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Review Article

A Review of the Triple Gains of Waste and the Way Forward for Ghana

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The postcolonial waste management practices in Ghana have consistently been identified with the discarding and disposal of waste in open dumps, wetlands, and landfills. These practices have only contributed to the glaring poor sanitation in the cities of Ghana. Insignificant quantity of the waste generated ends up in recycling and/or composting units for reuse. Given the current growth of Ghana's population, coupled with the emerging industrialisation, the country's overdependence on hydropower for energy and natural resources for production alone is dangerous. This paper provides a holistic review of the gains from solid waste. The paper reaffirms that, through appropriate technologies, waste possesses the intrinsic potential to generate renewable energy, resources, and income. In recommending, the main objective of waste management practices in Ghana should be about exploring the economic potentials of waste. Thus, waste disposal should be the last resort, and not the first option in waste management practices in Ghana.

1. Introduction

At a workshop at Geneva, the United Nations Statistics Division (UNSD) defined waste as materials that are not prime products for which the generator has no further use in terms of his or her own purposes of production, transformation, or consumption and of which he or she wants to dispose. The extraction of raw materials, processing of raw materials into intermediate and final products, the consumption of final products, and other human activities are ways through which waste may be generated [1]. Situated at the centre of the West African coast is Ghana, with a total land area of 238,533 square kilometres, about the size of Britain, and lies between latitudes 4 degrees and 12 degrees north and longitudes 4 degrees west and 2 degrees east. It shares boundaries with three French-speaking countries, Cote D'ivoire to the west, Togo to the east, and Burkina Faso to the north. To the south there are the Gulf of Guinea and the Atlantic Ocean. With a tropical climate coupled with tropical rainforest, agriculture is the mainstay of the economy. The projected population of Ghana for 2018 is 29,614,337 million, with a growth rate of 2.39% [2]. However, this population increase does not happen unaccompanied but come with its own issues such as rapid urbanisation linked with rampant waste generation. This stems from the changing human consumption patterns and the changing structure of the Ghanaian economy which facilitates the generation of various types of waste, especially municipal solid waste. Accra and Kumasi which are the largest cities in Ghana are estimated to generate about four thousand (4,000) tons of waste daily [3, 4]. To this end, the rate of waste generation in Ghana stands at 0.47 kg/person/day, which translates into about 12,710 tons of waste per day averagely [5]. These wastes either are thrown into open dumps, wetlands, landfills, and uncontrolled dumps or in some cases are incinerated in the open air. With these methods in use, an insignificant quantity of waste generated ends up in recycling and/or composting units for reuse amidst the varied untapped potentials from solid waste. Albeit, if the untapped potentials in waste are properly managed and fully exploited, they would provide a good quality of life for Ghanaians through energy generation, employment generation, income acquisition, and resource for goods production among many more.

Paradoxically, Ghana has not been able to translate its quantum of waste generated over the years into processed forms that could be utilised for other productive purposes; for energy generation, wealth generation, and resource for production, that could boost its emerging economic transition from subsistence agrarian economy to an industrialised and service oriented economy. The above disposition therefore spurs the authors to provide a holistic literature review of waste to establish or reestablish the gains in waste generation to inform policy makers to rethink the current waste management practices to accelerate the socioeconomic development of the country. The current literature review examines the documented literature on waste as products which the generator has no further use of it. This study takes a unique interdisciplinary approach by examining literature across a spectrum of gains that can be derived from waste product. Unlike other literatures on waste products which separately focused on waste generation, waste management, municipal solid waste combustion, and solid waste as renewable source of energy, the current study examines holistically the triple gains of waste and the way forward for Ghana. To this effect, three separate but interrelated gains from waste were examined: waste-to-energy; waste-to-income and; waste-to-resource.

2. Statistics on Waste Generation and Management in Ghana

Generally, Ghana depends largely on hydropower electricity for its production of goods and services. Hydropower energy is obtained from the design of facilities such as the Akosombo Dam and the Bui Dam. An addition to the energy mix is the construction of the Aboadzie thermal plants which uses fossil fuel. However, considering the current trends of population growth interfused with rapid urbanisation and its associated large and medium scale industrial establishments, reliance on these mix of energy alone is dangerous for the country as these facilities continue to fail the country during water level fluctuations especially with regard to energy generated from dams and global inflation in the cost of fuel, Aboadzie thermal plants.

Meanwhile, diverse alternative energy generation technologies are available and can be exploited to obtain energy to complement the traditional sources of electricity in the country. In the midst of the available alternatives, energy (electricity) generation from waste particularly municipal solid wastes (MSW) offers electricity at higher capacity while protecting the environment from land degradation and its attended health implications. Some appropriate technologies that exist for electricity generation from wastes include Combined Heat and Power (CHP), also known as cogeneration. Cogeneration is efficient, effective, clean, and reliable to generating power as well as thermal energy from solid waste. The significance of this method lies in its ability to reduce greenhouse gases which contribute positively to the ongoing global climate change [6–8].

Also, the conversion of biogas to electricity through fuel cell technology offers significant electricity for production and domestic consumption. Solid oxide fuel cell amidst others is considered to be the most auspicious technology to a wide range of scales [9, 10]. A biogas-fueled engine generator will typically convert between 18% and 25% of biogas to electricity [11]. With this estimation of energy generation from waste, it can be concluded that Ghana would have a more reliable and sustainable electricity source with higher capacity given the quantum of solid waste the country generates daily, weekly, monthly, and annually (see Table 1(a)). However, amidst the gains Ghana stands to derive from the recycling of waste, the country is yet to adopt a policy geared towards making effective use of the quantum of MSW generated in the country [5]. Basically, MSW is comprised of household refuse, nonhazardous solid waste emanating from industries, commercial and institutional establishments, which includes hospitals, and waste from the market and yard as well as street sweepings [12].

Undoubtedly, MSW and waste management strategies are key challenges to most developing countries of which Ghana is no exception. Even though Ghana has 35 institutionalised treatment plants, only 1% or 4 are operational for the treatment of waste [13]. Considering the myriad waste generation in Ghana over the years, this study presents the total MSW generation and management within the 6 respective Metropolitan Assemblies in Ghana based on the recent population and housing census as presented in Table 1(a). These six assemblies were selected and proved ideal for this study since Ghana is divided into 254 district assemblies and these districts are further categorised under 6 Metropolitan Assemblies for decentralisation purposes. The assemblies are as follows: KMA: Kumasi Metropolitan Assembly; CCMA: Cape Coast Metropolitan Assembly; AMA: Accra Metropolitan Assembly; TMA: Tema Metropolitan; TaMA: Tamale Metropolis; and STMA: Sekondi-Takoradi Metropolitan Assembly. Across the six metropolises, the Accra Metropolitan Assembly (AMA) recorded the highest tonnes of MSW followed closely by the Kumasi Metropolis (KMA). The resultant high figures could be attributed to the positioning of the national capital, vibrant industrial, and economic activities in the AMA, as well as the overpopulation of the KMA [14].

Of the total waste generated, approximately 44% are collected across the 6 metropolises, leaving a backlog of 56% which are either burned by household, dumped in skips (containers), dumped in the open (open space), dumped indiscriminately, buried by households, and/or disposed of through other inappropriate means. In an effort to rid the respective metropolis of the mountain of filths, these metropolises contract private waste management companies in a joint venture termed public-private partnerships (PPP) which over the years have witnessed a considerable increase particularly in the AMA, to assist in the collection and disposal of MSW at landfill sites [15, 16]. During the time of this census, Ghana's population was 24,658,823, an increase of 30.4 percent over the 2000 census population of 18,912,079.

With a population growth rate of 2.39% as at 2016/17, Ghana's population currently stands around 29,614,337

Table 1

(a) Municipal solid waste generation and management in Ghana by Metropolitan Assemblies

Municipal Solid waste	KMA		CCMA		AMA		TMA		TaMA		STMA	
	Quantity	Per cent	Quantity	Per cent	Quantity	Per cent	Quantity	Per cent	Quantity	Per cent	Quantity	Per cent
Total	440,283	100.0	40,386	100.0	501,903	100.0	70,797	100	35,408	100.0	142,560	100.0
Collected	75,879	17.2	2,202	5.5	298,178	59.4	39,753	56.2	1,652	100.0	32,206	22.6
Burned by household	19,551	4.4	3,705	9.2	13,402	2.7	4,745	6.7	2,886	100.0	11,311	7.9
Public dump (container)	258,958	58.8	22,887	56.7	156,481	31.2	15,416	21.8	20,934	100.0	67,133	47.1
Public dump (open space)	68,585	15.6	8,833	21.9	23,647	4.7	7,544	10.7	5,288	100.0	26,269	18.4
Dumped indiscriminately	8,230	1.9	882	2.2	5,408	1.1	1,481	2.1	3,685	100.0	1,958	1.4
Buried by household	7,137	1.6	718	1.8	1,412	0.3	298	0.4	798	100.0	2,999	2.1
Other	1,943	0.4	1,159	2.9	3,375	0.7	1,560	2.2	165	100.0	684	0.5

KMA: Kumasi Metropolitan Assembly; CCMA: Cape Coast Metropolitan Assembly; AMA: Accra Metropolitan Assembly; TMA: Tema Metropolitan; TaMA: Tamale Metropolis; STMA: Sekondi-Takoradi Metropolitan Assembly. ∗Sourced from the 2010 population and housing census district analytical reports; quantity of waste in tons/tonnes [48–52].

(b) Budgetary allocation for waste management by metropolis

KMA		CCMA		AMA		TMA		TaMA		STMA		
Year	Grand total (GH₵)	Year	Grand total (GH₵)	Year	Grand total (GH₵)	Year	Grand total (GH₵)	Year	Grand total (GH₵)	Year	Grand total (GH₵)	Total expenditure (GH₵)
2014	2,542,736	2014	1,211,889	2014	2,298,811	2014	2,111,067	2014	19,345,405	2014	272,000	27,781,908
2015	4,510,928	2015	1,311,986	2015	2,861,382	2015	16,372,954	2015	19,345,405	2015	614,843	45,017,498
2016	4,706,000	2016	1,373,986	2016	6,939,402	2016	12,123,496	2016	4,697,614	2016	652,289	30,492,787
2017	4,509,000	2017	2,529,799	2017	5,224,460	2017	12,203,240	2017	7,214,253	2017	2,334,512	34,015,264

∗Sourced from the respective composite budgets of the 6 metropolitan assemblies in Ghana [53–66].

million (2018 estimate) [2, 17]. The current population represents a percentage increase of 16.7 from the base year (2010) census. With this significant increase in population, changing patterns of consumption and the current spate of increased industrial activities due to government's ambition to reduce youth unemployment, it is possible that the percentage of increase during the next population and housing census would increase beyond the 30.4 percent. The implication for this could mean an increased rate of MSW generation in the country. Notwithstanding, the quantum of waste generated has the potential of providing a source of income to the government through cost saving and taxes and to citizens in the country through employment generation.

The privatisation of waste management has given rise to recent engagement of entrepreneurs in the waste management sector. Though there is an effort by private individuals to generate income from waste generation in the country, it needs more committed support. For instance, sachet water bags, empty bottles, and other forms of plastics are recently gathered and returned for cash and this serves as a source of employment for people. A study in Kumasi on solid waste management indicated that retrieval of plastics from the solid waste stream for reuse and recycling purposes undertaken by the informal sector generated revenue, in addition to generating employment for the citizenry [18]. Companies like Zoomlion Ghana, Asadu Royals, and J. Stanley, among others, are creating employment for a significant number of people through their waste management and collection services. In view of this, income is generated by the company, the government through taxes, and the employees. It must be stated that waste management goes beyond collection and disposal of waste but largely involves the generation of income from the waste generated and collected through employment creation and cost saving when the needed attention and support is given to it. A further elaboration, with respect to financial commitment, on Ghana's response to MSW management has been presented under Section 2.4.

2.1. Conceptual Framework. The framework below depicts the various uses and benefit that can be derived from solid waste. It depicts that solid waste could serve as an avenue for income generation, energy generation, and raw materials (See Figure 1).

2.2. Waste-to-Energy. A cardinal implement to achieving a more sustainable socioeconomic development in Ghana is energy. The importance of energy in the socioeconomic development of Ghana is echoes in an era where the country continues to battle with a reliable energy source in powering its industries, households, and the entire nation. Salient economic variables such as poverty reduction, employment opportunities, education, and demographic transitions do have a linear relationship with the availability of energy, as espoused by the International Atomic Energy Agency [19]. In view of this, for Ghana to successfully transition from a predominantly agrarian economy to an industrialised one, sufficient and affordable energy supplies remain a keystone.

Undoubtedly, the underlying catalysts for the immerse growth, development, and the subsequent maintenance of all economies in the world are energy. Its influential and sensitive effects have been largely witnessed in the developed and giant economies such as the United States, Japan, United Kingdom, Germany, and China [20]. At the onset of Ghana's independence, the Akosombo Dam, a hydropowered dam, generated enough energy capable of sustaining the developmental agenda of young and emerging economy of Ghana. So much was the energy that Ghana exported its energy to neighbouring countries. However, with the passage of time, the overdependence on hydropower for the socioeconomic development of the country currently has proven to be dangerous, especially at a time when the population is increasing at a rate of 2.39% as at 2016 and economic activities are booming. This has been experienced in the recent power outages in the country where several small-scale industries collapsed and/or were crippled, with the heavy industries retrenching over 1000 of its labourers [21]. Even though power plants were imported into the country to supplement energy generation from the Akosombo Dam, the initiative contributed to increasing cost of energy due to the thermal component of the said plants which operated on diesel or petrol.

As a remedy, more sustainable and appropriate energy sources have been suggested and paramount among the alternatives is energy from waste. Using waste to produce energy which is more sustainable and environmentally friendly is not a new idea but the needed interest, priority, and attention has not been given to the concept in Ghana although Zoomlion Ghana Limited adopted the concept recently in its new facility in the Abokobi Landfill site in Accra. The worry and surprising aspect to the low patronage of waste-to-energy facilities in Ghana is predicated on the amount of solid waste generated annually in the country, as well as the budgetary allocation towards making the cities clean. Nevertheless, converting waste to energy by employing appropriate technology has received tremendous embracement by other economies as Wiles [22] espoused that 125 waste-to-energy facilities were in operation in the United State as at 1993. In the European Union more than 64% of facilities use waste materials as alternative fuels [23].

Globally, the degree of alternative fuel use differs depending on the country [24]. Even though Netherland has the highest ratio (83%) of use of alternative fuel worldwide, Austria, Germany, and Norway have achieved significant replacement ratios of 60 to 63%, whereas that of Switzerland and Belgium was 47 to 49%. Although Italy and Spain have only achieved low replacement ratios, approximately 8.6% and 22.4%, respectively, as at 2004, these countries have increased their volume of alternative fuel from waste substitution in recent years. For instance, the use of alternative fuels from waste increased about 22% compared with the 2004 figure, when approximately 175,000 tons of waste materials were energetically recovery material in Spain [24]. In the United States, many plants reportedly met 20 to 70% of their energy requirement from the use of alternative fuels from waste in 2009 according to the Portland Cement Association.

A wide range of alternative fuels from waste are used, and these fuels can be classified into three basic groups, according to Mokrzycki and Uliasz-Bocheńczyk [25]: gas

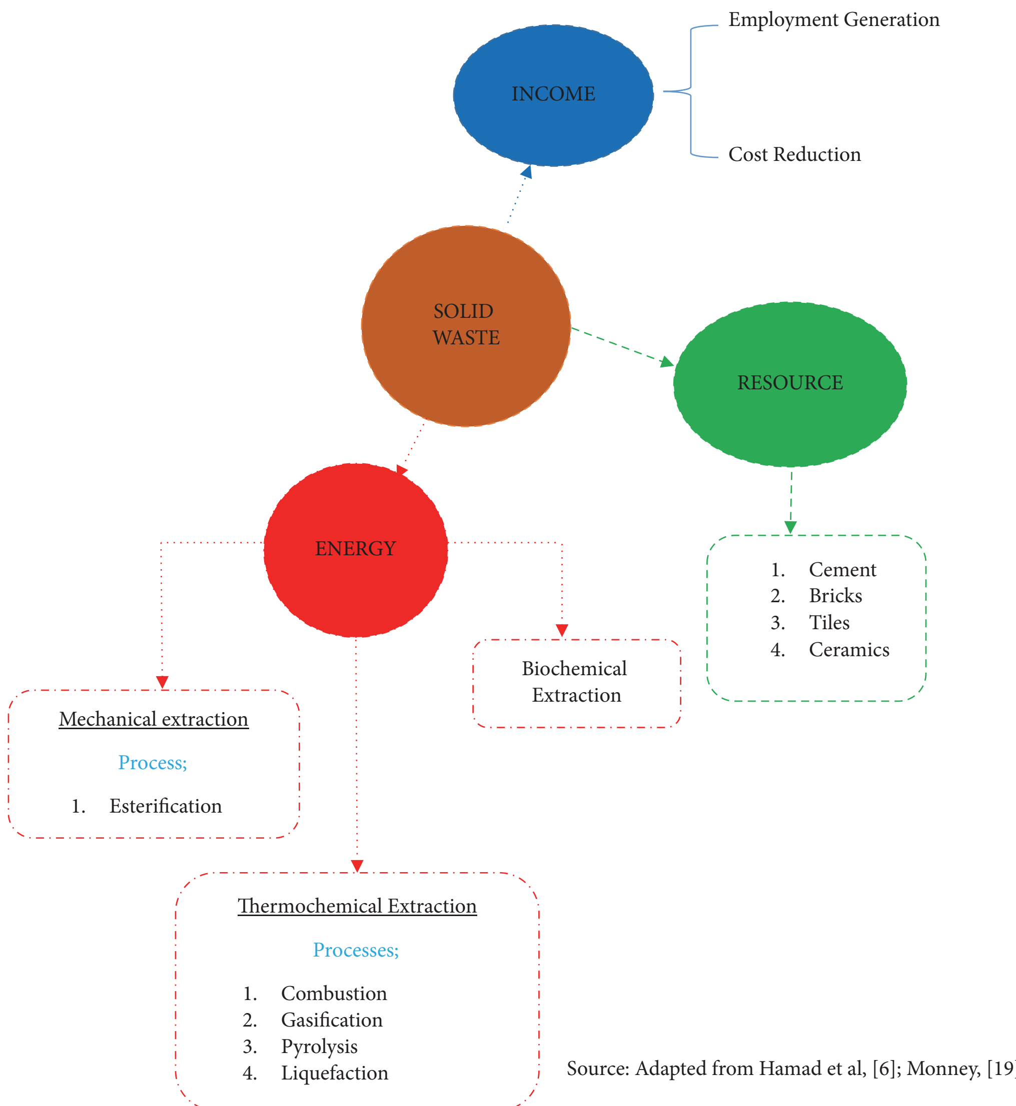

Figure 1: Conceptual framework on the uses and benefits of solid waste.

(e.g., landfill gas, pyrolytic gas, and biogas), liquid (e.g., used oils and solvents), and solid (wood waste, plastics, municipal waste, and textiles). In 2010 alone, appreciable percentages were recorded across different countries worldwide; Austria achieved 70% recycling (including composting) alongside 30% waste which was incinerated; Germany achieved 62% recycling alongside 38% incineration, while Belgium achieved 62% recycling alongside 37% incineration. As an energy source, energy from waste has a number of potentials beyond its renewable content including energy security, nonintermittent nature, varieties of potential energy outputs, reducing overdependence on fossil fuel usage, greenhouse gas emissions, pollution, and landfill dumping [6, 11].

The US Environmental Protection Authority (EPA) [26] states that waste-to-energy facilities are a "clean, reliable, renewable source of energy" and waste-to-energy facilities produce energy with "less environmental impact than almost any other source of electricity." Waste can be converted into energy in a range of ways through diverse appropriate technologies. Energy from waste is not just about waste management practice but produces valuable domestic energy source contributing to energy security. However, incineration has been the most well-known practice among other methods according to the UK Department for Environmental and Rural Affairs [11].

In view of this, numerous conversion options exist but the conversion of waste (solid) into useable form of energy can be broadly undertaken with three main process technologies: biochemical extraction, thermochemical extraction, and mechanical extraction [7]. For the first process, biochemical conversion, enzymes in the bacterial and microorganisms are used to fragment biomass. As regards biomass, the US Department of Energy [27] posits that "biomass is a term that includes all energy materials that emanate from biological sources, whether they are wood or wood wastes, residue of wood processing industries, food industry waste products, or municipal solid waste". The biochemical extraction or conversion procedure is regarded by Odlare et al. [28]

and Pant et al. [9] as one of the handful procedures that provide environmentally friendly direction for obtaining useable energy fuel from waste particularly municipal solid waste. Its environmental friendliness rests on its use of microorganisms to perform the conversion process by using anaerobic digestion with what is called "CHHP" (Combined Heat Hydrogen and Power) systems and fermentation [6, 8].

On the other hand, thermochemical conversion according to Hamad et al. [6] forms one component in a number of integrated waste management solutions in multifarious schemes. Four main kinds of conversion technologies are used in this conversion process: combustion, gasification, pyrolysis, and liquefaction [6]. Combustion is used over a wide range of commercial and industrial combustion plant outputs to convert the chemical energy stored in the solid waste into either heat or electricity. The process deals with the burning of biomass in air, by recycling the carbon fixed by photosynthesis in the growth phase [27]. Though biomass can be used to generate constant planned amounts of energy "base load", its constant supply in meeting demand peaks cannot be adequately ensured in the same way as gas due to the key role of waste management on a continuous basis. However, there is potential for energy from waste plants with a greater degree of flexibility that could be suitable for providing peak load electricity such as those that could provide biogas or pyrolysis oil, which could be stored and used when needed [11]. In their 2001 Renewable Energy Annual report, the US Department of Energy intimated that waste-to-energy with 2750 megawatts represents 27% of the biomass category. Generally, any type of biomass can be burned in practice, but combustion is realisable only for biomass that has been predried [29]. In combustion, a number of process equipment items including boilers and turbines are needed.

Meanwhile, gasification conversion process involves treating a carbon-based material with either oxygen or steam to produce gaseous fuel which can be cleaned and burned in a gas engine or transformed chemically into methanol that can be further used as synthetic compound. Pyrolysis conversion on the other hand deals with the heating of biomass in an oxygen free environment to produce liquid which is often called biooil or biocrude in varying yield of solid and gaseous fragments. To ensure effectiveness, the pyrolysis depends on the heating rate, temperature level, particles size, and retention time to produce the required energy [6]. Furthermore, liquefaction as the last waste-to-energy conversion process under the thermochemical conversion concerns low temperature cracking of biomass molecules to obtain liquid-diluted fuel as a result of high pressure. The process requires a temperature range of around 200 degrees Celsius to about 400 degrees Celsius. Lastly, mechanical extraction deals with the process of extracting oil from the seeds of waste. Targeted at producing biodiesel, the clamped down oil is made to react with alcohol through a process known as esterification. Mechanical extraction can moreover be broken down into three main classes: electricity generation, heat generation, and steam generation [6]. All the processes under the thermochemical conversion of waste to useable form of energy generate large quantity needed for indigenous consumption when appropriately performed.

In Africa, for instance, the Cows to Kilowatts project in Ibadan became the first plant in the world to simultaneously treat abattoir waste and provide domestic energy and organic fertilizer. The project generated the equivalent of 0.5 Megawatts (MW) of electricity daily. Similarly, the Thekwini Landfill Gas to Electricity project in Durban generated 7.5 MW of electricity from 2 landfill sites [30]. All these facilities add to the national electricity grids in the respective countries were they exist, thus easing the pressure on the other sources of energy. Also, waste-to-energy contributes 32% of the entire US electricity generation [27]. Conclusions could be drawn from these evidences that an innovative and sustainable energy alternatives exist in Ghana which can be tapped with the use of appropriate technologies. This energy can only be tapped into and increase energy generation in Ghana if it would focus its energies on converting waste to energy rather than dumping them in designated landfill sites. However, it must be noted that financing waste-to-energy facilities is difficult owing to its capital intensiveness but the gains from the facilities can offset the cost in the long run.

2.3. Waste-to-Income. Waste management and an exploration of its economic potentials is at an infant stage in Africa, specifically, Ghana. Perhaps, this may be due to a confluence of factors like social norms and associated concerns, natural environmental issues, economic factors, regional and national legislation, technological developments, human resource deployment, and historical influences, among others [31, 32]. Waste generation is an invitation to income generation when considered from the periscope of waste management economics [31]. Income from waste may be generated from the employment it creates and the cost it saves from waste collection and management. While other developed economies such as Australia, Singapore, and Sweden are profiting financially from the generation of solid waste, developing economies such as Ghana continue to regard all forms of solid waste to be fated for the landfill sites and see it as a burden as well as a problem to be addressed [33]. The contributing factor to the perception of waste as a burden fated for the landfill sites could be attributed to the lack of segregation of waste from the source.

In Australia, businesses in the private and public trading sector received an income of \$8.6b during the 2009-10 financial year, with waste services accounting for about \$5.1 billion (59.9%) of the total income generated and sales of recyclable or recoverable material contributed 26% in 2009. For private and public trading sector businesses, income from the commercial and industrial stream contributed 61.4% of waste services income, followed by the domestic and municipal waste stream (27.3%) and the construction and demolition stream (10.5%). In 2010, nonhazardous waste contributed 82.9% of waste services income. Nonrecyclable waste services contributed the most to waste services income (83.8%), with recyclable waste services accounting for the remaining 16.2%. The government sector received \$2.6 billion income in relation to waste activity. Rates, charges, levies, fines, and licenses from waste management activities contributed

77.1%, followed by waste services income (19.5%) and sales of recyclable or recoverable material (1.6%). The sources of waste services income for the general government sector were similar to the private and public trading sector, with nonrecyclable waste accounting for 84% of waste services income and recyclable waste accounting for 16%. The government sector organizations in New South Wales employed 2,311 people in activities related to waste management, contributing 39% of total government sector employment, followed by Western Australia (1,096 or 18.5%) and Queensland (1,036 or 17.5%). New South Wales contributed $971.8 million (37.4%) of total government sector income related to waste management activity, while Queensland contributed $548.2 million (21.1%). Moreover, expenditure related to waste management activity was highest for New South Wales at $826.1 million (38% of the Australian total), with Queensland contributing 418.1 million (19.2%) [34]. Meanwhile, with all these expenditure in other countries, Singapore has created an island from its solid waste, thus attracting tourists to the country and generating income for the whole country [33].

As espoused earlier in Section 2.1, the various ministries contract private companies to help in the management of MSW. Besides this, Ghana's Ministry of Sanitation and Water Resources in collaboration with Zoomlion Ghana Limited contracted about 45,320 youths under the Youth in Sanitation module under the Youth Employment Agency (YEA) to serve a dual purpose: as an employment avenue and also to rid the cities of filth. Huge sums of money are allocated to the management of MSW through the PPP besides other means of waste management practices such as the pay-as-you-dump policy in Ghana [35]. Although these partnerships have been in existence for long, the effective and viable means of waste management employed can be summarised as follows: generate, collect, and dispose of in landfill site (GCD). With the practice of GCD, the only proof available for its effectiveness or otherwise has been the continual mountain of filth witnessed across the length and breadth of the country. Of course, these initiatives have not proven effective considering the mountain of filth in the gutters, streets, and even landfill sites which is eventually driven by wind into surrounding communities [16]. Instead of, perhaps, contributing to the socioeconomic development of Ghana, the myriad MSW within the towns and cities effectively contribute to the outbreak of sanitation-related diseases and a dispensation of money for waste management purposes [16, 35].

Even though other countries are making huge gains from the generation of MSW by means of income generation [33, 36], Ghana persists to spend on waste management than generating income from waste, despite the economic viabilities of waste generated in the country. Reportedly, the Accra Metropolitan Assembly spends about US$ 3.45 million each year (GH₵ 6.7 million) on collection and transport of waste for disposal and GH₵ 550,000.00 a month to pay waste contractors and landfill maintenance. Poor sanitation resulting from indiscriminate waste disposal alone is estimated to cost the country $290 million every year. This share of money represents 1.6% of the country's Gross Domestic Product [37, 38]. However, the inability to effectively tap the dividends from waste generation and management significantly by the country may stem from the low investment due to the negative mindset towards waste management, low infrastructure, and poor research implementation.

The composite budget by the respective Metropolitan Assemblies as espoused in Table 1(b) and Figure 2 sheds light on the huge investment by the Ghana government towards waste management for the past 4 years (2014–2017) based on available data. Whereas government's expenditure to MSW management decreased in 2017, after peaking in 2015, the significant reduction needs to laud with caution considering government's ambition to making Ghana one of the cleanest cities in Africa. By a closer look at the yearly expenditure from 2014, coupled with new regulations targeted at improving sanitation in Ghana, a prediction could be made for an increased budgetary allocation in the coming years. For instance, between 2014 and 2015, budgetary allocation increased by 38 percent whereas that of 2016 decreased by 10 percent (−48%). However, in 2017, the total amount increased by 10 percent (10%). Recently, government allocated GH₵ 42,992,636 for sanitation management due to its commitment to making Ghana clean, a 21 percent increase from the 2017 budgetary allocation [39]. The staggering amount dedicated by the government towards MSW management raises a number of questions: why "waste" scarce national capital in the management of MSW when MSW, in itself, can generate income and energy and serve as a resource for the growth of the country as adopted in other countries? Or could attempt not be made at replicating the processes adopted in generating income from MSW in developed countries instead of spending scarce national resources in managing a recurrent and nonchalant induced attitude of MSW generation in the country?

2.4. Waste-to-Resource. According to Zimmermann [40], "resources are not, they become; they are not static but expand and contract in response to human wants and actions". The earth is made up of raw materials (neutral stuff) which only become a resource when it is able to satisfy the wants of man. In view of this, for a neutral staff to qualify as a resource, it must possess two essentially related but different attributes: the capacity to take advantage of opportunities and the capacity to extricate one's self from difficulties. Thus, whereas waste may be considered a neutral stuff to one person, it could become a resource if one finds the need to take advantage of it when appropriate technology exists for its potential to be tapped to satisfy a want. For instance, just until recently in Ghana, empty sachet water bags were either dumped into gutters, wayside, and/or thrown into bins for eventual disposal at the landfill site without any use for.

Conventionally, raw materials for production in industries across the globe come from the utilisation of neutral stuffs like clay, sand, stone, gravels, gold, diamond, manganese, timber, and steel, among others, which are tapped from the natural environment. Inherent in these neutral stuffs are the ability to cause harm to the environment with regard to their constant exploitation and/or be a blessing under the right environment and condition. As pointed out

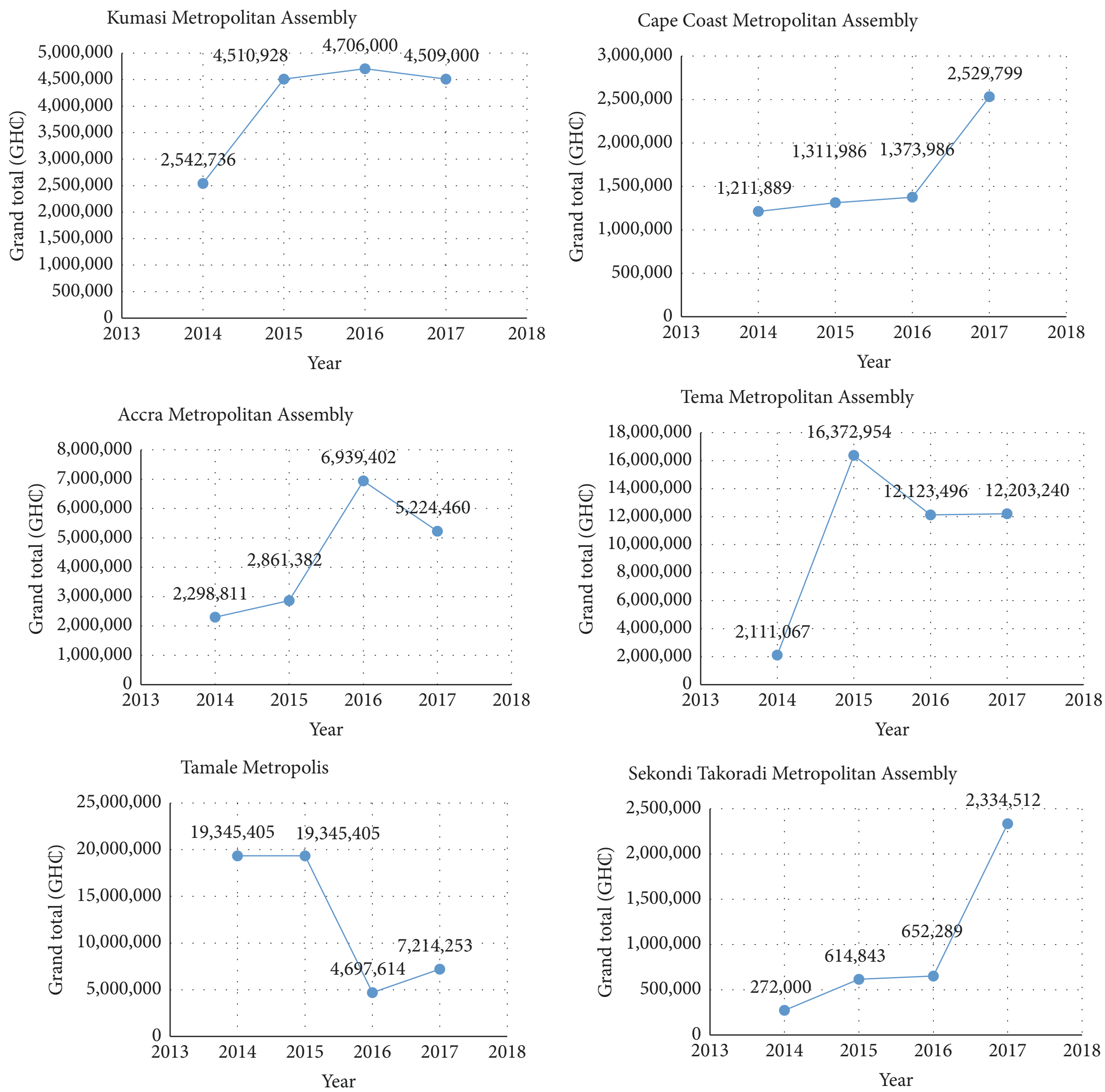

Figure 2: Line graphs showing the budgetary allocation for waste management by metropolis.

by Shah [1], waste may be generated during the extraction of raw materials for production which may be detrimental to the environment. To forfend the environment and at the same time conserve resources, efficient recycling of waste, particularly, and municipal solid waste for reuse is essential.

In view of this, experiences in some countries in both the developed and developing world indicate that several businesses and industries make use of waste as their raw materials to produce diverse goods. These are done to ensure environmental sustainability and management and promote cost saving in order to maximise profit. In India, the informal sector and secondary industries recycle up to 15–20% of solid wastes generated by the country in various building components [41]. Also, Pappu et al. [42] emphasised numerous examples on the availability of solid wastes of diverse forms from different sources, and how they have been transformed to derive different products for safe, sound, and substantial development in their country of production. Table 2 shows examples of solid waste types, their sources, and their potential products.

One important industry where waste materials are much needed for production is the cement industry. Solid wastes such as waste gypsum serve as important raw materials that are used as raw material substitutes in the clinker and the cement manufacturing process to provide significant savings in terms of natural resources. For example, about 38% replacement of limestone or 72% replacement of clay is from waste materials [34–37]. The precalciner stage can process approximately 20–40% of the raw material before the kiln calcination step and, consequently, increase the energy efficiency of the kiln operation. In the final stage of cement production, the mixture that is obtained, called clinker, is cooled and grounded with gypsum afterwards (approximately 5%) and added to other substitute's materials

Table 2: Types and nature of solid wastes and their recycling and utilization potential.

Types of Solid Waste	Sources	Potential Products
Agro Waste (Organic nature)	Baggage, rice and wheat, straw and husk, cotton stalk, saw mill waste, vegetable residues, sisal, groundnut, nut, shell	Particle boards, insulation boards, wall panels, printing paper and roofing sheet, fuel, bricks, acid proof, cement, polymer composite, cement board
Industrial waste (inorganic)	Coal combustion residues, steel slag, bauxite red mud, construction debris	Cement, bricks, blocks, tiles, paint, concrete, ceramics product, wood substitute products
Mining or mineral waste	Coal washeries waste, mining overburden waste, tailing from ion, copper, zinc, gold and aluminium industries	Bricks, tiles, lightweight aggregate, fuel
Non-hazardous other process waste	Waste gypsum, lime sludge, limestone waste, marble processing residues, broken glass and ceramics, kiln dust	Cement clinker, super sulphate cement, hydraulic binder, blocks, bricks, cement, fibrous gypsum boards, gypsum plaster
Hazardous waste	Metallurgical residues, galvanizing waste, tannery waste	Cement, bricks, tiles ceramics and board

Source. Pappu et al. [42].

from waste, such as slag, fly ash, and pozzolans to produce cement which is reground and packaged [43, 44].

Interestingly, though hazardous solid wastes are characterised by negative perception because of their high concentration of poisonous elements and properties (ignitability, corrosivity, reactivity and toxicity) which are unsafe to use commercially and economically, as well as their adverse effect on the environment, humans, flora, and fauna, these can also be recycled and reused as a resource. Hazardous waste from metallurgical residues, galvanizing waste, and tannery waste can be converted into products including cement, bricks, tiles, ceramics, and boards. It is therefore evident from such studies that there are great potentials for recycling of solid wastes released from different sources including industrial processes, agricultural processes, mining processes, and medical processes. As a result, many companies in some countries such as India are making good use of waste to manufacture products such as cement, wall panels, and tiles [29, 45].

In contrast, the recycling of waste to acquire materials for production has not gained strong root in Ghana. The country to a larger extent conceives waste management as discarding of waste with the aim of protecting the environment. Little attention is given to the reuse character inherent in waste generated in the country. Thus, these wastes, although are raw materials, continue to exist as neutral stuffs which pollute the environment and do contribute to the outbreak of sanitation-related diseases such as malaria, cholera, and typhoid. In their publication in May 1999, the Ministry of Local Government and Rural Development (MLGRD) outlined the basic principles of environmental sanitation, problems, and constraints. The role and responsibilities assigned to communities, ministries, departments, and agencies (MMDAs) and the private sector by the MLGRD impinge on environmental management and protection, legislation, and law enforcement and the criteria for specifying services and programmes, funding, equipment, and supplies, among others. Out of the National Sanitation Policy, the MLGRD has also developed a technical guideline document titled "The Expanded Sanitary Inspection and Compliance Enforcement (ESICOME) Programme guidelines".

The programme guidelines which are implemented by the MMDA's, routinely look at four broad areas, namely, effective environmental health inspections (Sanitary Inspections), dissemination of sanitary information (Hygiene Education), pests/vector control, and law enforcement. All MMDAs have developed waste management and environmental health plans to help solve the numerous sanitation problems [46]. However, a critical assessment of the policy' achievements indicates that the policy has not lived up to it expectations as heaps of solid, liquid, radioactive, and hazardous waste continue to flood the streets of the country. This is evident from the worst ever cholera outbreak in 2012, besides the predicament in the 1980s [47]. The management of plastic waste that resulted in a number of types of small-scale plastic waste recycling is still a neonate sector.

Some technologies that have been developed to assist recycling of waste have not worked to the mandate due to a multiplicity of factors including inadequate government financial support on recycling, lack of public awareness on the need to recycle waste, indifference of the public towards good waste management practices such as recycling, interinstitutional cooperation and collaboration, and low technical capacity. It must be emphasised that, with the current pace of natural resource exploitation in the country for production, recycling of recyclable waste as raw materials for production will serve a purpose of protecting the environment, conserving resource, and promoting the socioeconomic sustainable development of the country.

3. Conclusion

Ghana continues to spend on solid waste management whereas other countries persistently generate clean energy, income, and raw materials for production. The common practice of waste management in the country since independence has been the discarding and disposal of waste, with little attention given to the need to recycle waste to generate energy to boost the country's emerging economy. This paper holistically reviews the most significant gains from waste, particularly solid waste. The study emphasised that waste can be turned into valuable useable form for sustainable development of the country given the quantum of waste generated daily in the country. This paper therefore concludes by proposing a formula for waste: Waste = Energy + Income + Raw materials (Resources) (W = EIR). Having outlined these points, it is evident that when waste is made to imitate nature, in terms of energy flow and nutrient cycling, it can be integrated into the environment for mutual benefit. In recommending, the main objective of any waste management practice in Ghana should be about exploring economic potentials of waste as well as protecting the environment. Also, waste disposal should be the last resort, but not the number one option in the waste management practices in Ghana.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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