eventual enactment of the harmful waste decree in 1990, providing a legal framework for the management of waste particularly of the hazardous genre.

Further to this, as a response to criticisms of the FEPA decree, the government published an amended version in 1992 (Chokor, 1993; Akpofure and Echefu, 2001) cited by Chikowoye (2010).

2.4 Empirical Studies on Municipal Solid Waste Management in Nigeria

This section of the study examined various studies that have been conducted on waste management in Nigeria most especially those that were carried out on a large magnitude. Consequently, this study explored this area in two folds. In the first instance, it examined studies on waste generation, characterization and composition in Nigeria which mainly focused on end of pipe waste management strategy while the other section dwell on upstream waste management of 3Rs in Nigeria.

2.4.1 Studies on waste generation, characterization and composition in Nigeria

Studies on waste have been conducted in Nigeria focusing on generation, characterization and composition. One of such studies is the one conducted by Babayemi and Dauda (2009) on evaluation of solid waste generation, categories and disposal options in developing countries: a case study of Nigeria, the study was conducted to identify factors influencing the waste generation, solid waste types and categories, collection, disposal, reuse and recycling, and environmental problems. The results indicated large generation at high rate without a corresponding efficient technology to manage the wastes was a major constraint.

In a similar study, Ogwueleka (2009) work on municipal solid waste characteristics and management in Nigeria, the study was carried out to show solid waste management practices and problems. He observed that waste management is characterised by inefficient collection methods, insufficient coverage of collection system and improper disposal. He observed that waste density in Nigeria ranged from 280 to 370 kg/m³ and generation rate ranged from 0.44 to 0.66 kg/capita/ day in rural and urban city in Nigeria.

Furthermore, Salami *et al.* (2011) worked on characterisation study of solid wastes in Lagos State. The study was based on the tonnage of solid waste in Lagos State. It looked at parameters such as moisture content and density of the solid wastes, the volume of air required to oxidize the solid waste

completely, the mass of biodegradable material in the Municipal solid waste and the actual volume of methane gas expected from the solid waste which can be used for domestic purposes

Akinjare *et al.* (2011) also study the impact of sanitary landfills on urban residential property value in Lagos state, Nigeria. The study examined the impact of four state established landfills each with varying size and degree of contamination, the result reveals that residential property value increase with distance away from landfills site at an average of 60% for the four landfills.

Similarly, Fakere, Fadairo and Oriye (2012) worked on Domestic Waste Management and Urban Residential Environment in Akure, Nigeria. The study examined the impacts of domestic waste and disposal methods employed by the inhabitants of each building on the residential environment of some selected neighbourhoods of Akure, capital city of Ondo State, Nigeria. Findings showed that health of individuals cannot be considered in isolation of the buildings and the environment in which they live.

Samuel (2012) also worked on the role of social capital in community-based urban solid waste management in Ibadan metropolis, Nigeria. Where social capital was attributes of social organization, such as trust, cultural norms and social networks by which communities facilitate action. Empirical evidence suggests that communities with a high level of social capital are in better shape to organize a community-based urban solid waste management project, if the other factors remain supportive. The study suggests that to a great extent, social capital can influence the success of community-based urban solid waste management initiatives.

In the same vein, Uwadiogwu and Chukwu (2013) study strategies for effective urban solid waste management in Nigeria, using low density, medium density and high density for the study. Seven composite strategies were identified for urban solid waste management such as citizen mobilization, environmental education, strengthening of public agencies, logistic and infrastructural improvement, and technology among others

In a similar study on solid waste management in Lagos by Yetunde (2013) with special focus on how households handle their waste, how the municipal manages the waste generated from households, and the potentials for sustainable improvements in the sector from an environmental and resource recovery viewpoint following the waste management hierarchy, she observed that waste reduction, reuse, recycling and composting are potential management options for the state. Landfilling will remain an important option for final disposal but reliance on this method could be significantly reduced if management options are exploited to the maximum in a sustainable solid waste management structure.

David, Demonic, Tunde and Uchechukwu (2014) study medical waste management practices among selected health-care facilities in Nigeria, the study was to examine the procedure and techniques available in collection and segregation in health-care facilities in Ota, South Western Nigeria. From the analysis, they find out that Medical Waste (MW) management practices in most facilities are not totally in line with prescribed standard.

Burmamu *et al.* (2014) examined environmental impacts and management strategies of solid waste disposal in Jimeta-Yola, Nigeria, the results obtained indicated that 0.5–1.0 kg of solid wastes was generated by an individual in the city born out of ignorance and socio-economic related problems. It was gathered that the impact of solid wastes was on the increase as a result of inadequate environmental and health education in the metropolis.

Agbaeze, *et al.* (2014) worked on impact of Sustainable Solid Waste Management on Economic Development – Lessons from Enugu State Nigeria, the result of their findings revealed that waste management practice in Enugu was not scientific, unsustainable and at prerogative of people in power. It was discovered that the current waste management in Enugu does not give room for reuse, reduce and recycling of waste.

Considering the studies above, none of them have laid much emphasis nor examined sustainable upstream waste management of Reduce Reuse and Recycling. Besides, none of the studies

have extensively examined waste management of 3Rs in the context of greenhouse gas emission reduction which is the focus of this study.

2.4.2 Studies on sustainable waste management of 3Rs in Nigeria

Many studies have been conducted on waste management in Nigeria which primarily examined sustainable waste management of Reduce, Reuse and Recycling. Studies on this subject with national perspective were reviewed in this study.

Ibrahim (2010) carried out research on recycling of solid waste business in central Nigeria. In his study, quantitative method was used to examine the contribution of the underground economy to income generation, employment and value added. It was observed that ‘Yan Bola’ business is playing a crucial role in the local economy of the area. However, this study focus mainly on recycling and its socio-economic impact without reckoning on source reduction and reuse of waste which are preferred options in waste hierarchy and resource sustainability. Besides, his work has not address GHG gas emission reduction associated with recycling.

Chukwunonye (2010) worked on the analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Abuja, Nigeria. The result of his findings revealed that limited public awareness/education on MSW, obsolete and inefficient equipment and funding limitations are the major barriers and factors. However, he has not address the 3Rs in relation to specific wastes such as iron, aluminium, steel, copper and plastic and associated GHG emission reduction attached to them.

Awopetu *et al.* (2013) also worked on the reduction, reuse and recycling of solid waste in Makurdi metropolitan area of Nigeria. Emphasis was placed on public opinions and perceptions. Three zones were considered for the study and the findings of the study reveal that throughout all the three zones considered, awareness of the reduce/reuse/recycle strategies was fairly high. However, the accompanying facilities and training that would allow residents to implement waste behavioural improvements was lacking. Despite the relevance of this study in addressing 3Rs of waste

management, it only laid emphasis on public opinion and perception without focusing on any particular waste and its GHG emission reduction.

Clementina (2014) also carried out research on assessment of healthcare waste management practices in Enugu metropolis with the aim of assessing healthcare waste management practices by hospital staff. The study involved the survey of a cross section of four (4) tertiary health institutions. The study showed that there is significant variation in healthcare waste management practices and the sustainability factors (reduce, reuse and recycle). The test showed that the prominent method of healthcare waste management at the studied institutions was incineration leaving out other new and improved technologies for proper waste management. The study showed that the health institutions adopted minimal activities of reduce reuse and recycling. This study only compared different waste management methods adopted in healthcare industry with 3Rs. She observed the level of adoption of these methods without reckoning with municipal waste particularly metals and plastic that are commonly used and found in municipality for construction and packaging respectively.

Furthermore, Mas *et al.* (2015) also carried out research on exploring reduce, reuse and recycle (3Rs) awareness, practice among oil and gas workers and its influence on their productivity. It aimed to determine the level of employees' awareness and attitude towards 3Rs and determine its influence on their productivity. He found that the employees have a high level of awareness on 3Rs, yet their practices are at the low to moderate levels which he attributed to the low management's support towards the 3Rs. However, the study has not highlights wastes in term of reduce, reuse and recycle couple with GHG emission reduction that is associated with it.

In addition, kofoworola (2016) explored the comparative assessment of the environmental implication of management options for municipal solid waste in Nigeria. GHG emissions from MSW treatment options and alternative options were examined using the Solid Waste Management Greenhouse Gas (SWM GHG) model. Alternative scenarios considered a combination of options including collection of recyclable materials, dumping in unmanaged disposal sites, landfill without

and with biogas collection, and incineration for electricity production. The results showed that the contribution of the current management strategies to global warming is 10.7 Mt CO₂ eq/yr. MSW management options featuring primary material recycling and energy recovery had reductions in GHG emissions of between 22-67% compared to the current scenario - highlighting the important contribution of recycling and energy production from MSW treatment options in reducing GHG contribution of the MSW sector. Despite the similarity of this study with the current study, the focus of the two studies are not the same, his study focused on recycling and its GHG emission saving in relation to alternative management options such as; dumping, incinerator among others, while the focus of this study is primarily on specific waste commonly found in Municipalities (Iron, Aluminium, Copper, Steel and Plastic) that are subjected to integrated waste management of 3Rs and its GHG emission reduction.

From the review of the literatures above, it became apparent that, to date, research had not been conducted with broad emphasis on 3Rs that addressed municipal waste utilization focusing on metals like Iron, Aluminum, Steel, Copper and Plastic and their GHG emission reduction saving in southwest Nigeria. To this end, this study therefore embarked on this phenomenon to address the knowledge gap.

CHAPTER THREE

RESEARCH METHODS

3.1 Introduction

This section contains methods used for the study. It consists of the types and sources of data required, sampling techniques, instrument for data collection and data analytical methods.

3.2 Types of Data Required

The types of data required for the assessment of municipal solid waste utilization on Greenhouse reduction using 3Rs in southwest Nigeria are:

- i. Mass of raw materials such as; iron, aluminium, copper, steel and plastic reduced during industrial production/ton;
- ii. mass of waste such as; iron, aluminium, copper, steel and plastic reused during industrial production /ton;
- iii. Mass of waste such as; iron, aluminium, copper, steel and plastic recycled during industrial production /ton;
- iv. mass of waste such as; iron, aluminium, copper, steel and plastic generated by the residents in the study area /ton;
- v. mass of virgin iron, aluminium, copper, steel and plastic used during industrial production /ton;
- vi. factors that affect waste management of 3Rs;
- vii. Greenhouse gas emission factors for virgin; iron, aluminium, copper, steel and plastic/short ton
- viii. Greenhouse gas emission factors for reduce/reuse; iron, aluminium, copper, steel and plastic/short ton
- ix. Greenhouse gas emission factors for recycle; iron, aluminium, copper, steel and plastic/short ton

3.3 Sources of Data

The data for this study was sourced from primary and secondary sources. The primary data was collected from the employees of various companies sampled for the work in the study area, such data include factors that affect waste management using 3Rs strategy. While secondary data were collected from the records of the companies sampled for the work on the amount of reduction, reused and recycled they have carried out during production process over the years. The energy usage during industrial production using virgin raw materials and the energy used, using waste as raw materials was also collected. Besides, data from State Environmental Protection Agencies (SEPAs) on the amount of waste generated precisely on Iron metals, Aluminium, Copper, Steel and Plastics by the residents in the selected state were collected for the study.

3.4 Sampling Techniques and Sample Size

The population of the study consist of all the six states in the Southwest Nigeria namely; Lagos, Oyo, Ogun, Ondo, Osun, and Ekiti States out of which four states (Lagos, Oyo Ogun and Osun) were sampled as shown in figure 12. The four states were selected because of availability of waste recycling plants which were spatially concentrated on them. In the study, manufacturing companies that make use of waste such as iron metals, aluminium, copper, steel and plastics were considered in the selected states. The study adopted multistage sampling techniques because only one sampling techniques cannot capture it. As such, purposive sampling was used for the selection of companies in the Southwest Nigeria that have bearing with reduce, reuse and recycling of waste particularly iron metals, aluminium, copper, steel and plastics. While simple random sampling method was applied for selecting individual employee for questionnaire administration in the waste oriented companies sampled for the work.



Figure 12: Selected States in Southwest Nigeria
Source: National Space Research Development Agency, (2015)

In order to make selection of the require number of variable for this study, a reconnaissance survey was carried out in thirty (30) major waste recycling companies in four states across the southwest Nigeria. The states are Lagos, Ogun, Oyo and Osun. The companies were largely concentrated in Lagos. Besides, other states in the study area such as Osun and Oyo, have no waste management companies that specialise in some wastes like Aluminium and copper. Therefore, sample size for this study was based on the available waste management companies identified and their spatial distribution across the selected states. However, because of the different wastes to be considered for this study (Table 13) which include Iron metal, Aluminium, Copper, Plastic and Steel, purposive sampling techniques was used to select ten (10) companies in such a way that it covers the chosen states and all waste types identified for this study.

Table 13: State and Companies Sampled for the Study.

State	Companies	Waste/Material Recycled	Companies Selected
Lagos	1. Effect Phone and Gadget	Electronics	1.kasfai Global resources
	2. Infigo System Global Limited	Plastic recycling	2 Infigo System Global Limited
	3. O.K Plastic limited	Plastic manufacturing	3. Envirocycles. Limited
	4. Oliver Adam Global Concept		
	5. Envirocycles. Limited		
	6. Maintenance System Consultants	Metal recycling	
	7. Wecyclers Ltd.	Metal recycling	4. Technovas Industries Ltd.
	8.Technovas Industries Ltd.	Aluminium Metals	5. Taaleng limited
	9. Taaleng limited		6. Flicks Pet Bottles
	10. Flicks pet bottles	Metals	7. O.K Plastic limited
	11.Greener Rightview limited		
		Copper, Aluminium, metal	
		Plastics	
	12.G4r (MF)Industrial limited	Aluminium, paper	
	13.Kasfai Global resource	Can and waste materials	
	14. Metricton recycle	Plastic, Nylon	
	15. Chestron limited	Metal, plastic, rubber, iron metal & steel	
	16. Ecoplastiv and aluminium recycle limited	Plastic, electronics, wood-dust	
	17. Dosrem Nigeria Enterprises		
	18.Ira Enterprises	Can, plastic, scrap Nylon	
	19. Aspat Ventures Nigeria		
		Plastic and aluminium	

		Plastic and Nylon	
		Plastic and Nylon	
		Plastic recycling	
		Plastic	
Oyo	1. Marken Industries Ltd	Metal	
	2. Siyanbad International Company	Metals	8. Siyanbad International Company
	3. Hengina GEC2 OMODE LTD	Plastic Recycling	
Ogun	1. Metal Recycling Industries Limited	Metal/steel Metal	9. Metal Recycling Industries Limited
	2. Shongai Packaging Ltd	Plastic	
	3. Simbiat Ajoke Resources Nig. Ltd	Metal recycling	
	4. RB Law Metal Consult and associate	Copper, aluminium ,container recycling metal recycling	
	5. Saibu scrap iron		
	6. phonix recycling		
Osun	1. Prism Steel mail, Ikirun	Metal	10. Prism Steel mail, Ikirun
	2. Ife Iron Steel, Ile-Ife	Metal	
	3. Crystalmond venture, Ile-ife	Electronics, Metal scrap, Nylon	
Total	30		10

Source: Researcher's fieldwork, 2016/ www.vconnect.com

3.5 Methods of Data Collection

In order to collect data for this study, two stages were involved. The first stage involves the reconnaissance survey which was primarily carried out to understand the environmental phenomenon and other variables to be met in the field and to understand the terrain in which the data will be collected. Besides, research assistants were equally carried along in this process for familiarization and introduction of the organizations where the data will be collected to engender easy data collection.

To collect secondary data which mainly focused on the quantity of waste generated and made available for reuse and recycling (iron metal, aluminium, copper, steel and plastic) in southwest Nigeria, introduction letter was collected from the Head of Department of Geography and Environmental Management University of Ilorin. The letter was taken to the Solid Waste Management Agencies in four states sampled for the study. Consequently, the data was made available through their offices in the department of research and statistics. Surprisingly, only few of these agencies have a comprehensive data on solid waste and those that are available are not up-to-date.

In the same vein, the waste processing companies were equally visited and the introduction letter collected from the department was given to them for identification and to know my intention of visiting their organization. Despite the introduction letter couple with my visible intention, there was a stiff resistance by most of the recycling and waste processing companies. The main reason given was that it is part of their policies not to release their data for research purposes. However, this hitch was eventually overcome by persuasion; consequently, the fieldwork was carried out for data collection with the aid of research assistants across the selected companies by examined their inventories for a period of six years. Ten (10) Research assistants were engaged and one was allocated to each company. The primary data was equally collected using questionnaire and interview schedule.

3.5.1 Questionnaire administration

The questionnaire was designed in five Likert Scale of strongly agreed, agreed, neutral, disagreed and strongly disagreed in a close ended structure. According to Jeovany *et al.* (2014) a sample size of 10% is sufficient for statistical enquiry provided the population is not more than one thousand. To this end, the questionnaire was administered to 10% of the employees of manufacturing companies sampled for this work using stratified random sampling method. The administration of the questionnaire covered junior, senior, and management cadre of the employees in the organizations. In administering the questionnaire, the nominal row of the company staff was obtained from the personnel department in order to know the total number of staff in the organization and the questionnaire was apportioned to

each cadre in proportion to what they bear to staff population using simple random sampling. This is meant to elicit response on factors that promote waste utilization in their organizations.

3.5.2 Interview schedule

Interview schedule was used to extract information from the state environmental protection agencies, seller of reuse and recycling items, legal practitioners and law enforcement agency, head of waste associations, regulatory agency, academicians, employees of waste recycling companies, as well as ordinary residents in Southwest Nigeria. The people interviewed are; the head/managing directors of the state environmental protection agencies, leaders of sellers of reuse and recycling associations, divisional crime police officer, state coordinators of National Environmental Standard Regulatory and Enforcement Agency, academicians not below rank of senior lecturer in the University, production managers of waste recycling companies and ordinary residents in the study area who are literate to responds to waste management issues. Consequently, ten respondents were selected in each state for all the categories mentioned using simple random sampling techniques.

This was used to obtain in-depth information relating to concepts, perceptions and practices in the reduction, reuse and recycling of waste and how it has contributed to Greenhouse gases reduction. Interview schedule have been used in similar studies by Balch and Mertens (1999), Mbeng (2009), Refsgaard and Magnussen (2009), Chinkuwonnye (2010) as well as Samuel (2012) on municipal solid waste management gaining greater insight on the subject and resolving unexpected issues encountered by questionnaire.

3.5.3 Validity of the instrument.

In other to validate the questionnaire for this research, ten (10) experts in the department of Geography and Environmental Management at University of Ilorin were given ten copies of the questionnaire to examine. The essence of this is to see how relevant the questionnaire is to the chosen topic, the content and the wordings. Besides, a pilot study was carried out before the questionnaire was finally administered to the respondents.

3.5.4 Reliability of the instrument

The questionnaire was administered to twenty (20) people in the manufacturing companies sampled for the study in two states in Southwest Nigeria. The variables considered are waste and virgin resources usage. The result was collected after few days, and the action was repeated for the second time to see the level of agreement of the results of the questionnaire being administered on the two occasions. The level of agreement was examined using rank correlation. The instrument was considered reliable with the value of correlation coefficient $(r) > 0.7$.

3.6 Methods of Data Analysis

In order to analyse the data generated from the field, both descriptive and inferential statistics was used. Such descriptive statistics include; mean, mode and median, while chart, tables, and graphs were used to present the results. In order to estimate waste utilization index, two approaches were used. The first approach used was relative index; this was used to estimate relative change in waste usage over the study period as shown in equation (1.0)

$$\text{Relative Index} = \frac{QI}{QB} \times 100 \dots\dots\dots(1.0)$$

QI = Quantity used in the current year – Quantity used in the base year

QB = Quantity used in the base year.

Similarly, in order to predict the quantity of waste used out of the quantity generated in the study area, multiple regression analysis was used as shown in equation (2.0). Waste utilization index quantifies solid waste flows and measures the extent to which materials may be reduced, reused and recycled as substitutes for virgin materials usage.

$$U = a + R_1X_1 + R_2X_2 + R_3X_3 + \dots + e \dots\dots\dots(2.0)$$

Where,

- U = total amount of waste generated
- R_1 = estimate of quantity of raw materials reduced
- R_2 = estimate of quantity of waste reuse

- R_3 = estimate of quantity of waste recycled
- X_1 = amount of raw materials reduce /tons
- X_2 = amount of waste reuse/tons
- X_3 = amount of waste recycle/tons
- a = the constant term
- e = error term

In the same vein, inferential statistics such as Factor Analysis (FA) was used to identify factors that affect waste utilization using 3Rs strategy in Southwest Nigeria. The analysis was carried out by collapsing, grouping similar variables into dimension and identified the latent variable that has contributed to the factors. This analysis was carried out using SPSS Software 20. The input variables used in the study that were thought to drive waste utilization using 3Rs were selected on the basis of theoretical reasoning, observations made from environment and from the available pertinent literature.

As a result of this, fourteen variables were chosen. The input variables are:

- X_1 =availability of market for reuse and recycled products
- X_2 = health and safety of the environment
- X_3 = government policy
- X_4 = employment generation
- X_5 = level of education and awareness
- X_6 = scarcity of raw materials
- X_7 = energy consumption
- X_8 = cost of production
- X_9 = population increase
- X_{10} = demand for reuse and recycled products
- X_{11} = conservation of virgin resources
- X_{12} = religious factor
- X_{13} = availability of technology
- X_{14} = reduction of greenhouse gasses

In order to achieve the third objective, time series analysis was used to examine the utilization temporal pattern of waste for a period of six (6) years. The period covers 2012-2017.

Decomposition model for trend $U_t = (S_t \times T_t \times E_t)$ (2.0)

Where:

U_t = amount of waste utilized

S_t = seasonal decomposition

T_t = trend cycle component (2012-2017)

E_t = irregular component (fluctuation)

t = time (years)

Similarly, the fourth objective was achieved using Two Way Analysis of Variance (ANOVA), this statistical tool was used to examine if there is any significance difference among virgin, reduced, reused and recycled material during industrial production on GHGs emission in Southwest Nigeria (Table 13 and 14). To accomplish this objective, the emission factors which consist of the distance between point of haulage of waste generated to recycling company, the energy consumption during industrial production of virgin resource and waste recycled for the five materials considered were used. Research has shown that energy consumption during operational activities such as recycling, manufacturing and waste processing can be used to measure the amount of greenhouse gases emission saving (Janya and Nimala, 2012; USEPA, 2015).

Table 14: Virgin and Waste Quantity for ANOVA Analysis

		Greenhouse gas		
Waste Type		Virgin resource	Source Reduction/reuse	Waste Recycle
		Iron		
		Aluminium		
		Steel		
		Copper		
		Plastic		

Source: Researcher, (2017)

The two-way ANOVA formula for the computation is shown below.

Two-way Analysis of Variance

$$\text{Computation for mean} = \frac{1}{ab} \sum X_{jk} \dots\dots\dots \text{Equation 3.1}$$

The (corrected) total sum of square

$$Tss (V) = \sum (X_{jk}^2 - \frac{T^2}{ab}) \dots\dots\dots \text{Equation 3.2}$$

Variation between waste types on greenhouse gas emission

$$T_r = \frac{1}{b} \sum (T_j^2 - \frac{T^2}{ab}) \dots\dots\dots \text{Equation 3.3}$$

Variation between management types (3Rs) on greenhouse gas emission

$$V_c = \frac{1}{a} \sum (T_i^2 - \frac{T^2}{ab}) \dots\dots\dots \text{Equation 3.4}$$

$$\text{Error sum of square } V_e = V - V_r - V_c \dots\dots\dots \text{Equation 3.5}$$

Table 15: Two-way Analysis of Variance Table

Source	SS	Df	MS	F
Main Effect A	SSA	a-1	SS / df	MS(A) / MS(W)
Main Effect B	SSB	b-1	SS / df	MS(B) / MS(W)
Interaction Effect	SSI	(a-1)(b-1)	SS / df	MS(A*B) / MS(W)
Within	SSW	N - ab,	SS / df	
Total	SST	N – 1		

Source: Lawal and Famoye, (2013)

The fifth objective was achieved using EPA's Waste Reduction Model (WARM) GHG algorithm, it was used to estimate the amount of greenhouse gas on waste reduction, reuse and recycling practices, expressed in tons of carbon dioxide saved. WARM was an algorithm developed by United States Environmental Protection Agency (USEPA, 2012) to calculate greenhouse gas emissions for baseline and alternative waste management practices. The model incorporates 34 types of materials and five waste management options. These options include source reduction, recycling, combustion, composting, and land filling. The model calculates emissions in metric tons of carbon dioxide equivalent across a wide range of material types (see appendix v) commonly found in municipal solid waste. This model was also employed by Gabriel and David (2014) for solid waste management alternatives for Lagos municipality. For this work, monthly total tonnage WARM approach was used

Monthly total tonnage warm model algorithm

$$A \times \left(\frac{D}{M} \right) \text{tons CO}_2 = Q \quad \text{.....Equation 3.7}$$

Where,

A = Amount of waste generated/ tones in a month

D = Greenhouse Gas Emission Factors (see appendix v)

M = Total amount of waste (reduce, reuse and recycle) /month

Q = Amount of carbon dioxide save in metric

3.7 Ethical Consideration

In order to ensure success and effective participation of respondents in this study, the researcher considers needful the ethical consideration. To this end, the researcher informed the participants of the aim of the study and detail briefing was made in order to seek their consents. The participants were given the consent form to fill and endorsed to signify their readiness to partake in the study. In the process of undertaking this study, all research assistants were protected against assaults and embarrassment by providing identification tag to them as research assistants. The security outfit in the study area were duly informed of the duration of the study in order to guarantee the safety of the research assistants. The research was carried out in such a way that the participants were not harmed in anyway during the research and thereafter on the basis of their involvement and their identity was made confidential. The researcher also ensure that the content of the brief was logical and chorological to ensure adequate understanding by the participants.

The data collected from individual and organizations for this research shall be kept confidential and strictly use only for this research purpose. Besides, the data collected shall not be given or revealed to the third party. The integrity test was placed on all the data to confirm their reliability in order to ensure the true picture of the study. In the same vein, the researcher also ensure that no deceptive practices were exhibited in whatever form in order to solicit responses from respondents during data collection stage. However, participants were given freedom to withdraw from the research at their own will without any rancour subject to the dictate of their minds. The findings of the research will be published in reputable journals and at the same time disseminated to the stakeholders by given a copy to them.

CHAPTER FOUR

ESTIMATING WASTE UTILIZATION INDEX USING 3RS STRATEGY

4.1 Introduction

In order to estimate waste utilization index of 3Rs in southwest Nigeria, the researcher consider it fit to examine the nexus between the socio-economic characteristics of the respondents and waste. This necessitates the division of this section into two. The first section deals with the socio-economic characteristics of the respondents because it has been proved that waste generation has a direct bearing on socio-economic of the populace. While the main objective was explored using relative index and multiple regression analysis. Consequently, a total of four hundred (400) employees were sampled from ten (10) selected companies. Out of this, 370 respondents filled and returned the administered questionnaire which translates to 93% success rate, while the remaining 7% were unable to fill and return the questionnaire.

4.2 Socio-Economic Characteristics of the Respondents

This section of the analysis examines the socio-economic characteristics of the respondents sampled from selected companies in Southwest Nigeria. The choice of company's employee for questionnaire administration was premised on the fact that they assume to have in-depth knowledge of waste most especially the sources, usage, economic potential and its other associated benefits. The variables considered as shown in (Table 4.1) are; age, sex, marital status, religion, level of education and employment status of the respondents. The choice of these variables was to unveil the relationship between sustainable waste management of 3Rs and the utilization of the selected wastes in the study area.

Table 4.1: Socio-Economic Characteristic of the Respondents in the Recycling Companies Sampled in Southwest Nigeria

Factors	Variable	Frequency	Percentage %
Age structure	18-30	200	54
	31-45	110	29
	46-60	50	14
	61 and above	10	3
	Total	370	100
Sex	Male	300	81
	Female	70	19
	Total	370	100
Marital status	Single	170	46
	Married	140	38
	Divorce	40	11
	Widow	20	5
	Total	370	100
Religion	Christianity	180	49
	Islam	160	43
	Traditional	20	5
	Others	10	3
	Total	370	100
Educational structure	Primary	40	11
	Secondary	80	22
	NCE/OND	160	43
	HND/B.Sc	70	19
	M.Sc/Ph.D	20	5
	TOTAL	370	100
Employment status	Casual staff	200	54
	Permanent staff	150	41
	Others	20	5
Total		370	100

Source: Researcher's Fieldwork, (2018)

The table 4.1 revealed the socio-economic characteristic of the respondents in the recycling companies sampled for the study in Southwest Nigeria. The data was collected through questionnaire survey and analysed using descriptive statistics (Table 4.1). The first variable examined was the age of the respondents. This was considered necessary in order to know the preferred age of the workforce mostly employed in recycling industries and the factors necessitating the choice. The analysis of the responses in the age structure revealed that 200 (54%) are within the age bracket 18-30 years. This age bracket forms the largest percentage of the workforce in recycling sector of the economy in the geographical zone. This may be as a result of energy demanding operational activities of the recycling companies which this age bracket has the energy to shoulder. Similarly, the category of people in age bracket 31-45 years constitutes a significant proportion of the workforce with a response rate of 150 (29%). Critical evaluation of this age bracket equally revealed that they are strong to meet the energy demand of the recycling companies. While the categories of respondents in age bracket (46-60) years only constitute 50(14%). The respondents in this age bracket are very few compared to other age brackets because most of them are old and the energy demand for operational activities in all these companies can be risky and injurious to their health. Consequently, the companies may not like to engage their services. While those in age bracket 60 and above are only 10 (3%) which has similar old age attribute. the information is shown with the pie-chart in figure 4.1

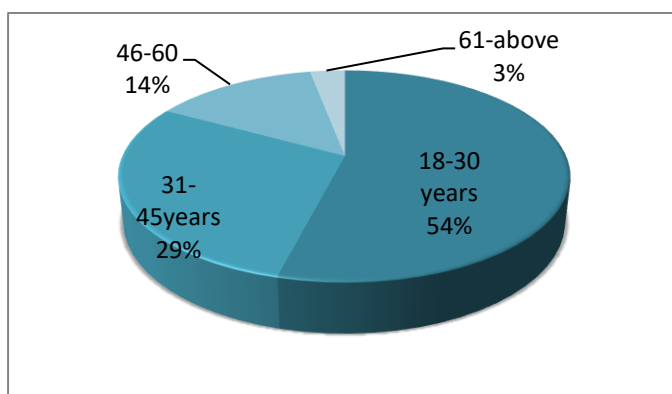


Figure 4.1: Age Distribution of the Respondent

Source: Researcher's fieldwork, (2018)

Considering the sex structure of the respondents, the researcher deems it necessary to examine the sex of the workforce because recycling industries which is the focus of this study require a substantial amount of energy for its operational activities. Consequently, the energy demand of the recycling industries in southwest Nigeria show that majority of the workforce are male with a response rate of 300 (81%), while the remaining 70 (19%) were female. The reasons for this cannot be unconnected with the nature of jobs in recycling industry which may quite supers the energy available within female folds. This is illustrated with figure 4.2

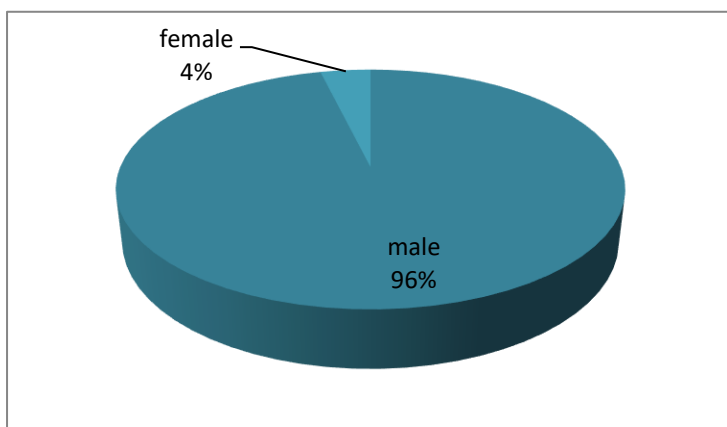


Figure 4.2: Sex Distribution of the Respondents

Source: Researcher's fieldwork, (2018)

In the same vein, the marital status of the respondents was examined, this was considered necessary to unveil the contribution of adult men and women to economic sphere of waste management industries in the region. The result of the analysis revealed that majority of the respondents were single with a response rate of 170 (46%), while 140 (38%) were married, the number of respondents that fall into divorce category were 40 (11%) and only few 20 (5%) are widows. From the result, it is obvious that people without marital partners dominated recycling industries in southwest Nigeria as shown in figure 4.3

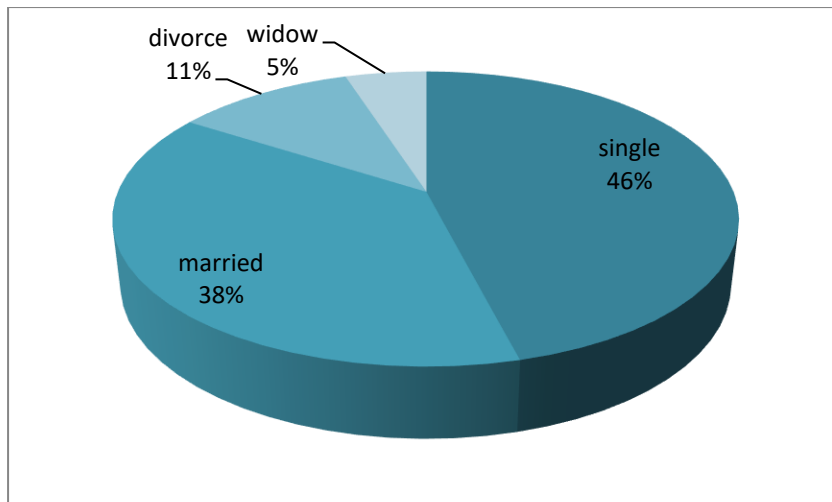


Figure 4.3: Marital Status of the Respondents
Source: Researcher's fieldwork, (2018)

In order to examine the contribution of worker's faith to waste management and utilization in the study area, the religion of the respondents was examined, the analysis revealed that majority of the respondents were Christian with a response rate of 180 (49%), while the number of respondents that practice Islamic religion were 160 (43%) and 20 (5%) practice Traditional religion, while 10 (3%) practice other religion. Actually, every section of the religion in the study area is well represented (figure 4.4) and they had demonstrated their readiness and active participation in sustaining environmental resources. The religion affiliations have not in any way prevented people for working in recycling industries in southwest Nigeria.

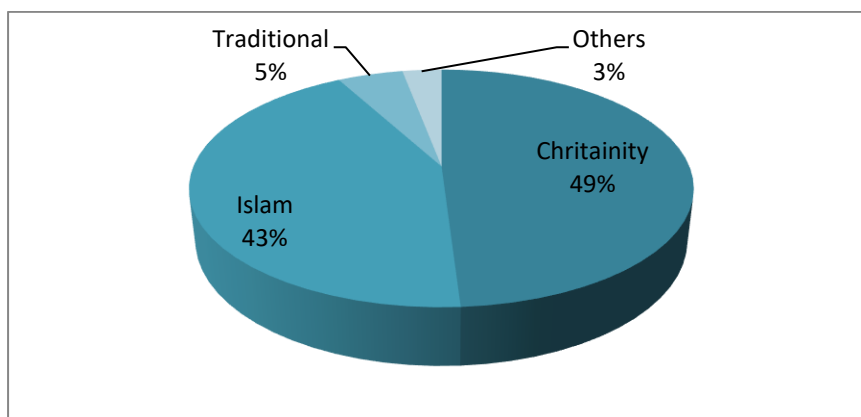


Figure 4.4: Religion of the Respondents
Source: Researcher's fieldwork, (2018)

The educational qualification of the respondents who are equally the employees of the selected waste management companies was examined. This was basically carried out to know the contribution of education towards waste management strategy of 3Rs and sustenance of environmental resources in the study area. In this regard, various echelons of education were considered ranging from primary to Doctoral level. Surprisingly, every strata of education were employed in waste management industry in southwest Nigeria, this further strengthens the findings of Kofoworola (2016) that every 150,000 tons of waste recycled has the capacity to creates nine jobs. The analysis revealed that majority of the respondents are holder of OND/NCE with a response rate of 160 (43%). while secondary school leavers constitute 80 (22%) of the workforce, and the graduate constitute 70 (19%) of the workforce and those with higher qualification are 20 (5%). The analysis above shows that recycling industry in Southwest Nigeria makes use of staff with lower qualification compared to those who have acquired greater feat in education as shown in figure 4.5. This might be one of the major reasons why recycling is at low ebb in the region. The industry is perceived to be earmarked for poverty stricken people without job, consequently the economic fortune associated with waste has not been efficiently harnessed.

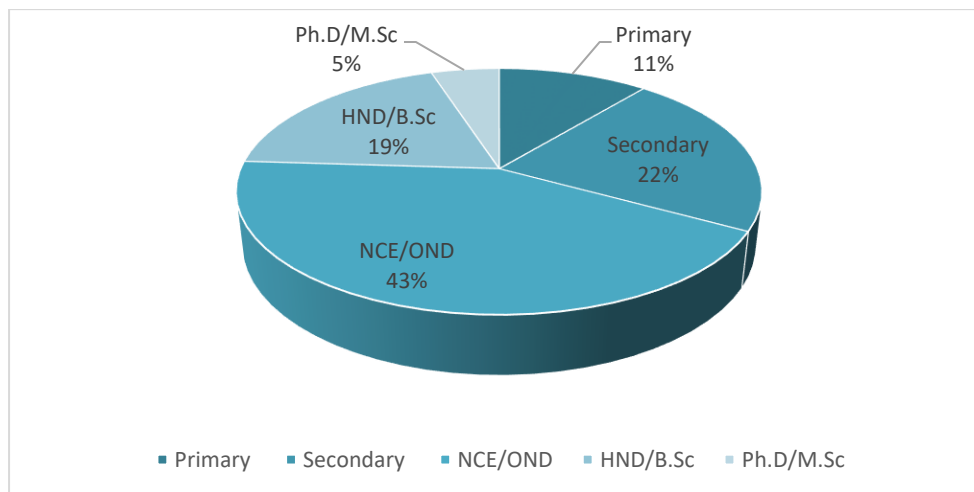


Figure 4.5: Educational Qualification of the Respondents
Source: Researcher's fieldwork, (2018)

The employment status of the respondents was equally x-rayed; this was examined to see the level of job security in recycling industries (Figure 4.5). The result of the analysis shows that casual and other staff dominated the recycling industries as their major source of manpower with a response rate of 200 (54%) and 20 (5%) respectively, while the permanent staff are only 150 (41%). The permanent staffs are those at the management cadre in the organization who help to run the affairs of the companies. This might be one of the reasons why people with higher qualification are not ready to work in recycling industries.

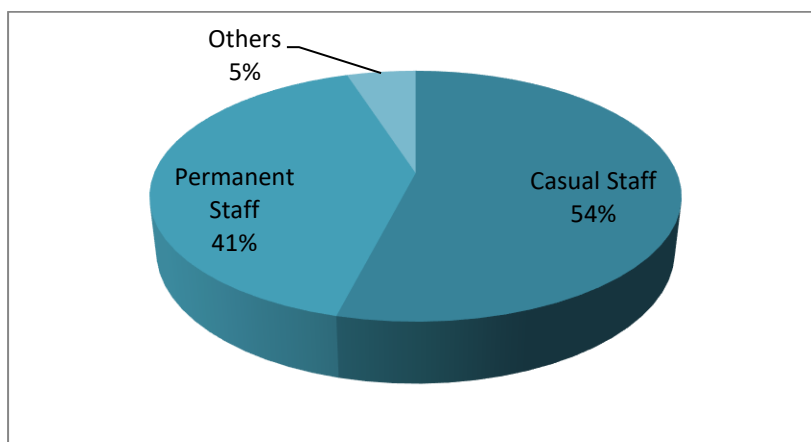


Figure 4.6: Employment Status of the Respondents
Source: Researcher's fieldwork, (2018)

4.3. Utilization Index of Waste Based on 3Rs of Waste Management

In order to estimate the index of waste utilized in Southwest Nigeria, the quantity of waste reduce/reuse and recycled for six years were considered. This was carried out in order to make comparison overtime on how recycling industries make use of waste in the region. In order to achieve this, two methods were used. In the first approach, relative utilization index was considered basically to identify the relative annual change overtime on waste usage in southwest Nigeria. In the second approach, a model was developed using multiple linear regression in order to predict and estimate how quantity of waste generated has affected 3Rs in southwest Nigeria.

4.3.1 Relative waste utilization index based on 3Rs

In order to obtain relative waste utilization index in southwest Nigeria, year 2012 was taken as the base year in which other years were to be compared with. This year was chosen because of the availability of comprehensive data set which was made available by the recycling companies sampled for the study in the region. Evidence from literature have shown that one of the major challenges of recycling industry is that necessary data are not available and often difficult to collect (Schaik and Reuter, 2010; Paul *et al.*,2015). This has equally characterized most of the recycling industries in the study area. To estimate the index of waste utilized, the average quantity of waste reduced and recycled were considered as shown in Colum 2 and 3 in table 4.1.1 and the percentage change was obtained as the difference between the average quantity reduced and recycled in the base year and those in the preceding years divided by the base year multiplied by 100 as shown in Colum 4 and 5 in table 4.1.1

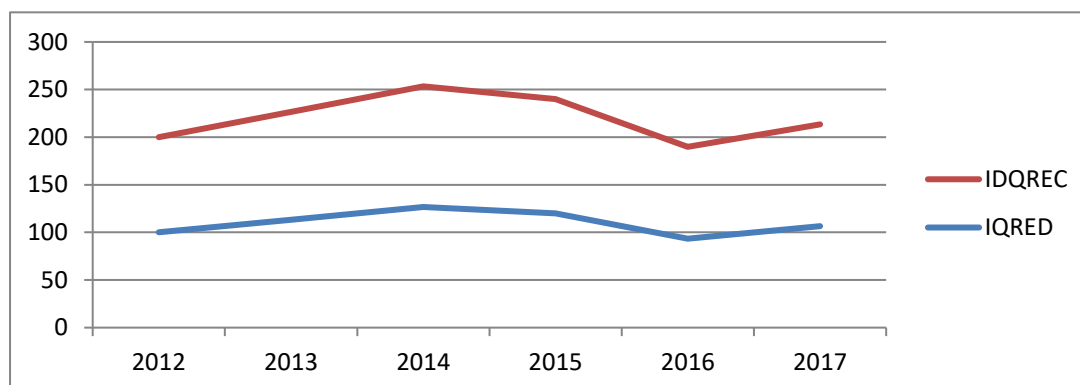
Table 4.1.1: Estimated Index of Aluminum Reduced/Recycled for Six Years in Southwest Nigeria

Year	Average Quantity reduced	Average quantity recycled	% Change in Quantity Reduced	% Change in Quantity Recycled	Index of Quantity Reduced	Index of Quantity Recycled
2012	30332.02	56277.94	Base Year	Base year	100	100
2013	34376.28	63781.66	13.3333	13.33332	113.33	113.33
2014	38420.55	71285.31	26.66664	26.66652	126.67	126.67
2015	36398.42	67533.54	19.99999	20.00002	119.99	120
2016	28332.02	54277.9	-6.59369	-3.55386	93.41	96.45
2017	32354.54	60029.8	6.667937	6.666662	106.67	106.67
Average					110.01	110.52

Source: Researcher's fieldwork, (2018)

The table 4.1.1 shows an increase of 13.33% in the quantity of Aluminum reduced and recycled in recycling industry in the year 2013, 26.67% in the year 2014, 20% in the year 2015 while in the year 2016 there was a decrease of 6.59% in the quantity of Aluminum reduce and 3.55% recycled compare to the year 2012. In the same vein, there was an increase of 6.66% in the year 2017. The average utilization index of Aluminum in the region over the period under investigation was 10% for reduction

and 11% for recycling. The graph (Figure 5.1) show time series fluctuation in the utilization index of Aluminum over a period of six years.



IQRED =Index of quantity reduced, IDQREC=Index of quantity recycled

Figure 4.1.1: Time Plot Utilization Index of Aluminum Reduce/Recycled Between 2012-2017
Source: Researcher's fieldwork, (2018)

Table 4.1.2: Estimated Index of Steel Reduced/Recycled for Six Years in Southwest Nigeria

Year	Average quantity reduced	Average quantity recycled	% Change in quantity reduced	% Change in quantity recycled	Index of quantity reduced	Index of quantity recycled
2012	14752.26	8728.01	100	100	100	100
2013	16719.23	9889.48	13.33335	13.30739	113.33	113.31
2014	18686.19	11052.95	26.66663	26.63769	126.67	126.64
2015	17702.71	10471.21	19.99999	19.97248	119.9	119.97
2016	13752.26	7728.01	-6.77862	-11.4574	93.41	88.55
2017	15735.74	9307.74	6.66664	6.642178	106.67	106.64
Average					109.99	109.185

Source: Researcher's fieldwork, (2018)

Table 4.1.2 show the utilization index of steel for a period of six years, the analysis revealed that there is an increase in usage of steel over the six years except in the year 2016 where there is a shortfall of 11.50% compared to the base year. However, the average reduction in waste utilization index for steel is 9.99% increase. While that of recycle is 9.185% increase over the base period. The (figure 5.1.2) show the time series fluctuation in steel utilization index for the six years

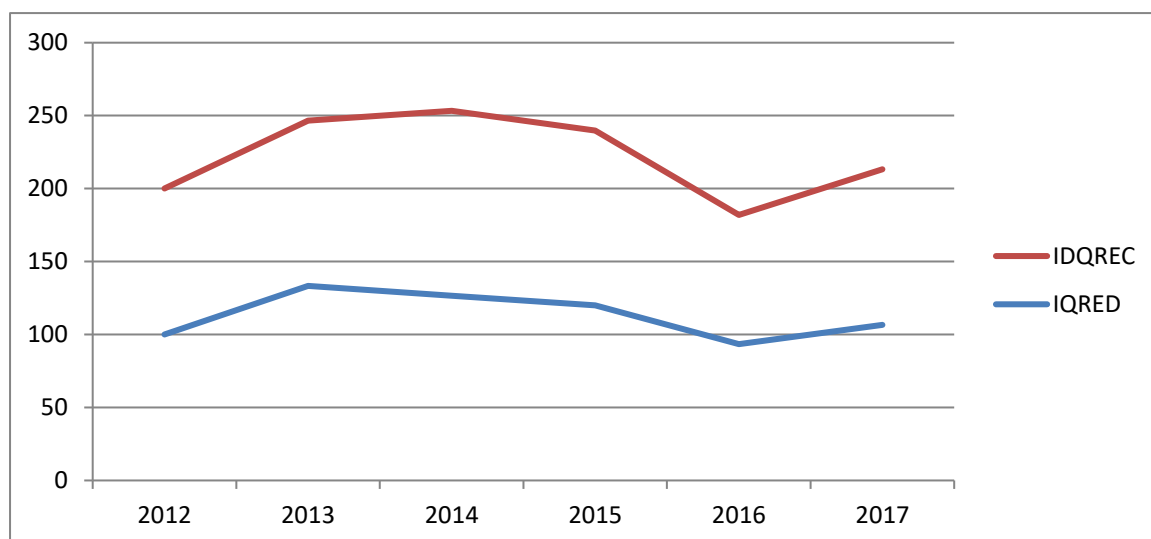


Figure 4.1.2: Time Plot Utilization Index of Steel between 2012-2017 in Southwest Nigeria
Source: Researcher's fieldwork, (2018)

Table 4.1.3: Estimated Index of Copper Reduced/Recycled for Six Years in Southwest Nigeria

Year	Average quantity of waste reduced	Average quantity of waste recycled	% Change in quantity reduced	% Change in quantity recycled	Index of quantity reduced	Index of quantity recycled
2012	42976.91	28876.07	100	100	100	100
2013	48707.16	32726.21	13.33332	13.33332	113.33	113.33
2014	54437.42	36576.35	26.66667	26.66665	126.67	126.67
2015	51572.29	34651.28	20	19.99999	120	119.99
2016	43976.91	28976.05	2.326831	0.346238	102.33	100.35
2017	45842.04	30801.14	6.666673	6.666662	106.67	106.67
Average					111.5	111.16

Source: Researcher's fieldwork, (2018)

Table 4.1.3 show the utilization index of Copper for a period of six years, the analysis revealed that there is an increase in usage of Copper over the six years compared to the base year. However, the average reduction in waste utilization index for copper is 12% increase. While that of recycle is 11% increase over the said period. The figure 4.1.3 show the time series fluctuation in Copper utilization index for six years.

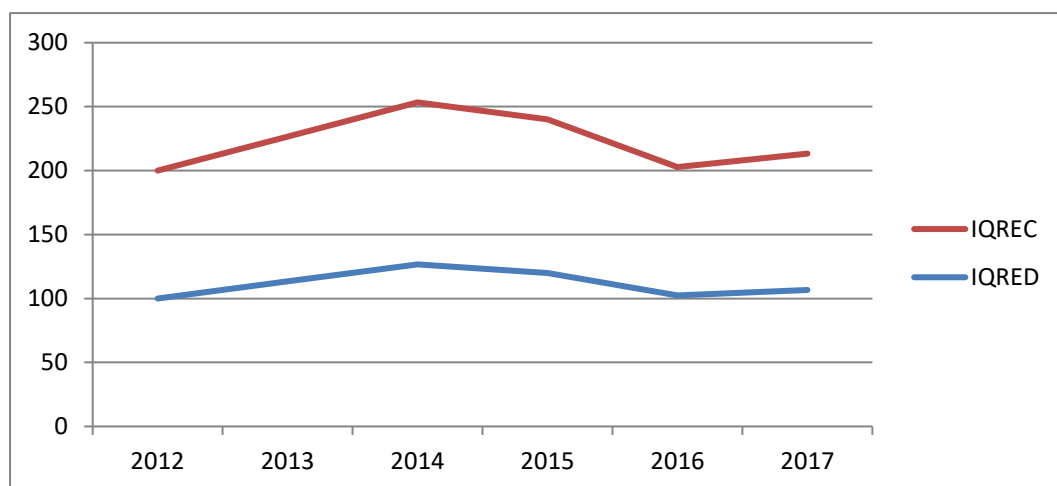


Figure 4.1.3: Time Plot Utilization Index of Copper in the Southwest

Source: Researcher's fieldwork, (2018)

Table 4.1.4: Estimated Index of Iron Reduced/Recycled for Six Years in Southwest Nigeria

Year	Average quantity of waste reduce	Average quantity of waste recycled	% change In quantity reduce	% change In quantity recycled	Index of waste reduced	Index of waste recycled
2012	432900	507780	Base year	Base year	100	100
2013	490620	575484	0.01155	13.33333	100.01	113.33
2014	547600	642320	26.49573	26.49573	126.49	126.49
2015	518000	607600	19.65812	19.65812	119.66	119.65
2016	407567	477780	-5.85193	-5.90807	94.15	94.1
2017	461760	541632	6.666667	6.666667	106.66	106.67
Average					7.83	110.04

Source: Researcher's fieldwork, (2018)

Table 4.1.4 shows the utilization index of iron for a period of six years, the analysis revealed that there is an increase in usage of Iron over the six years compared to the base year. However, the average reduction in waste utilization index for Iron is 7.83% increase. While that of recycle is 10.04% increase over the said period. The figure 4.1.4 show the time series fluctuation in Iron utilization index for the period of six years.

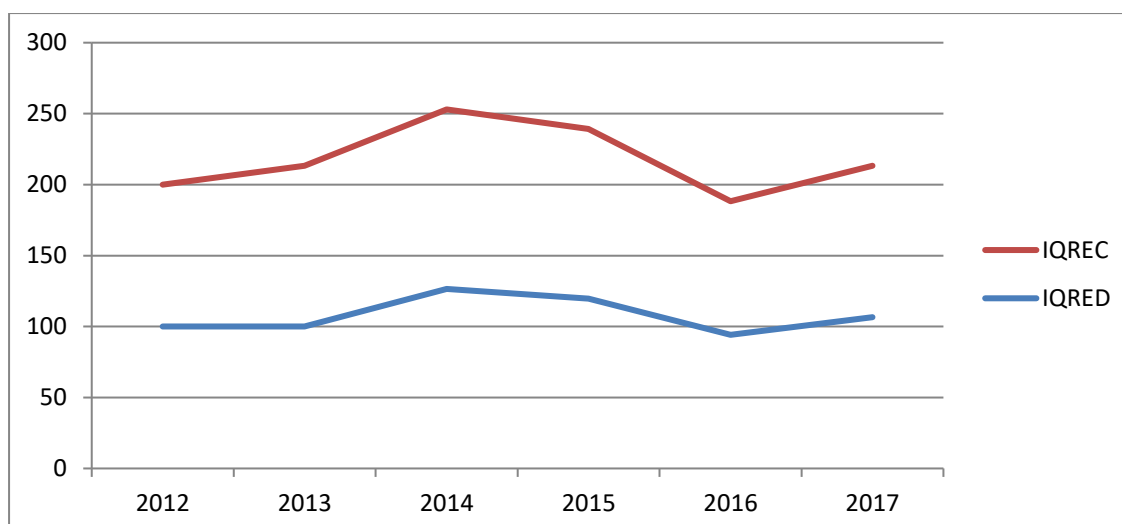


Figure 4.1.4: Time Plot Utilization Index of Iron in the Southwest
Source: Researcher's fieldwork, (2018)

Table 4.1.5: Estimated Index of plastic Reduced/Recycled for Six Years in Southwest Nigeria

Year	Average quantity of waste reduced	Average quantity of waste recycled	% Change In quantity reduced	% Change in quantity recycled	Index of waste reduced	Index of Waste recycled
2012	14752.26	437042.4	100	100	100	100
2013	16719.23	438190.5	13.33335	0.262708	113.33	100.26
2014	18686.19	407389.2	26.66663	-6.78497	126.67	93.22
2015	17702.71	419968.3	19.99999	-3.90674	119.99	96.09
2016	13752.26	399117.5	-6.77862	-8.67761	93.23	91.33
2017	15735.74	416796	6.66664	-4.63258	106.67	95.37
Average					109.98	96.05

Source: Researcher's fieldwork, (2018)

Table 4.1.5 shows the utilization index of Plastic for a period of six years. The analysis revealed that there is a decrease in usage of plastic over the six years except in the year 2013 where there is an increase of 0.26% compared to the base year. However, the average reduction in waste utilization index for plastic is 9.98% increase. While that of recycle is 3.95% decrease over the said period. The figure 4.1.5 show the time series fluctuation in plastic utilization index for six years

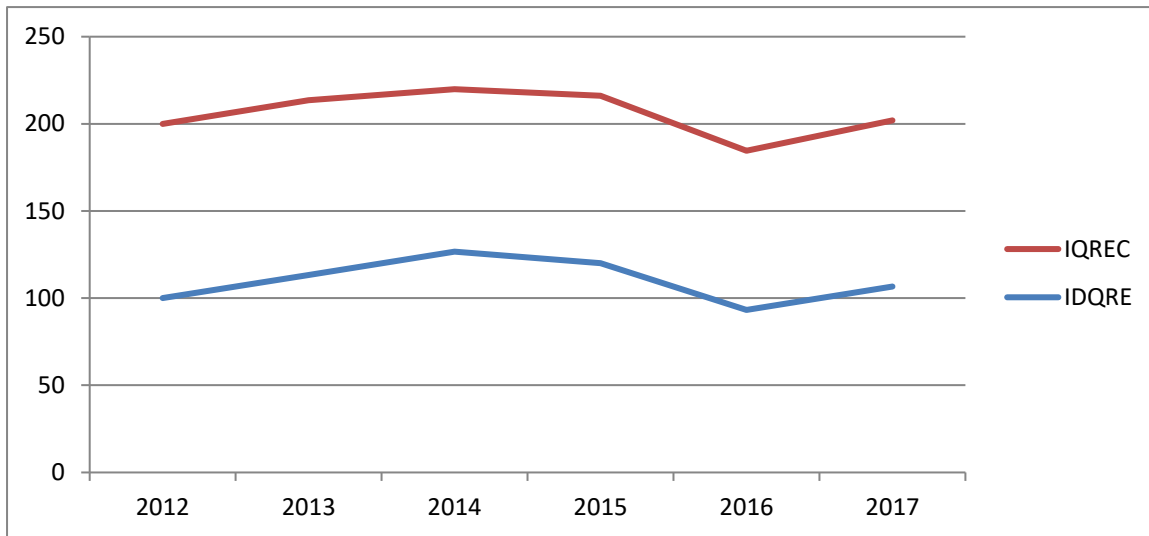


Figure 4.1.5: Time Plot Utilization Index of Plastic for Six Years in Southwest Nigeria

Source: Researcher's fieldwork, (2018)

4.3.2. Predicting Utilization Index of Waste Based on 3Rs of Waste Management

In order to predict the utilization index of the five wastes considered in this study, the data collected from the waste management agencies in the states considered was used coupled with those collected from companies utilizing waste on reduce, reuse and recycling in the study area. The quantity of waste generated for the six years was considered to be dependent variable while the quantity reduced/reused and recycled for the six years was considered to be independent variable. In order to actualize this, the data were subjected to regression analysis using SPSS 20.0. The output was used to develop a model to show linear relationship between the quantity of waste generated and their utilization.

In order to predict the waste usage, a linear model was established between waste generation and the integrated waste management of reduce reuse and recycle using regression analysis. In this case, each material under investigation was considered separately for easy prediction.

Table 4.2.1: Establishing linear model between waste generated and aluminum usage

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.973	.946	.911	1.75855	1.810

Source: Researcher's fieldwork, (2018)

The table 4.2.1 shows the model summary and overall fit statistics, the adjusted R square of the model is 0.911 with the R square of 0.946 which means that the linear regression explains 94.6% of the variance in the data. The Durbin-Watson $d = 1.810$, which is between critical values of $1.5 < d < 2.5$. shows that there is no first order linear auto-correlation in the data. The essence of testing for the autocorrelation was to ensure that, a correct decision was made on output of ANOVA of the model.

Table 4.2.2: ANOVA to establish linear model for aluminium

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	164.056	2	82.028	26.525	.012
Residual	9.278	3	3.093		
Total	173.333	5			

Source: Researcher's fieldwork, (2018)

The ANOVA in table 4.2.2 is the linear regression F-test with $F = 26.525$ at 5 degree of freedom, since the significant value of $0.012 < 0.05$ it is a clear indication that the test is highly significant. Thus, there is a linear relationship between quantity of waste generated and Aluminium usage in Southwest Nigeria in the model.

Table 4.2.3 : Coefficients of linear model for aluminium

Model	Unstandardized Coefficients		Standardize d Coefficients	T	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	-.661	2.573		-.257	.814	-8.850	7.528
QRE	1.157	.183	.856	6.321	.008	.574	1.739
QRCY	1.450	.315	.623	4.603	.019	.448	2.453

Source: Researcher's fieldwork, (2018)

The table 4.2.3 shows the regression coefficients, the intercept and the significance of all coefficients in the model. It was find out that the linear regression analysis estimates the linear regression function to be

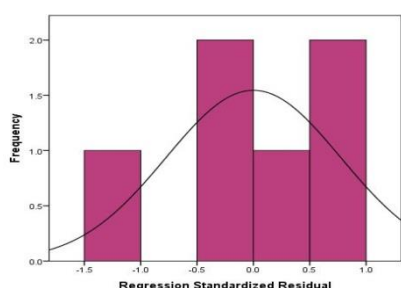
$$QWG = -0.661 + 1.16(QRE) + 1.450(QRCY) \dots\dots\dots 1$$

Where,

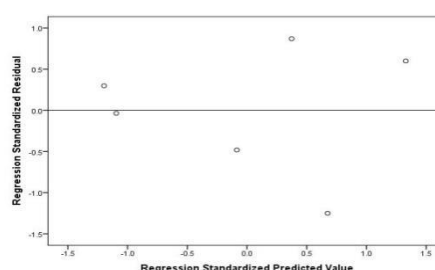
QWG = Quantity of Waste Generated

QRE=Quantity Aluminium Reduced during production

QRCY=Quantity of Aluminium waste recycled



a.



b

Figure 4.2.1: Regression Residual and Predicted Value of Model 1

Source: Researcher's fieldwork, (2018)

The model (Equation 1) revealed that at an average there is reduction of 0.661 in the quantity of waste generated when aluminium is subjected to a management option of reduce and recycled in southwest Nigeria. In the same vein, a unit ton in quantity of waste generated lead 1.16% increase in quantity of Aluminium reduced/reused and 1.15% increase in quantity of Aluminium recycled.

Table 4.2.4: Establishing linear model between waste generated and steel usage

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.821	.674	.670	1.880	1.721

Source: Researcher's fieldwork, (2018)

The table 4.2.4 shows the model summary and overall fit statistics, the adjusted R square of the model is 0.670 with the R square 0.674 which means that the linear regression explains 67.4% of the variance in the data. The Durbin-Watson = 1.721, is between the two critical values of $1.5 < d < 2.5$ this show that there is no first order linear auto-correlation in the data.

Table 4.2.5: ANOVA to Establish Model for Steel

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	156.89	2	78.45	33.60	.010
Residual	7.004	3	2.33		
Total	163.89	5			

Source: Researcher's fieldwork, (2018)

The ANOVA table is the F-test, with $F = 33.60$ at 5 degree of freedom, since the significance value of $0.01 < 0.05$, we accept that the test is highly significant. Thus, there is a linear relationship between quantity of waste generated and steel usage in the model.

Table 4.2.6: Coefficients of linear Model for steel

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
(Constant)	-.844	2.643		8.357	.004	-0.921	6.007
QSR	1.516	.507	.877	2.461	.041	9.27	84.215
QSRec	4.407	.152	.278	2.488	.009	4.05	2.329

Source: Researcher's fieldwork, (2018)

The table 4.2.6 shows the regression coefficients, the intercept and the significance of all coefficients in the model. The linear regression analysis estimates the linear regression function to be

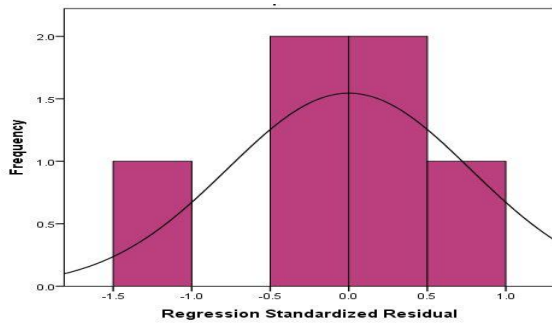
$$QWG = -0.844 + 1.516*(QSR) + 4.407*(QSRec) \dots\dots\dots 2$$

Where,

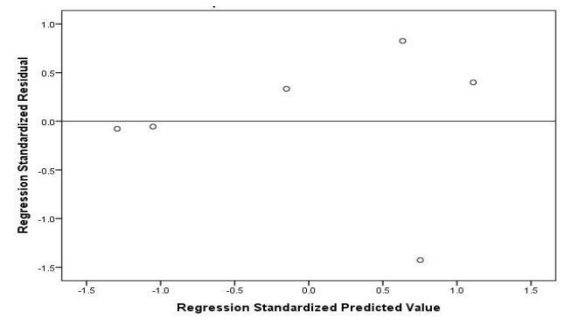
QWG =Quantity of Waste Generated

QSR= Quantity Steel reduced during production

QSRec= Quantity steel waste recycled



a.



b.

Figure 4.2.2: Regression Residual and Predicted Value of Model 2

Source: Researcher's fieldwork, (2018)

The model (Equation 2) revealed that at an average, there is a reduction of 84.4% in the quantity of steel waste generated by subjecting steel to a management options of reduce/reuse and recycled in southwest Nigeria. This reduction might be occasioned by the economic value of steel waste in the study area. Besides, a unit ton in the quantity of waste generated in Southwest Nigeria lead to 1.516% increase in the quantity of steel reduced/reused and 4.407% increase in quantity of steel recycled in the region.

Table 4.2.7 : Establishing linear model between waste generated and plastic usage

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.934	.873	.788	98.41602	2.42

Source: Researcher's fieldwork, (2018)

The table 4.2.7 shows the model summary and overall fit statistics, the adjusted R square of our model is 0.788 with the R square 0.873 which means that the linear regression explains 87.3% of the variance in the data. The Durbin-Watson = 2.842 lies between the two critical values of $1.5 < d < 2.5$ therefore there is no first order linear auto-correlation in the observed data.

Table 4.2.8: ANOVA to establish model for plastic

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	198996.195	2	99498.097	10.273	.045
Residual	29057.139	3	9685.713		
Total	228053.333	5			

Source: Researcher's fieldwork, (2018)

The ANOVA table is the F-test, with $F = 10.27$ at 5 degree of freedom, since the value of $0.045 < 0.05$ we accept that the test is highly significant, thus there is a linear relationship between waste generated and plastic usage in our model.

Table 4.2.9: Coefficients of Linear Model for Plastic

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	219.660	88.255		2.489	.089		
QPR	1.053	.234	.949	4.510	.020	.958	1.043
QPRec	1.858	.629	.287	1.364	.266	.958	1.043

Source: Researcher's fieldwork, (2018)

The table 4.2.9 shows the regression coefficients, the intercept and the significance of all coefficients in the model, the linear regression analysis estimates the linear regression function to be

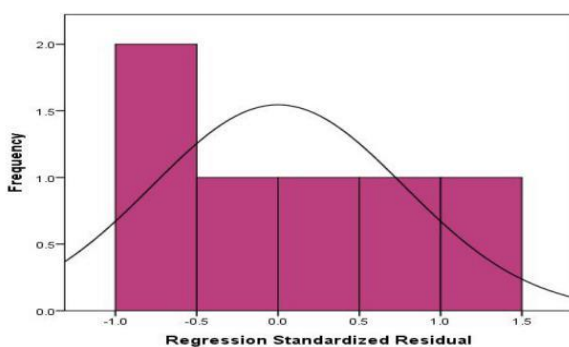
$$QWG = 219.66 + 1.053(QPR) + 1.858 (QPRec).....3$$

Where,

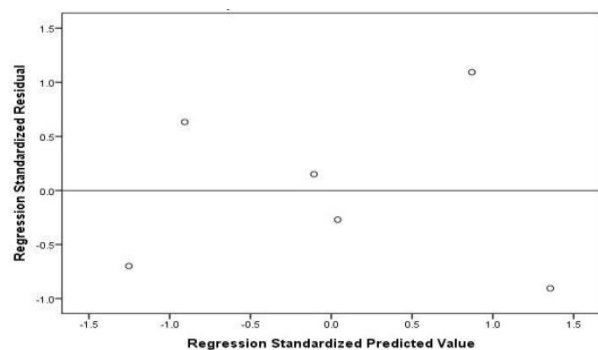
QWG = Quantity of Waste Generated

QPR = Quantity of Plastic reduced during production

QPRec= Quantity Plastic waste recycled



a.



b.

Figure: 4.2.3: Regression Residual and Predicted Value of Model 3

Source: Researcher's fieldwork, (2018)

The model (Equation 3) revealed that at an average there is an increase of 219.66% in the quantity of plastic waste generated by subjecting plastic to a management options of reduced/reuse and recycle in southwest Nigeria. Besides, a unit ton in the quantity of waste generated in southwest Nigeria has led to 1.053% increase in quantity of plastic reduced/reused and 1.858% increase in quantity of plastic recycled. The result here is quite amazing; the expectation is to observe a decrease in the quantity of plastic waste generated as a result of management option of 3Rs. However, the result may due to plastic being one of the major packaging materials for industrial finished goods in the study area.

Table 4.2.10: Establishing linear model between waste generated and copper usage

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.961	.924	.873	75.97999	2.14

Source: Researcher's fieldwork, (2018)

Table 4.2.10 shows the model summary and overall fit statistics, the adjusted R square of the model is 0.873 with the R square 0.924 which means that the linear regression explains 92.4% of the variance in the data. The Durbin-Watson $d = 2.14$ lie between the two critical values of $1.5 < d < 2.5$, therefore there is no first order linear auto-correlation in the observed data

Table 4.2.11: ANOVA to establish linear model for plastic

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	210734.456	2	105367.22	18.252	.021
Residual	17318.877	3	5772.959		
Total	228053.333	5			

Source: Researcher's fieldwork, (2018).

The ANOVA table is the F-test, with $F = 18.25$ at 5 degree of freedom, the test is highly significant. Since the value of $0.021 < 0.05$ at 95% level of significance. Thus, there is a linear relationship between waste generated and Copper usage in the model.

Table 4.2.12: Coefficients of linear model for copper

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-46.502	95.048		.489	.658		
QCR	1.167	.198	1.007	5.892	.010	.867	1.153
QCRec	.949	.280	.580	3.394	.043	.867	1.153

Source: Researcher's fieldwork, (2018)

The table 4.2.12 shows the regression coefficients, the intercept and the significance of all coefficients in the model. The linear regression analysis estimates the linear regression function to be

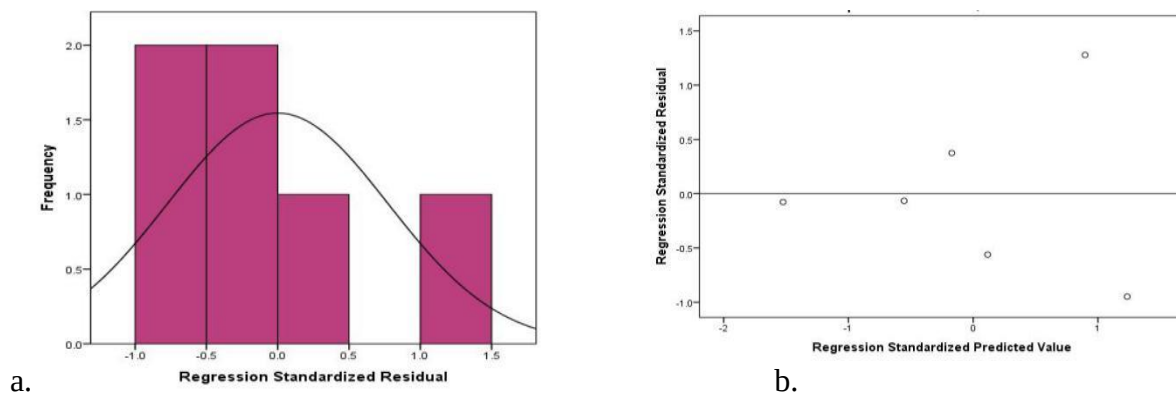
$$QWG = -46.502 + 1.167(QCR) + 0.949(QCRec) \dots\dots\dots 4$$

Where,

QWG = Quantity of Waste Generated

QCR = Quantity reduce in Copper

QCRec= Quantity recycled in Copper

**Figure 4.2.4:** Regression Residual and Predicted Value of Model 4

Source: Researcher's fieldwork, (2018)

The model (equation 4) revealed that at an average there is decrease of 46.50% in the quantity of copper waste generated in southwest Nigeria. Copper is one of the most valuable materials in electrical conductivity as such its economic potential is relatively high. this huge reduction in the quantity of

coppers waste is further strengthened by higher price of N500 per kg of it waste in the study area which is higher compare to all other waste considered in this study. In the same vein, a unit ton in the quantity of waste generated in southwest Nigeria has led to 1.17% increase in quantity of Copper reduced/reused and 0.95% increase in quantity of Copper recycled.

Table 4. 2.13: Establishing linear model between waste generated and iron usage

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.947	.897	.828	88.69359	2.198

Source: Researcher's fieldwork, (2018)

The table 4.2.13 shows the model summary and overall fit statistics, the adjusted R square of the model is 0.828 with the R square 0.89, this implies that the linear regression explains 89.7% of the variance in the data. The Durbin-Watson ($d = 2.198$) lies between the two critical values of $1.5 < d < 2.5$ therefore there is no first order linear auto-correlation in the observed data.

Table 4.2.14: ANOVA to establish linear model for iron

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	204453.674	2	102226.837	12.995	.033
	Residual	23599.660	3	7866.553		
	Total	228053.333	5			

Source: Researcher's fieldwork, (2018)

The ANOVA table 5.2.14 is the F-test, with $F = 12.995$ at 5 degree of freedom, the test is highly significant since the significant value of $0.33 < 0.05$, at 95% level of confidence, this show that there is a linear relationship between quantity of waste generated and iron usage in the model.

Table 4.2.15: Coefficients of linear model for iron.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-150.043	172.639		-.869	.449		
QIR	2.046	.794	.502	2.577	.042	.907	1.102
QIRec	1.336	.269	.970	4.975	.016	.907	1.102

Source: Researcher's fieldwork, (2018)

The table 4.2.15 shows the regression coefficients, the intercept and the significance of all coefficients in the model. The linear regression analysis estimates the linear regression function to be

$$QWG = -150.043 + 2.046(QIR) + 1.336(QIRec) \dots \dots \dots 5$$

Where,

QWG = Quantity of Waste Generated

QIR = Quantity Iron reduced during production

QIRec = Quantity iron waste recycled

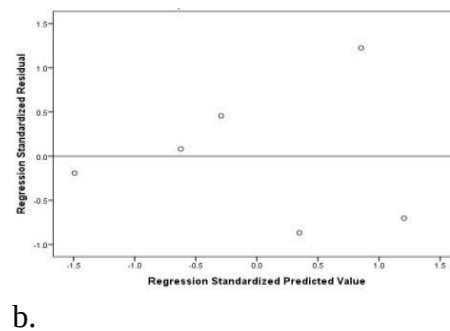
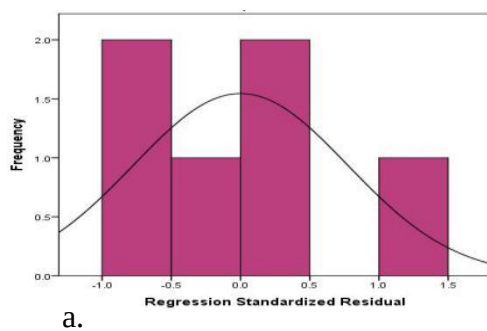


Figure: 4.2.5: Regression Residual and Predicted Value of Model 5

Source: Researcher's fieldwork, (2018)

The model (Equation 5) revealed that at an average there is a reduction of 150.043% in the quantity of waste generated by subjecting iron to management options of reduce/reuse and recycle in southwest

Nigeria. Similarly, a unit ton in the quantity of waste generated in Southwest Nigeria has led to 2.046% increase in quantity of iron reduced/reused and 1.336% increase in quantity of iron recycled.

4.4 Interview on Waste Utilization in Southwest Nigeria

In order to have a broader view on waste utilization in the study area, interview was conducted for the residents of the area. The major areas explore include; types of waste available in the area, identification of wastes that are commonly reuse and recycle and the extent of usage of the identified wastes.

4.4.1 Interview of residents on types of waste available in Southwest Nigeria

In order to have a comprehensive interview on the types of waste the residents can identify in the region, the central dumpsite at Onibueja in Osun state Southwest Nigeria was visited. Pursuant to this, permission was sought from the general manager of Osun Waste Management Agency (OWMA) in a bid to have access to the dumpsite. The essence of visiting the dumpsite was to correlate the responses of the respondents with the actual waste available within the region. Consequently, the dumpsite manager took the pain to take the researcher round the dumpsite. The available wastes identified in the dumpsite include: Nylon, Papers, Plastic, Copper, Brass, Aluminium, Electronics, Zinc and other biodegradable wastes (Plate 6). Surprisingly, most of the wastes available in the dumpsite were those identified by the residents in the region. This was equally affirmed in the literature by Fakere *et al.* (2012).



a. Electronic



b. Plastic and Pets



b. Biodegradable



Paper

Plate 6: Identification of Various Wastes in Southwest Nigeria: Evidence from Onibueja Central Dumpsite in Osogbo, Osun State.

4.4.2 Waste commonly utilized in southwest Nigeria

Having identified the available waste in the region, the study further seeks to know if some of these wastes were subjected to 3Rs of waste management. The primary reason for this is to know if the people in the region explored the economic potential inherent in the identified wastes. Besides, to know their sustainability drive for the available natural resources vis-à-vis the use of identified wastes in conserving resources to meet future generation's need. In the real sense of it, most of the people interviewed were quite abreast with available waste and what they commonly used them for. However, their responses show that most of the wastes were mainly recycled in order to get resources from them, according to waste characterization study the total metal scrap in municipal waste was 1.8% in southwest Nigeria (Olanrewaju and Ilemobide, 2009). But the current characterization study has shown

that the quantity of metal scrap has reduced to 1% due to increase in reuse and recycling rate in the study area (Figure 4.1). This translate to people's awareness on the economic potential of scrap metals in Southwest Nigeria. While those commonly reused were plastics, nylon, clothing materials, papers and vital parts of mechanical and electronics wastes as components during repairs among others. However, the biodegradable component of the waste which constitute the larger percentage (43%) were left to decay in Oyo, Ogun and Osun states without subjecting it to further processing and usage. However, in Lagos state, the biodegradables were used in the production of fertilizer (Plate 7) for agricultural productivity. Consequently, Non-usage of the larger proportion (biodegradables) of the generated waste in other states has contributed to source of greenhouse gases at the various dumpsites in Southwest Nigeria.



Plate 7: Biodegradable Component of Municipal Solid Waste Use for Organic Fertilizer in Lagos State

Source: Researcher's fieldwork, (2018)

CHAPTER FIVE

5.1 FACTORS AFFECTING WASTE UTILIZATION USING 3RS STRATEGY

In order to identify the major factors that affect the utilization of municipal solid waste using 3Rs of waste management in Southwest Nigeria, fourteen input variable as shown in earlier part of the study were considered. The selection of these variables was based on theoretical reasoning, literature search and environmental consideration. The respondents are the employee of the recycling companies considered for this study. The fourteen variables were subjected to Factor Analysis (FA) using IBMSPSS 20. The first output from the analysis is a table of descriptive statistics for all the variables under investigation. Typically, the mean, standard deviation and number of respondents (N) who participated in the survey were given. The output of the mean revealed that population increase is the most important variable that promote waste utilization in the study area. It has the highest mean of 4.81 as shown in (Table 5.1). Evidence from literature has shown that one of the dominant factors responsible for waste generation is population (Rushbrook and Pugh, 1999; John *et al.*, 2006; Igoni *et al.*, 2007; Kofoworola, 2007; Sha'Ato *et al.*, 2007) which in this case has positively affected its utilization in the region at the same time. This is a clear indication that the higher the quantity of waste generated the more waste will be available for (recycling, reuse) industrial utilization.

Table 5.1: Descriptive Statistics of the Variables Considered in the Study

Variables	Mean	Std. Deviation	N
Availability of market for reuse and recycled products	1.68	.466	370
Health and safety of the environment	4.26	.735	370
Government policy	3.97	.867	370
Employment generation	2.01	.836	370
Level of education and awareness	2.68	1.230	370
Scarcity of raw materials	1.19	.396	370
Energy consumption	4.14	.412	370
Cost of production	1.54	.530	370
Population increase	4.81	.394	370
Demand for reuse and recycled products	1.72	.447	370
Conservation of virgin resources	4.34	.475	370
Religion factor	4.09	.909	370
Availability of technology	1.12	.330	370
Greenhouse gas emission reduction	3.94	.713	370

Source: Researcher's fieldwork, (2018)

In order to examine if the sample required for identification of the factors are adequate or not, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy test was carried out. According to Kaiser (1974) a value of 0.5 was recommend as minimum values, the KMO measure in this study is 0.498, which is close to 0.5 and therefore can be accepted (Table 5. 2)

Table 5.2: KMO and Bartlett's Test of Sampling Adequacy

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.498
Bartlett's Test of Sphericity	Approx. Chi-Square	1653.117
	Df	91
	Sig.	.000

Source: Researcher’s fieldwork, (2018)

5.1.1 Communalities that Explained the variables

In order to identify which of the variables should be included in the factor analysis, the communalities were examined. A threshold of 0.5 was set for all the variables and any extraction greater than 0.5 was considered. Based on the table (5.3), all the variables were required for the extracted factors. For instance, over 88% of the variance in “population increase” was accounted for, while 80% of the variance in “Level of education and awareness”, “Cost of production” and “Demand for reuse and recycled products” was accounted for by the extracted factors (Table 5.3). In the same vein, as we observed from (Table 5.3), all the variables are to be considered for the identification of the factor responsible for waste utilization in the study area.

Table 5.3: Communalities Explained by Each Variable

Variables	Initial	Extraction
Availability of market for reuse and recycled products	1.000	.534
Health and safety of the environment	1.000	.755
Government policy	1.000	.691
Employment generation	1.000	.676
Level of education and awareness	1.000	.827
Scarcity of raw materials	1.000	.662
Energy consumption	1.000	.654
Cost of production	1.000	.855
Population increase	1.000	.884
Demand for reuse and recycled products	1.000	.824
Conservation of virgin resources	1.000	.605
Religion factor	1.000	.721
Availability of technology	1.000	.697
Greenhouse gas emission reduction	1.000	.534

Source: Researcher's fieldwork, (2018)

5.1.2 Total variance explained by each factors

The Eigenvalues in table 5.4 was divided into three sub-sections; Initial Eigenvalues, Extracted Sums of Squared Loadings and Rotation Sums of Squared Loadings. For the purpose of this study, only Extracted Sums of Squared Loadings was considered. Here, the first factor accounts for 22.31% of the variance, the second 12.61%, the third 11.14%, the fourth 8.95%, the fifth 8.42% and the sixth 7.43% while all the factors combined together accounted for 70.864% of the total variation.

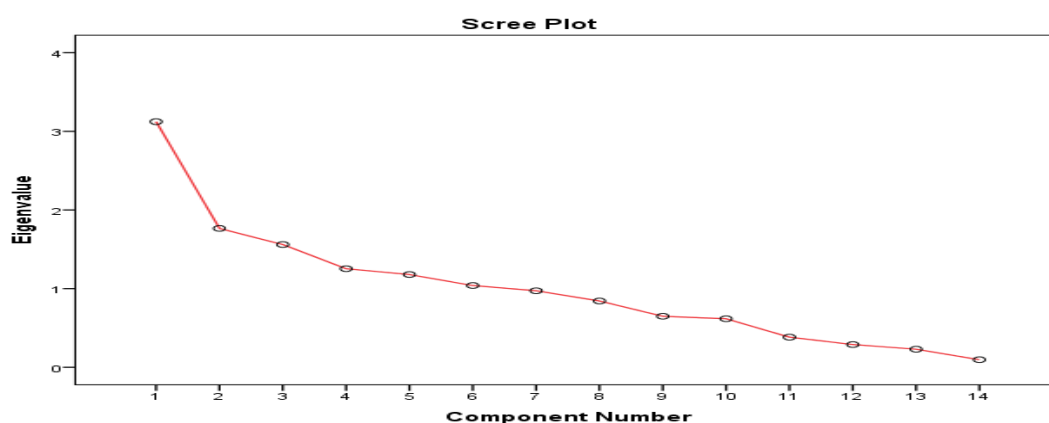
Table 5.4: Variables Loadings for the factors

Componen t	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.123	22.307	22.307	3.123	22.307	22.307	2.330	16.640	16.640
2	1.765	12.610	34.917	1.765	12.610	34.917	2.263	16.168	32.808
3	1.561	11.147	46.064	1.561	11.147	46.064	1.449	10.348	43.155
4	1.253	8.952	55.016	1.253	8.952	55.016	1.444	10.314	53.469
5	1.179	8.421	63.438	1.179	8.421	63.438	1.361	9.718	63.187
6	1.040	7.426	70.864	1.040	7.426	70.864	1.075	7.676	70.864
7	.973	6.950	77.813						
8	.843	6.021	83.834						
9	.649	4.633	88.467						
10	.617	4.408	92.875						
11	.383	2.734	95.609						
12	.289	2.063	97.672						
13	.230	1.642	99.314						
14	.096	.686	100.000						

Source: Researcher's fieldwork, (2018)

5.1.3 Scree plot that shows the number of factors to be retained

The scree plot (Figure 5.1) is a graph of the eigenvalues against all the factors. The graph is useful for determining how many factors to be retained. The point of interest is where the curve starts to flatten. It can be seen that the curve begins to flatten between factors 3 and 4. However factor 7 and above have an eigenvalue of less than 1, hence they are not significant. Consequently, only six factors have been retained.

**Figure 5.1:** The Scree Plot Showing the Number of Factors Retained in the Analysis

Source: Researcher's fieldwork, (2018)

5.1.4 Component matrix

The table 5.5 shows the loadings of the fourteen variables on the six factors extracted. The higher the absolute value of the loading, the more the variable contributes to the factors. We have extracted six factors where important items with similar responses are in component 1 and simultaneously in component 2, 3, 4, 5 and 6. The threshold of 0.5 was set and any loading less than this value was suppressed (Table 5.5)

Table 5.5: Component Matrix of the Variables used in the Study

Variables	Component					
	1	2	3	4	5	6
Population increase	.810					
Religion factor	.754					
Conservation of virgin resources	.687					
Demand for reuse and recycled products	.647					
Energy consumption	.549	-.472				
Availability of technology	-.482					
Health and safety of the environment		.597				
Employment generation		.500				
Scarcity of raw materials			.715			
Level of education and awareness	.480	-.534	.546			
Government policy				.701		
Availability of market for reuse and recycled products				.461		
Greenhouse gas emission reduction					.565	
Cost of production						.884

Source: Researcher's fieldwork, (2018)

5.1.5 Rotated component matrix to reduce number of variable on each factor

The idea of rotation is to reduce the number of factors on which the variables under investigation have high loadings to makes the interpretation of the analysis easier. Looking at the table (5.6) we can see that energy consumption, Conservation of virgin resources and Religion factor are substantially loaded on Factor (Component) 1, While demand for reuse and recycled products and population increase are substantially loaded on Factor (component 2), while availability of technology, scarcity of raw materials, greenhouse gas emission reduction and level of education and awareness were substantially loaded on factor (component 3), while health and safety of the environment and

employment generation, are loaded on factor (component 4), while government policy and availability market for reuse product are substantially loaded on factor (component 5), while the cost of production is equally loaded on the sixth component.

Table 5.6: Rotated Component Matrix of the Variables used in the Study

variables	Component					
	1	2	3	4	5	6
Energy consumption	.768					
Conservation of virgin resources	.707					
Religion factor	.701					
Demand for reuse and recycled products		.894				
Population increase		.862				
Availability of technology		-	.511			
Scarcity of raw materials		.618				
Greenhouse gas emission reduction			.703			
Level of education and awareness			.564			
Health and safety of the environment			.526			
Employment generation				.863		
Government policy	-.542			.569		
Availability of market for reuse and recycled products					.759	
Cost of production					.632	.922

Source: Researcher's fieldwork, (2018)

5.1.6 Naming the factors that promote waste utilization in southwest Nigeria

Factors names were given by considering the variables featuring in each of the factor components. Selection of representative variable from each factor was based on variables having maximum factor loadings (absolute value) in the respective factors as well as their relative importance in the same group. In order to select the representative variable, a threshold of 0.7 was used as a cut-off point. This approach was adopted by Koh and Low (1988) and Anupam *et al.* (2011) however they ensure that the selected variables were able to reasonably explain the behavior of other variables in the same factor.

Table 5.7: Variables Selected Based on Absolute Factor Loading and Factor's Names

Components	Variables (selected)	Factors (name)
1	Energy consumption, resources conservation	sustainability factor
2	Demand for reuse and recycled products, population increase	Economic factor
3	Scarcity of raw materials,	Scarcity of raw materials
4	Health and safety of the environment, employment generation	Safety and poverty reduction
5	Government policy	Government green policy
6	Cost of production	Cost benefit

Sources: Researcher's fieldwork (2018)

Table 5.7 has identified six factors as the motive behind waste utilization in Southwest Nigeria as opined by the responses elicited from staff of recycling industries. The factors are; sustainability factors, economic, environmental education and awareness, safety and poverty reduction, government green policy and cost benefit associated with waste utilization. This was further strengthened by interview conducted in the study area.

However, Fred (2010) has pointed out in literature that environmental resource sustainability has remained the cornerstone for the adoption of reduce, reuse and recycle of waste in Nigeria. It is a platform where environmental resources most especially the virgin ones can be conserved for future generation of which this study has equally identified. Besides, Ibrahim (2010) and Agbaeze *et al.* (2014) also averred in literature that integrated waste management of 3Rs has promoted economic development by providing raw materials for industrial production. In the same vein, Olorunfemi and Raheem (2010) further buttressed that the adoption of 3Rs of waste management in Nigeria was

occasioned by poverty the view which was further supported by Sule and Aremu (2010) that many people now depend on waste as a means of livelihood both in developing and developed countries. In consonance with this view, it was further amplified in a study conducted by Kofoworola (2016) that waste in its economic domain reduce poverty by generating employment across its value chains.

To further reinforcing the support of the factors identified in this study, IPCC (2001) posited that the greening of waste sector has been one of the drivers for the adoption of Integrated Waste Management of 3Rs. Painstakingly, government has made greening of waste sector as one of the avenues through which resources can be tapped. This has come to fore by introducing regulations as a driving force that promote efficient and responsible waste management. It has promoted the emergence of different markets for reuse and recycled products in southwest Nigeria. In a similar manner, cost of managing waste during industrial production compare to virgin raw materials has been pointed out in literature by El-Haggar (2007) and Seadon (2006) as one of the factors that has made the introduction of 3Rs a necessity

5.2 Interviews on Factors Affecting Waste Utilization

This section of the study presents the results of the interview carried out on the field. As stated in chapter three, interview method was used mainly to validate and strengthen evidence and findings gathered from statistical analysis and questionnaire survey. Consequently, interview was carried out to cover most of the areas explored by the questionnaire.

Table 5.8: Outline of the People Interviewed in Southwest Nigeria

People	Responses Elicited
State Waste management Agencies	What are performance/policy indicators for the 3Rs, Are you using them? How effective are these policies?
Residents in Southwest	perception on municipal solid waste utilization of 3Rs
Employee of recycling company	Problems encounter in utilising waste, sources of waste and technology availability
Sellers of reuse and recycled products	Patronage of products made from waste / price variation
Academicians	Environmental sustainability and greenhouse gas reduction of virgin resource compare to waste

Source: Researcher's fieldwork (2018)

5.3 Interview of State Waste Management Agencies

The four state agencies selected in Southwest were visited in order to elicit responses on the policy indicator on 3Rs and how effective they are in the geopolitical zone. The agencies are; Osun Waste Management Agency (OWMA), Oyo Waste Management Agency (OYOWMA), Lagos Waste Management Agency (LAWMA) and Ogun State Environmental Protection Agency (OSEPA). Based on the result of the interview, all these state agencies have a comprehensive policy indicator for Reduce, Reuse and Recycling of wastes most especially the solid waste. To this end, it has necessitated all the state agencies to establish department of recycling in all their respective states. One of the focuses of their policy indicator is to track and review the progress of policy feedback and measure performance, market creation for 3R-related products, Green Procurement, technologies and services. These are in line with the factors earlier revealed by the factor analysis above.

5.4 Interview on how Resident Sell and Buy Waste in Southwest Nigeria

Having identified the economic potential in waste, the people in the Southwest have developed the idea of selling and buy any of their materials that have exhausted its lifespan. The major buyers of the waste in the region are the scavengers. They move from one place to another with their wheelbarrows sourcing for waste. They buy in small quantity and sell to the agents who finally transport and sell to the companies that recycled and processed them to usable materials. In some cases, the residents on their own also sell directly to the major agents who buy from the scavengers. Based on the interview, the average price for these wastes in southwest are as shown in the table 5.9

Table 5.9: Cost of Recyclable Materials in Southwest Nigeria

s/n	Materials/ (Kg)	Price (N)
1	Aluminium	100
2	Iron	30
3	Steel	100
4	Copper	500
5	Plastic	20

Source: Researcher's fieldwork, (2018)

However, people in southwest make use of recycled products and second-hand materials and the reasons they advanced was that they are more durable and cost less than those manufactured directly with virgin materials from the companies.

5.5 Resident's Perception on Benefits of Utilising Waste.

The people in the southwest acknowledged that waste utilization is beneficial in many ways. Some of the benefits associated with waste utilisation mentioned by the residents are: general cleanliness of the environment, provision of raw materials (Plate 6) for our industries, prevention of pollution and environmental contamination, conservation of environmental resources, employment generation and sources of income to the government and individual among others. According to Kofoworola (2016), every 150,000 tons of waste recycled creates nine jobs. This is substantial in a

country of 185.99 million with unemployment rate of 18.8% as at February 2018 (www.tradingeconomics.com/nigeria). This can be substantiated by various activities going on in most of the waste processing industries in Southwest Nigeria.



Plate 8: Waste Processing Factories in Lagos
Source: Researcher's fieldwork, (2018)

5.6 Interview of Divisional Crime Police Officer on Associated Crime on 3Rs of Waste Management in Southwest Nigeria.

Due to economic viability of waste in recent time, the associated crime has also soared tremendously. The major crimes revealed include trans-boundary smuggling of used materials from other countries such as clothing materials, metals, abandoned vehicles and e-waste among others. The scale of these illegal transboundary shipments of wastes is growing; estimates from 2010 indicate that 40 percent of electronic wastes from Europe alone are being exported to Asia and Africa (Ysdenova and Bengtsson, 2011). According to Jinglei *et al.* (2010) in Dejo (2012) in Nigeria, the estimates of the number of computer imports found to be non-functioning range from 75 to 95 percent of each shipment. On the parts of the scavengers who source for waste from street and various dumpsites in the geographical zone, many of them have integrated theft with the profession under the pretence of looking

for materials that are no longer useful to the owner (waste). They mostly engage in this nefarious act when owners are not around most especially at the working hours of the day. To this end, most of the major dumpsites in southwest are under key and lock in the night while in the day time; they are under the supervision of dumpsite managers. Besides, it has necessitated the formation of various scavenger associations and waste agent associations. This has come to fore as a means of synergizing between the general public, law enforcement agents and waste users in order to stem the crimes. Consequently, most of the recycling companies and other allied waste users only buy waste from registered waste agents in Southwest Nigeria in order to avoid unnecessary litigations.

5.7: Interview of Company's staff that Operates 3Rs of Waste Management in Southwest Nigeria

In order to examine the operational activities of the companies and other allied industries that make use of waste in southwest Nigeria, the researcher deem it fit to interview their employees. The major areas explored include; sources of their waste and how they transport it into their companies for production, the major problems they encounter during this process, the company technological capability to accommodate the waste, the profitability of utilising waste for production at the expense of virgin resources, the major problems they encounter in using waste as raw materials and how they incorporate Extended Product Responsibility (EPR) into their production plans.

5.8 Sources and How Companies Get Waste for utilization

The major sources of waste for companies and other allied industries that utilise waste in southwest are from scrap agents. These agents are spatially located in different parts of the country. The agents have to register with the company as a supplier while at the same time shoulder the responsibility of transporting the waste from their buying centres to the various companies' production sites. The major problems commonly encounter in getting these wastes to the company as opined are; sorting and loading, falling of vehicles and pricing among others. However, they revealed that they have constant supply of raw materials (waste) at any time for production.

5.9 Technological Capability of Companies Utilising Waste in Southwest Nigeria

Most of the companies visited in Southwest Nigeria to certain extent are capable of utilizing waste supplied by their agents base on their responses. In fact, it was amazing when they revealed that the available machines and technology they have can accommodate up to 250 tonnes of iron metal, 13 tons of Aluminium and 6 tons of copper waste on average per day. Besides, most of the wastes considered in this research have their ingot production machines that can run shift twice daily. This is a clear indication that waste processing and utilization has a promising future in the southwest region.

5.10 Extended Product Responsibility (EPR) and Waste Management of 3Rs in Southwest Nigeria

Actually, Extended Product Responsibility has not been much more pronounced in Southwest Nigeria by many manufacturing companies. This is one of the major factors that have accelerated the untimely swell-up of many dumpsites in the region. Most of the respondents agreed that their companies do not have any programme put in place to address Extended Product Responsibility. They are of the opinion that any of their materials that come back to the company were equally treated as waste. The concept of buy-back has not been laid emphasis on as a means of addressing waste problems by most of the recycling industries in the study area as amenable by NESREA and the state agencies.

5.11 Variation in Price of Goods Produced with Virgin Materials and Waste

In order to verify if there is any significant difference in price of goods produced from waste and that of virgin materials, the responses from various companies show that the price were the same in all respect. In fact, their submissions revealed that the qualities of the products from both sources are the same. Therefore, there is no room for buyers of these products to negotiate for price on the basis of raw materials difference after production. However, in the area of reuse, they gave a contrary opinion. Residents in Southwest Nigeria who I was opportune to interviewed revealed that the price of already used items were not the same with those that were produced newly. Most especially, clothing materials, furniture, construction and demolition materials among others. As such, variation in price has created a large market for reuse items in the study area.

5.12 Summary of Interview on Factors Responsible for Waste Utilisation in the Study Area

Having interacted with various companies and individuals in the study area, evidence through the interview has clearly shown that many factors have occasioned waste utilization in Southwest Nigeria. In the first instance, education and awareness have provided the platform in which other factors rest. Government, non-governmental organisation and individual are now aware that nothing is waste. This was supported from literature by Ajibade (2007) that indigenously nothing is considered wasteful in the region. This have been amplified by the government sustainability drive couple with level of poverty and unemployment in the region, this among other factors have stimulated government to have policy framework on 3Rs of waste management both at state and federal levels in recent time. Consequently, it has led to springing up of many recycling companies in the study area and Nigeria as a whole. Besides, the production cost in utilising waste compare to virgin resources is relatively low, while availability of market for reuse and recycled products have equally created a friendly atmosphere for optimum utilization of available waste in the region. This was further strengthened by the result of the analysis on factors that are stimulating the use of waste in southwest Nigeria in which cost of production has been identified as one of the dominant factors. More importantly is the energy consumption in relation to recycling of waste.

CHAPTER SIX

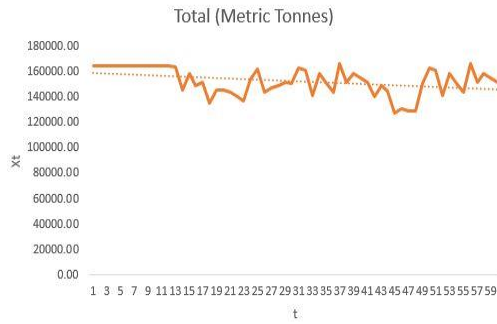
TRENDS IN THE PRACTICE OF WASTE UTILIZATION OF 3RS

6.1 Introduction

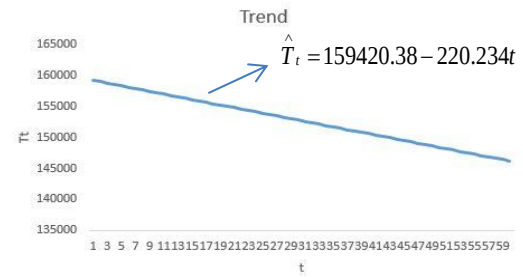
Over the years, wastes in southwest region have been subjected to different treatment options such as the use of incinerator, landfill, composting among others. However, adoption of a sustainable integrated waste management strategy of 3Rs which is a new phase of waste management universally acclaimed to holistically address waste problems have been evaluated in this chapter. This chapter of the study seeks to explore how these practices have advanced in the study area overtime. Besides, it further examined the extent of adoption of this waste management techniques (3Rs) in the region.

6.2 Estimation of Waste Generation and Utilization Trend

In order to examine the pattern in waste generation and utilization in the study area, the trend was examined for each material under investigation. The visual inspection of the time plot was first carried out in order to detect the trend and seasonality in the observed data. The inspection of the plot below shows that there is a little systematic downward movement about the mean which indicates that the series are not stationary as shown in figure 6.1a. Consequently, the data was differenced in order to ensure stationary. The pattern shows that there is fluctuation in the quantity of waste generated which equally affect the quantity utilized for the five materials in the study area over the period under investigation. Besides, the trend shows that there was a downward movement signifying a reduction in the quantity of waste generated during this period as shown in figure 6.1b below. This reduction might be occasioned by the intensified recycling and reduction strategy amplified by factors such as poverty reduction, cost-benefit, level of education and awareness among others.



a.



b

Figure 6.1: Time Plot and Trend on Total Waste Generated of Quarterly Series from 2013-2017
Source: Researcher's fieldwork, 2018

Similarly, the trend in utilization of the five materials under investigation was carried out in order to make comparison (figure 6.2a) on how 3Rs of waste management has impacted on the quantity of waste generated overtime in the study area. The trend signifies a downward movement which implies that there is a reduction in the quantity of waste generated as a result of quantity utilized in relation to 3Rs overtime. The trend equation in figure 6.2b for all the five materials considered show a negative coefficient. i.e. as the year increases there is a decrease in quantity of waste generated by 50.654 for plastic, 1.9118 for Iron, 0.05353 for Copper, 0.1147 for Aluminium and 0.09994 for Steel. This may be considered beneficial because if the trend continues, there is tendency for the recycling industry in Nigeria to achieve the sustainable waste management envisage globally in term of resources conservation which will eventually lead to zero waste status in relation to the wastes considered in this study.

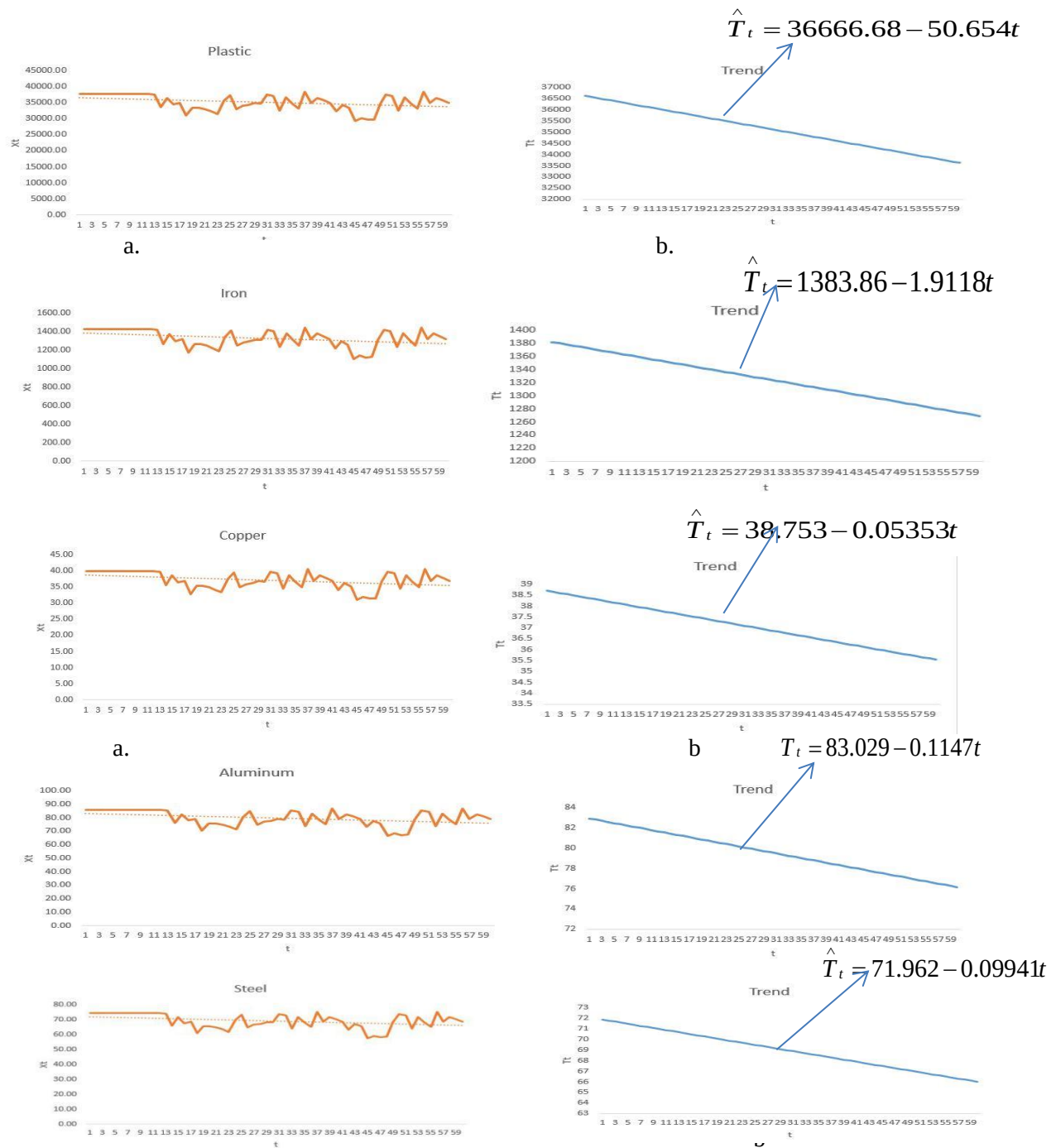


Figure 6.2: Time Plot and Trend of Quarterly Series of Materials Utilized from 2013-2017
Source: Researcher's fieldwork, (2018)

CHAPTER SEVEN

7.0 USE OF VIRGIN RESOURCES AND WASTES ON GHGs EMISSION REDUCTION

This chapter is mainly concerned with the identification of variation on greenhouse gases emission reduction between virgin resources and waste in the study area. Basically, five wastes were considered which are: Iron, Aluminium, steel, copper and plastic. Table 7.1 show the emission factors for the virgin resources and the five waste materials.

Table 7.1: Greenhouse Gas Emission Factors for Material Management Options (MTCO₂E/Short Ton)

Materials	Virgin Manufacturing	Reduction(reuse) Manufacturing	Recycling Manufacturing
Mixed Iron	-6.24	-3.70	-4.34
Aluminium (can)	-11.09	-4.91	-9.11
Steel can	-3.67	-3.06	-1.81
Copper wire	-7.08	-7.01	-4.71
Plastic PET	-2.2	-2.	-1.12

Source: Adapted from USEPA (2016)

The emission factors in table 7.1 was used as a basis for estimating the quantity of greenhouse gas saved by virgin and the five wastes in the study. The quantity in tons of the reused and recycled waste is shown in table 7.2

Table 7.2: Quantity of Waste reused and Recycled between (2012-2017) by Recycling Companies

Quantity /tons					
Years	Fe	Al	Plastic	Steel	Copper
2012	117,000	6,177.60	52,022.50	4,821	5559.84
2013	132,600	7,001.28	58,225.50	5,463.80	6301.152
2014	148,000	7,824.96	57,428.50	6,106.60	7042.464
2015	140,000	7,413.12	49,827	5,785.20	6671.808
2016	118,000	6,177.60	47,022.50	5,821	5559.84
2017	124,800	6,589.44	56,234	5,142.40	5930.496
Total	680400	41184	320760	33140	37065.6

Source: Recycling Companies sampled, (2018)

Table 7.3 show the greenhouse gas (CO₂) emission saved by virgin and reused waste. The mean (x) greenhouse gas emission saved by Virgin resources across the five selected materials is 1,449,985.742/short tons while reduced/reused waste has 882,628.03/short tons; and recycled waste has 2,177,490.56/short tons of greenhouse gas (CO₂) conservation.

Table 7.3: Greenhouse Gas Emission of Virgin Resource, waste Reduced/Reused and Recycled

Greenhouse gas (CO ₂) emission saved				
Waste Type		Virgin resource	Source Reduction/reuse	Waste Recycle
	Iron	4,134,106	2,883,780	3,382,596
	Aluminium	456,730.55	202,213.83	7,063,004.73
	Steel	1,986,342.19	98,348.39	58,177.4
	Copper	289,373.88	286,512.73	192,507.12
	Plastic	383,376	942,285.20	191,167.55
	Total	7,249,928.62	4,413,140.15	10,887,452.8
Mean (X)		1,449,985.742	882,628.03	2,177,490.56

Source: Researcher, (2017)

In order to verify if there is any significant difference in GHG emission saving reduction for the five materials considered base on management options of 3Rs, a two-way ANOVA test was carried out. The major areas considered were mainly between subject's effects which examined if there is any significant relationship between management options and the materials considered in the study and greenhouse gases while at the same time examined the Post -Hoc test which examined the variation in GHG among the five materials.

7.1 Test Between Waste, Management Options and Greenhouse Gas

The test between subject's effects examined if there is any significant difference between management options and the materials considered in the study and greenhouse gas. This variation is calculated as the ratio of mean square deviation, otherwise known as the (F) statistic. The extent or how

significant (insignificant) the calculated variation is, is reflected by the value of the (P) statistic; where P value (column 6) is less than 0.05, variation in the mean between factors is said to be statistically significant (i.e. where $P \leq 0.05$ the level of variation is said to be statistically significant) the result (table 4.9) show that there is significant variation in greenhouse gas emission between materials type, at 0.05 level of significance with ($P=0.019$). However, the result further revealed that there is no significant difference in greenhouse gas emission based on management option of reduce, reuse and recycled since $0.083 > p=0.05$, while the result also shows that there is no significant difference in greenhouse gas emission between interaction effect of material and management techniques (table 4.9) since $0.107 > 0.05$.

Table 7.4 : Two-Way ANOVA Test between Material and Management Types

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	999569217188.331 ^a	13	76889939783.718	537.090	.034
Intercept	427247257702.171	1	427247257702.171	2984.398	.012
MAT	925198188154.445	4	231299547038.611	1615.668	.019
MGT	20658571399.287	2	10329285699.643	72.152	.083
MAT * MGT	51479619397.523	7	7354231342.503	51.371	.107
Error	143160289.710	1	143160289.710		
Total	1431330172203.194	15			
Corrected Total	999712377478.041	14			

Source: Researcher's fieldwork, (2018) R Squared = 0.89 (Adjusted R Squared = .788)

MAT= materials , MGT= Management Options, MAT* MAGT= Interaction effect

7.2 Post-Hoc Test for Significance of Individual Variables

In order to examine the significance relationship of the variables on greenhouse gas emission, a Post-Hoc test was carried out for multiple comparison as shown in table 7.4. though the test between subject's effects (table 7.4) helped to determine the statistical significance of variance between the factors, it does not indicate the actual point of variation, it was therefore necessary to carry out a post-hoc test. The post hoc-test result in table 7.2 shows the difference in predicted means for each pair of

factor levels. Column 2 and 3 of the table display the pair of factor being tested. Where P-value (column 6) is less than 0.05, variation in the means between factors is said to be statistically significant. Thus the variation between each material and others on greenhouse gas emission variation can be identified. The result of the analysis as shown in table 7.2 revealed that there is significant difference in greenhouse gas emission when compare Iron with all the materials considered in this study in terms of, reduce/reuse and recycling in the study area. Since the value of aluminium, copper, steel and plastic (column 5) are less than p-value of 0.05 at 95% level of confidence. This might be as a result of large quantity of iron being recycled in the region compare to other waste.

However, there is no significance difference in greenhouse gas emission between Aluminium and Copper, steel and Plastic, as shown in table 7.4 since their value is greater than p-value of 0.05 at 95% level of confidence. Evidence from literature has shown that Copper exhibits a significance difference in energy use between virgin and recycled manufacturing as such higher GHG emission in the production process (EPA,2015). The result obtained in this study might be due to quantity of aluminium utilized which are comparatively similar to copper.

In the same vein, the result shows that there is no significant difference in greenhouse gas emission between Steel and all other materials recycled in the study area except iron. This may be attributed to low greenhouse gas emission factor of Steel and the quantity recycled in the study area which is small compare to other materials considered in this study. While there is no significance difference between plastic and all other materials in the study since the computed values of all the wastes are less than 0.05 at 95% level of confidence.

Table 7.5: Post -Hoc Tests for multiple Comparisons of the Five Wastes

(I) material type	(J) material type	Mean Difference (I-J)	Std. Error	Sig.	P value
Iron	Aluminum	604352.1633*	9769.34968	.021	0.05
	Copper	620296.3833*	9769.34968	.021	
	Steel	649931.4667*	9769.34968	.020	
	Plastic	609267.2933*	9769.34968	.021	
Aluminum	Iron	-604352.1633*	9769.34968	.021	
	Copper	15944.2200	9769.34968	.655	
	Steel	45579.3033	9769.34968	.273	
	Plastic	4915.1300	9769.34968	.974	
Copper	Iron	-620296.3833*	9769.34968	.021	
	Aluminum	-15944.2200	9769.34968	.655	
	Steel	29635.0833	9769.34968	.405	
	Plastic	-11029.0900	9769.34968	.802	
Steel	Iron	-649931.4667*	9769.34968	.020	
	Aluminum	-45579.3033	9769.34968	.273	
	Copper	-29635.0833	9769.34968	.405	
	Plastic	-40664.1733	9769.34968	.304	
Plastic	Iron	-609267.2933*	9769.34968	.021	
	Aluminum	-4915.1300	9769.34968	.974	
	Copper	11029.0900	9769.34968	.802	
	Steel	40664.1733	9769.34968	.304	

Source: Researcher's fieldwork, (2018)

The figure 7.1 show the estimated marginal means of the GHG, the lines on the graph can be used to measure the nature of relationship among the materials. Base on the graph, the three lines on the graph are not parallel to each other for iron, it is a clear indication that there is significant difference in greenhouse gas emission of iron in terms of virgin, reduce/reuse and recycled components of waste. However, there is no significance difference in management options of virgin, reduce/reuse and recycled in terms of aluminium, copper, steel and plastic as indicated by the interaction effect of the lines on figure 7.1 which the mixed-effect and Post-Hoc Test in table 7.5 has clearly shown.

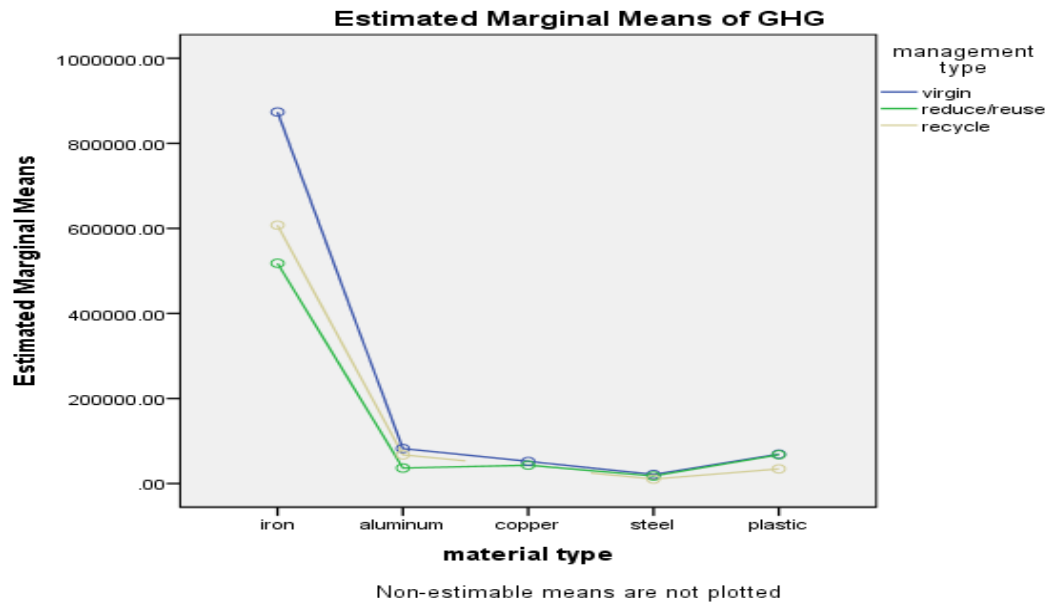


Figure 7.1: Estimated Marginal Greenhouse Gas Based on Materials and Management Options of 3Rs
Source: Researcher's fieldwork, (2018)

CHAPTER EIGHT

8.0 GREENHOUSE GAS (CARBON) EMISSION SAVING REDUCTION THROUGH 3RS

In order to estimate the amount of greenhouse gases emission reduction in waste utilisation using 3Rs of waste management in Southwestern Nigeria, Waste Reduction Model (WARM) was used. The model applied the Life Cycle Assessment (LCA) methodology to estimating the GHG emission avoided through reducing, reusing and recycling of waste. It estimates the amount of Greenhouse Gas (GHG) emission reduction beginning at the waste generation point. The Waste Reduction Model Greenhouse emission factors (Table 8.2) was used to compute the emissions associated with materials types in the following four materials management options: virgin input, source reduction/reuse and recycling.

In the calculation of avoided GHGs emission, the researcher takes into consideration what would have been generated (GHG) by raw material production mainly through virgin input. In this case, two types of data were used: specific emission factors and quantity of material used/tons during industrial production for each types of material. Specific emission factors for each material are available through EPA (2016) Waste Reduction Model (Table 8.2) which takes into consideration emissions produced by energy, non-energy process as well as transportation. The collection and transfer of MSW to treatment facilities have an impact on the GHG emissions results due to the potential difference in transportation distances (Lino *et al.*, 2013). Information on transport distances to treatment facilities at the macro level are not available for Nigeria, and are extremely difficult to estimate (Kofoworola, 2016). Therefore, they were assumed to be equivalent to the one in WARM of EPA (2016) as used in (Table 8.2).

8.1 Estimation of avoided GHG emission procedure

The quantity of waste recycled was considered as the basis for the estimation of the greenhouse gas emission saving for the materials management options for a period of six years. The emission factors were multiplied by the equivalent quantity of recycled waste, reduced/reuse and virgin materials and

the difference was taken to obtain the avoided greenhouse gas emission as shown in equation 8.1 below

$$EMS = QR \times VEF - \{QR \times REF + QR \times RCEF\} \quad (8.1)$$

EMS=Emission Saving

QR=Quantity of Waste Recycled

VEF=Virgin Emission Factor

REF=Reduction Emission Factor

RCEF=Recycle Emission Factor

Table 8.1: Quantity of Waste Recycled between (2012-2017) by Recycling Companies

Quantity /tons					
Years	Fe	Al	Plastic	Steel	Copper
2012	117,000	6,177.60	52,022.50	4,821	5559.84
2013	132,600	7,001.28	58,225.50	5,463.80	6301.152
2014	148,000	7,824.96	57,428.50	6,106.60	7042.464
2015	140,000	7,413.12	49,827	5,785.20	6671.808
2016	118,000	6,177.60	47,022.50	5,821	5559.84
2017	124,800	6,589.44	56,234	5,142.40	5930.496
Total	680400	41184	320760	33140	37065.6

Source: Recycling Companies sampled, (2018)

Table 8.2: Emission Factors for Material Management Option (MTCO₂E/Short Ton)

Materials	Virgin Manufacturing	Reduction(reuse) Manufacturing	Recycling Manufacturing
Mixed Iron	-6.24	-3.70	-4.34
Aluminium (can)	-11.09	-4.91	-9.11
Steel can	-3.67	-3.06	-1.81
Copper wire	-7.08	-7.01	-4.71
Plastic PET	-2.2	-2.	-1.12

Source: Adapted from USEPA (2016)

Table 8.3: Estimated GHG Emission Reduction for Iron between (2012-2017)

Year	Virgin (A)	Reduced/reuse(B)	Recycled (C)	Emission saving =A-(B+C)
2012	730,080	432,900	507,780	-210,600
2013	827,424	490,620	575,484	-238,680
2014	923,520	547,600	642,320	-266,400
2015	873,600	518,000	607,600	-252,000
2016	730,080	432,900	507,780	-210,600
2017	778,752	461,760	541,632	-224,640
Total				-1402920

Source: Researcher's fieldwork, (2018)

**Figure 8.1:** GHG Emission Saved by Recycling Iron in Southwest Nigeria (2012-2017)

Source: Researcher's fieldwork, (2018)

The figure 8.1 showed the materials management option for a period of six years. The chart revealed that the higher the reduce/reuse and recycling input, the larger the GHG emission that was saved. The total average estimated GHG emission saved on iron in southwest Nigeria over the six years was -1402920/ short tons. The emission of greenhouse gas due to iron was highest in the year 2014 out of the six years considered.

Table 8.4: Estimated GHG Emission Reduction for Aluminium between (2012-2017)

Year	Virgin (A)	Reduced/reuse(B)	Recycled (C)	Emission saved=A-(B+C)
2012	68,509.58	30,332.02	56,277.94	-18,100.38
2013	77,644.19	34,376.28	63,781.66	-20,513.75
2014	86,778.81	38,420.55	71,285.39	-22,927.13
2015	82,211.50	36,398.42	67,533.52	-21,720.44
2016	68,509.58	30,332.02	58,277.94	-18,100.38
2017	73,076.89	32,354.54	60,029.80	-19,307.45
Total				-120669.53

Source: Researcher's fieldwork, (2018)

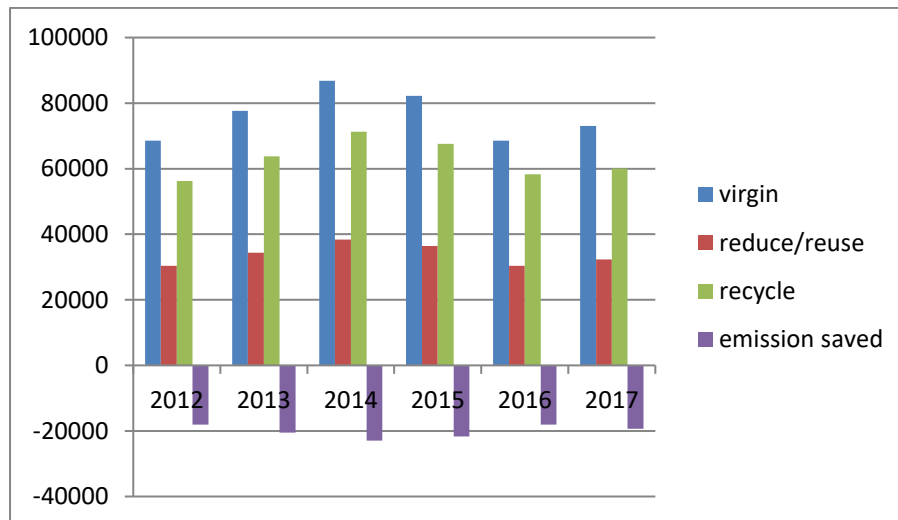


Figure 8.2: GHG Emission Saved by Recycling Aluminum in Southwest Nigeria (2012-2017)

Source: Researcher's fieldwork, (2018)

The figure 8.2 showed the materials management option for a period of six years. The chart revealed that the higher the reduce/reuse and recycling input the larger the GHG emission that was saved. The total average estimated GHG emission saved due to Aluminum in southwest Nigeria over the six years was -120669.53/ short ton. The emission of greenhouse gas due to Aluminum was highest in the year 2014 and lowest in the year 2012 out of the six years considered

Table 8.5: Estimated GHG Emission Reduction for Steel between (2012-2017)

Year	Virgin (A)	Reduced/reuse (B)	Recycled (C)	Emission saving=A-(B+C)
2012	17,693.07	14,752.26	8,728.01	-5,787.20
2013	20,052.15	16,719.23	9,889.48	-6,556.56
2014	22,411.22	18,686.19	11,052.95	-7,327.92
2015	21,231.68	17,702.71	10,471.21	-6,942.24
2016	17,693.07	14,752.26	8,728.01	-5,787.20
2017	18,872.61	15,735.74	9,307.74	-6,170.87
Total				-38571

Source: Researcher's fieldwork, (2018)

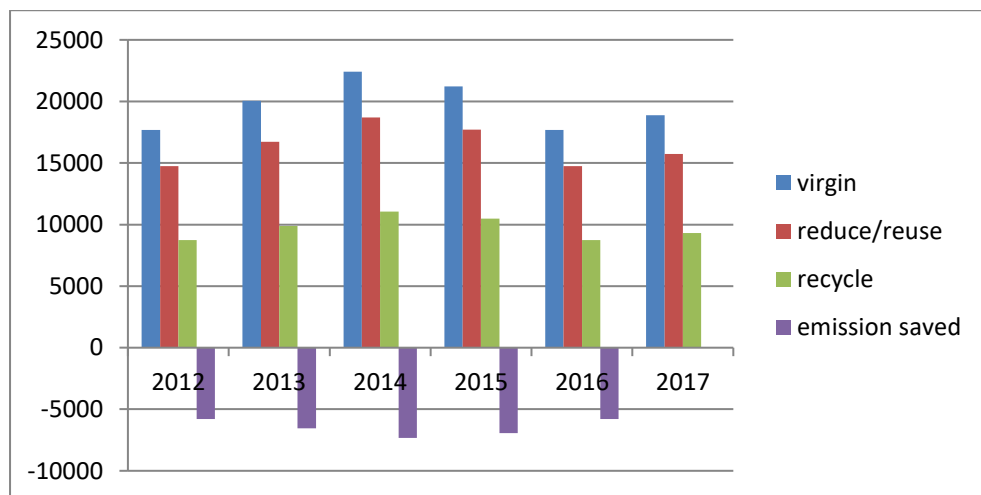


Figure 8.3: GHG Emission Saved by Recycling Steel for Six Years in Southwest Nigeria

Source: Researcher's fieldwork, (2018)

The Figure 8.3 showed the materials management option for a period of six years. The chart revealed that the higher the reduce/reuse and recycling input the larger the GHG emission that was saved. The total average estimated GHG emission saved due to Steel in Southwest Nigeria over the six years was

-38571/ short tons. The emission of greenhouse gas due to Steel was highest in the year 2014 out of the six years considered

Table 8.6: Estimated GHG Emission Reduction for Copper between (2012-2017)

Year	Virgin (A)	Reduced/reuse (B)	Recycled (C)	Emission saving=A-(B+C)
2012	43,406.06	42,976.91	28,876.07	-28,446.92
2013	49,193.54	48,707.16	32,726.21	-32,239.83
2014	54,981.14	54,437.42	36,576.35	-36,032.63
2015	52,087.28	51,572.29	34,651.28	-34,136.29
2016	43,406.06	42,976.91	28,876.07	-28,446.92
2017	46,299.80	45,842.04	30,801.14	-30,343.38
Total				-189645.97

Source: Researcher's fieldwork, (2018)



Figure 8.4: GHG Emission Saved by Recycling Copper in Southwest Nigeria (2012-2017)

Source: Researcher's fieldwork, (2018)

The Figure 8.4 shows the materials management option for a period of six years. The chart revealed that the higher the reduce/reuse and recycling input the larger the GHG emission that was saved. The total average estimated GHG emission saved due to Copper in southwest Nigeria over the six years was -189645.97/ short tons. The emission of greenhouse gas due to copper was highest in the year 2014 out of the six years considered

Table 8.7: Estimated GHG Emission Reduction for Plastic between (2012-2017)

Year	Virgin (A)	Reduced/reuse (B)	Recycled (C)	Emission saving A-(B+C)
2012	56050.4	55049.5	28025.2	-27024.3
2013	63225.12	62096.1	31612.56	-30483.54
2014	72639.84	71342.7	36319.92	-35022.78
2015	69052.48	67819.4	34526.24	-33293.16
2016	58290.4	57249.5	28624.75	-27583.85
2017	64117.76	62972.8	32058.88	-30913.92
Total				-184321.55

Source: Researcher's fieldwork, (2018)

**Figure 8.5:** GHG Emission Saved by Recycling Plastic in Southwest Nigeria (2012-2017)

Source: Researcher's fieldwork, (2018)

The Figure 8.5 show the materials management option for a period of six years. The chart revealed that the higher the reduce/reuse and recycling input the larger the GHG emission that was saved. The total average estimated GHG emission saved as a result of 3Rs on plastic in southwest Nigeria over the six years was -184321.55/ short tons. The emission of greenhouse gas due to plastic was highest in the year 2014 out of the six years considered

Table 8.8: Materials Emission Saving Reduction of GHG in Southwest Nigeria (2012-2017)

Materials	CO ₂ emission reduction saved	CO ₂ (%)
Iron	-1402920	72.5
Aluminum	-120669.52	6.2
Steel	-38571	2.0
Copper	-189645.97	9.8
Plastic	-184321.55	9.5
Total	-1936128.04	100

Source: Researcher's fieldwork, (2018)

The table 8.9 shows the percentage of greenhouse gas emissions saving due to different materials considered in this study. The greenhouse gas emission saved due to recycling of iron is large compare to other scrap metals and plastic, it has the largest percentage of 72.5%. However, the quantity of iron material recycled was equally large over this period. Evidence from data generated show that most of the companies recycle 250 tons of iron per day. The total metal scrap in municipal waste was 1.8% in Southwest Nigeria (Olanrewaju and Ilemobide, 2009). But the current characterization study showed that the quantity of scrap metal in municipal waste has reduced to 1% due to increase in recycling rate in the study area. A study by Ohimain (2013) revealed that 83 – 86% of scrap metals recovered from MSW in Bayelsa state in Nigeria consists of iron and steel, this result is in line with the quantity of metal recycled and its associated greenhouse gas emission in Southwest Nigeria base on this study.

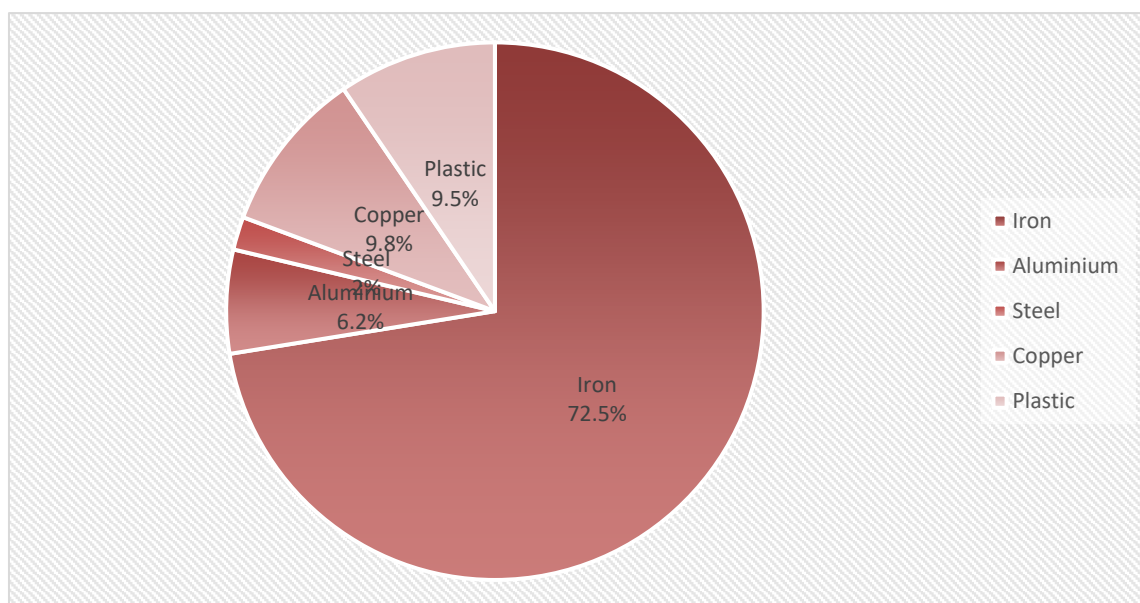


Figure 8.6: Percentage Composition of Greenhouse Gas Emission Saved due to 3Rs in Southwest Nigeria (2012-2017)

Source: Researcher's fieldwork, (2018)

8.2 Interview on Greenhouse Gas Emission Due to 3Rs of Waste Management

Interview was conducted in order to correlate the information obtained from questionnaire survey and people perception on greenhouse gas emission saving in the study area. The people interviewed are shown in table 8.2.1 below and the responses elicited from them.

Table 8.2.1: People Interviewed and the Responses Elicited

People interviewed	Responses elicited
Residents in southwest Nigeria	Awareness and perception of the relationship between 3Rs and GHGs
Recycling Company staff (NESERA)	Awareness of the relationship between 3Rs and GHs emission Policy indicator on GHGs, enforcement methods and its reduction strategies
Academicians	Greenhouse gas awareness

Source: Researcher's fieldwork, (2018)

8.2.1: Perception of Residents on 3Rs and Greenhouse Gas Emission

The residents were interviewed in order to know their perceptions on how waste utilization has contributed to greenhouse gasses emission reduction saving in Southwest Nigeria. Despite the people's level of awareness on benefit associated with 3Rs of waste management, they are not yet in tune with the relationship between 3Rs and greenhouse gasses. To my surprise, majority of the people interviewed were not aware that waste deposited at landfills on decay generate some of the greenhouse gases let alone of having impact on climate change. However, the enlightened ones who I was lucky to interview have an in-depth knowledge of waste utilisation of 3Rs and how it can reduce greenhouse gas emission

8.2.2: Enforcement Framework on GHGs in Southwest Nigeria

Greenhouse gases reduction enforcement in Nigeria takes its cue from other multilateral agreement across the Globe. The NESREA is the agency responsible for regulation of different gases into the atmosphere which include the greenhouse gases such as methane, CO₂, NO_x among others. The Federal Republic of Nigeria official gazette on national environmental (Ozon Layer Protection) regulation No 64/Vol.96/ S.I.32/2009 is the framework that regulate the emission of gasses into the atmosphere. However, the agency opined that they periodically carry out campaign, sensitization and awareness, monitoring, compliance and enforcement in order to ensure greenhouse gases emission reduction is achieved. However, Afon (2007) buttressed this in literature that lack of legal enforcement has been one of the major drawbacks in effective management of waste and its associated problems in Nigeria.

CHAPTER NINE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

9.1 Summary of Findings

Today, people no longer see waste as waste but resource that is not properly managed that is thrown away. However, due to increase in level of awareness, scarcity of raw materials and available technology, people's perception has begun to change and this has led to springing up of different waste minimization, reuse and recycling companies in Southwest Nigeria. At global level, the sustainability drive for resource usage has necessitated different conventions in order to sensitize people to how they can harness anything vendible in waste. This study therefore examined the extent to which wastes have been utilized in southwest Nigeria and its implications on greenhouse gas emission reduction. The study precisely laid emphasis on five major wastes that are commonly utilized in the study area, which are; Iron, Aluminum, Copper, Steel and Plastic.

The study was carried out in order to identify the major factors responsible for wastes utilization, the extent of their usage (index), and the trends in the usage for a period of six years, the variation in the emission status of the material and the quantity of greenhouse gas reduction emission saving for this period. In order to achieve this, a reconnaissance survey was carried out in order to identify the available recycling companies and their locations couple with the materials they recycled in the study area. In this regard, thirty companies were identified. Since all the identified companies cannot be used for this study, a multistage sampling technique was employed in which ten companies were selected in all. This consequently led to selection of ten companies to x-ray the usage of the waste under consideration and the Greenhouse gas associated with them using purposive sampling techniques.

Data were sourced from different companies sampled for the study and state waste management agencies. Interview was equally conducted in order to strengthen the result of the quantitative analysis. The people interviewed include; ordinary resident in the study area, law enforcement agents, employee of recycling companies, sellers of reuse and materials made from waste and academicians.

The result of the analysis revealed that:

- i. The utilization index of waste base on the management option of 3Rs varies between 10-29% from the base year 2012 for the six years under investigation
- ii. The result of the model shows that there is a linear relationship between the waste generated and its usage in Southwest Nigeria. The parameter of the regression model revealed that at an average there is reduction in the quantitate of waste generated by 66.1%,84.4%, 46.5% and 150% for Aluminum, steel, copper and iron respectively while plastics increase by 219.6%. Besides a unit ton in the quantity of waste generated led to 1.16% change in index of Aluminum reduce/reuse and 1.15% change in index of Aluminum recycling, 1.516% change in index of steel reduced/reused and 4.407% change in index of steel recycled, 1.167% change index of copper reduced/reused and 0.949% change in index of copper recycled,1.053% change in index of plastic reduced/reused and 1.858% change in index recycled while that of iron is 2.046% reduced/reused and 2.046% recycled.
- iii. Six factors were responsible for utilizing waste in Southwest Nigeria. The identified factors are; sustainability, economic, environmental education and awareness, safety and poverty reduction, government green policy and cost benefit associated with waste usage and they all accounted for 70.86% of the total variation in waste usage in Southwest Nigeria
- iv. The study revealed that as the year increases (2012-2017) there is a decrease in quantity of waste generated by 50.654 for plastic, 1.912 for Iron, 0.054 for Copper, 0.115 for Aluminium and 0.099tons for steel over the study period (2012-2017)
- v. Aside, the result of the analysis further shows that there is a significant difference in greenhouse gas emission saved between waste and virgin resource at 5% level of significance based on materials ($p=0.019<0.05$) type and not on management techniques ($p=0.08>0.05$) of 3Rs
- vi. The study revealed that the greenhouse gas emission saving over the period under investigation was large in the year 2014 out of the six years considered

- vii. There is significance difference in greenhouse gas emission with Iron has the largest greenhouse gas emission (72%) saving in the study area and steel the least (2%) out of all the waste under investigation for the period.
- viii. The result of the interview shows that people in the study area are in turn with different waste available couple with the economic potentials inherent in the identified waste.
- ix. The major regulatory agencies identified are the state waste management agencies and NESREA and the success of regulation was as a result of the synergy between the two regulatory agencies in the study area. Besides,
- x. The interview conducted has equally revealed that waste utilization has associated crimes due to its economic viability, such crime includes; transboundary movement of waste, stealing of scrap metals among others.

9.2 Implications of the Study

9.2.1 Economic implication

From empirical data, the research results show that reduce, reuse and recycling of waste most especially the municipal solid wastes considered in this study have economic implications. The most significant and conspicuous among these is less cost of production, that is, reduction in the cost of processing and treatment of Iron, Aluminum, copper, steel and plastic is low in bringing their products back into economic value chain compared to use of virgin raw materials. This in essence translate to increase in the profit margin of investors and entrepreneurs thereby attract them to invest more into green production using reduction, reuse and recycling of waste instead of virgin metals and plastic. Besides, 3Rs of Iron, Aluminum, copper, steel and plastic reduce unemployment rate, poverty and increase the Gross Domestic Product of southwest Nigeria and the country at large.

9.2.2 Environmental and health implication

The implication of 3Rs of waste management in relation to environment cannot be overemphasized, increase in reduction, reuse and recycling of Iron, Aluminum, copper, steel and plastic

as shown by utilization index over the years indicates that less waste of Iron, Aluminum, copper, steel and plastic will be generated in the study area thereby reduce the quantity of these materials that are going into the landfills most especially in the state capitals where land for economic activities is getting diminished on daily basis. Consequently, it will create more land for other economic activities in the region. In the same vein, it will set pace for zero waste status in future for Iron, Aluminum, copper, steel and plastic in the southwest region provided the trends in waste utilization index can be maintained and sustained. It will equally reduce pollution associated with the metals and plastic thereby improve health status of the residents, environmental contamination, flooding among others. Besides, it will reduce the quantity of greenhouse gases emission which by extension translates to global climate change mitigation.

9.2.3 Resource sustainability implication

The study implication on resources sustainability further strengthen the need by the government in southwest Nigeria to encourage Extended Product Responsibility, industrial symbiosis and industrial ecology since they all help in conversion of waste generated by one industry as a feedstock to another for industrial production thereby limiting the virgin resource usage particularly iron, aluminum, steel, copper and plastic that has high economic potentials thereby creating room for future generation to have access to them.

9.3 Conclusion and Recommendations

9.3.1 Conclusion

This study is on assessment of waste utilization and its impact on greenhouse gas emission reduction in southwest Nigeria. The researcher hereby concluded based on this study that; utilization of waste through integrated waste management of 3Rs has contributed to waste and greenhouse gas emission reduction in southwest Nigeria. The extent of adoption of 3Rs is largely driven by economic benefit rather than resource sustainability and environmental protection. In the study area, iron has the largest contributing to the reduction of greenhouse gas emission reduction while steel has the least due

to large quantity of iron being recycled compared to other waste in the study area. Besides, the index of waste utilization in southwest Nigeria has relatively increase over the years under investigation. This can be attributed to changes in the level of awareness, institutional policy framework and resource scarcity. Finally, government conscious efforts through sensitization and awareness couple with enforcement using regulatory agencies such as NESREA and SEPAs has promoted integrated waste management of 3Rs in southwest Nigeria.

9.3.2 Recommendations

Based on the findings of this study, the following recommendations were made:

- i. Government should intensify effort on her green policy most especially in the area of market creation and green procurement for reuse and recycled products in Southwest Nigeria in order to facilitate optimum utilization of waste
- ii. Recycling companies should lay more emphasis on materials like Copper and Aluminum since they have higher greenhouse gas emission saving and more economic potential than Iron that dominated recycling industry in Southwest Nigeria.
- iii. Regulatory agencies should synergize more and ensure enforcement and compliance of manufacturing companies in southwest Nigeria to operate and promote Extended Product Responsibility of their waste in order to facilitate 3Rs of waste management
- iv. Residence in Southwest Nigeria should promote source separation of their waste in order to promote easy operational strategy of 3Rs by recycling companies
- v. Sensitization and awareness should be promoted through capacity building on linkages between waste, greenhouse gases and climate change in the study area in order to maximize environmental benefit of 3Rs
- vi. Resources sustainability drive of government should be anchor on Reduce, Reuse, Recycling, Repair and Recovery (5Rs) of waste in the study area since it is a new frontier in attainment of zero waste.

- vii. Other waste management options like ‘burning and dumping should be discouraged in order to create room for more waste as raw materials for recycling industries in Southwest Nigeria
- viii. Since reduce, reuse and recycling of waste have become one of the domains for poverty reduction and employment generation, government policy should be eco-friendly to enable recycling companies maximize the cost benefits associated with waste usage in the study area.
- ix. Since there is linear relationship between waste generated and its usage in the study area, biodegradable which constitute the largest percentage of total waste generated in the study area should be effectively utilized in the production of organic fertilizer in the region

9.4 Contribution to Knowledge

This study revealed that there is a linear relationship between wastes considered in this study in terms of generation and their usage in the study area. Therefore, this study advanced knowledge in revealing that, the utilization of the wastes in terms of 3Rs is directly proportional to their; generation, availability for reuse and recycled, which consequently led to reduction in greenhouse gas emission saving in the study area.

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APPENDICES

APPENDIX I: QUESTIONNAIRE

Department of Geography and Environmental Mgt.

University of Ilorin.

P.M.B 1515

Ilorin, Nigeria

Sir/ Ma,

INTRODUCTORY LETTER

I am a postgraduate student conducting a research on *Assessment of Municipal Solid Waste Utilization and Greenhouse Gas Reduction Using 3Rs Model in Southwest Nigeria*. I am seeking for your support for the filling of the questionnaire. The questionnaire is meant only for the academic research and any information given will be kept confidential,

Thanks

Yours faithfully,

Ogunleye Victor Tola

Section 1: Demographic Information of the Respondents

- a. Age of the respondents
 - i. 18- 30
 - ii. 31-45
 - iii. 46-60
 - iv. 61 and above
- b. Sex
 - i. male
 - ii. female
- c. Marital status
 - i. single
 - ii. married
 - iii. divorce
 - iv. widow
- d. Religion
 - i. Christianity
 - ii. Islam
 - iii. Traditional
 - iv. Others
- e. Educational qualification
 - i. primary
 - ii. secondary
 - iii. NCE/OND
 - iv. HND/B.Sc
 - v. M.Sc/Ph.D

f. Employment cadre

- i. Junior staff Service
- ii. Senior staff
- iii. Management staff
- iv. others

Section Two

Questionnaire on factors that promote waste utilization

✓ Tick the appropriate option(s)

SA=Strongly Agree, A= Agree , U=Undecided, D=Disagree , SD =Strongly Disagree

1. The following factors promote waste utilization in your organization

S/n	Variables	SA	A	U	D	SD
1	Availability of market for reuse and recycled products					
2	Health and safety of the environment					
3	Government policy					
4	Employment generation					
5	Level of education and awareness					
6	Scarcity of raw materials					
7	Energy consumption					
8	Cost of production					
9	Population increase					
10	Demand for reuse and recycled products					
11	Conservation of virgin resources					
12	Religion factor					
13	Availability of technology					
14	Greenhouse gas emission reduction					

APPENDIX II: INTERVIEW SCHEDULE

1. Interview for Directors of State Waste Management Agencies

- a. Do you have any policy for 3Rs of waste management in your state?
- b. If yes, what are the policy indicators for 3Rs of waste management in your state?
- c. Are you using them?
- d. How effective are these policies?
- e. Are the general public and recycling companies aware of these policies?

2. Interview for Residents in Southwest Nigeria

- a. what type of waste can you identify in your area?
- b. how often do you make use of them?
- c. can you mention those that you commonly use?
- d. what do you use them for?
- e. Do you know if there is any economic potential in waste?
- f. if yes, do you buy or sell any of your waste?
- g. who are the people that buy waste from you?
- h. is there any benefit you derive by utilizing waste?
- i. Are you aware of any relationship between waste and greenhouse gasses?

3. Interview Schedule for Seller of Reuse and Recycled Materials

- i. what stimulate you to engage in business of reuse and recycled materials?
- ii. How profitable is the business?
- iii. What is the level of patronage of reuse and recycled products?
- iv. Is there any significant difference in price of reuse item compare to virgin product?
- b. What are the challenges encounter in the business?

4. Interview Schedule for Divisional Police Crime Officer

- i. What are the associated crimes encountered in waste management of 3Rs in your area?

- ii. How often do you come across cases related to reuse and recycling of waste?
- iii. Who are the major culprits?
- iv. What are the steps taken to address these problems in your area?

5. Interview Schedule for Recycling Company Staff

- i. When does your company come to existence?
- ii. What inform the establishment of the company?
- iii. How do you get your raw materials?
- iv. What are the major problems encountered during this process?
- v. Do you have technological capability to utilise your raw materials?
- vi. What are the major challenges in using waste as raw materials?
- vii. Is there any significant profit margin in utilising waste as raw materials compare to virgin resources?
- viii. How do you incorporate Extended Product Responsibility into your production plans?
- ix. Is there any significant difference between price of goods made from waste and that of virgin resources?

6. Interview Schedule for Monitoring and Regulatory Agency (NESREA)

- i. Do you have any law and policy framework that relate to 3Rs of waste management?
- ii. How do these laws and policies operate in your state?
- iii. How do you enforce these laws and policies on waste management of 3Rs and greenhouse gases?
- iv. What is the level of adherence to these laws and policies in your areas?

7. Interview Schedule for Academicians on GHGs

- 1. How does integrated waste management of 3Rs promote sustainability of environment?
- 2. What impact does integrated waste management of 3Rs has on Greenhouse gasses reduction?

3. What are the major greenhouse gasses from waste and how do they contribute to climate change?
4. What are the multiplier effects of these greenhouse gasses /climate change to socio-economic activities?
5. How can we disseminate this to enlighten the people in the study area?