GREENER JOURNALS

Greener Journal of Social Sciences

ISSN: 2276-7800 ICV 2012: 5.99

The Potential of Municipal Solid Waste as a Clean Development Mechanism (CDM) Project in Kano Metropolis, Nigeria

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Research Article

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ABSTRACT

This paper assesses the potential of the CDM mechanism in the municipal solid waste disposal sector in Kano metropolis, Nigeria, where population growth of about 3%per annum and unprecedented urbanization of 40% per anum has resulted in high waste generation. The waste typical of developing countries consist mainly of organic matter and poor management due to a number of factors has meant less than 30% of the waste is actually managed and the waste that is managed is also deposited in unsanitary landfill to decompose and produce methane. Methane capture from landfills in Kano metropolis can be a good CMD project which now accounts for about 22% of CDM projects in countries like India, Brazil and Indonesia. Its popularity is due to its benefits of improved sanitation, renewable energy generation and the fact that methane has a global warming potential 21 times that of CO2. Data for this study was collected through fieldwork, questionnaire surveys and informal interviews conducted with senior officials of the agency responsible for waste management on the existing solid wastes management practices, and status of landfill management. Secondary data were collected through reviews of the Kyoto protocols, relevant documents on UNFCC and Nigeria's communication to UNFCC.

Keywords: Climate change, Green house gasses (GHG), Developing countries, Landfill, Biodegradable.

INTRODUCTION

Today climate change is recognized as one of the most important challenges facing the international community and the most significant effort to address the challenge to date is the Kyoto protocol which the industrialized nations referred to as annex 1 countries to reduce their GHG emissions by 5.2% of the levels in 1990 during the first phase of the Protocol from 2008 to 2012. In December, 2012, the Doha amendment to the Kyoto protocols that extended the duration of the protocol from January 2013 to 31st December 2020 was adopted. Developing countries or non – annex 1 countries, such as Nigeria, have no GHG emission restrictions, but have financial inducements to develop Green House Gasses Reduction projects in exchange for carbon credits (UNFCC,2005). There are six Green House Gases identified under the Kyoto Protocol, namely, carbon dioxide (CO2), methane (CH4), nitrogen protoxide (N20), the hydrofluorocarbons, perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) (Yasmin, 2005).

To enable annex 1 countries meet their targets, the Kyoto Protocol provides flexibility mechanisms namely: the Clean Development Mechanism (CDM) and the Joint Implementation (JI), which involves setting up Emission Reduction projects in developing countries in exchange for Emission Reduction Units (ERUs) and Emissions Trading involving the trading of carbon. The CERs/ERUs generated under CDM/JI projects are used to offset the carbon emissions of annex 1 countries and consequently assist them to meet their targets under the Kyoto Protocol or sold freely in the carbon market.

The Clean Development Mechanism (CDM) under the Kyoto Protocol essentially allows governments or private entities in industrialized countries to establish projects with low Green House Gas emissions known as Emission Reduction (ER) projects in developing countries and receive Certified Emission Reductions (CERs) referred to as carbon credits from the project activity. The CDM has two main goals which are to assist industrialized countries to achieve their targets under the Kyoto Protocol and promote sustainable development in developing countries (*Ibid*).

Many developing countries have taken advantage of the opportunity offered by the CDM to attract projects and investment that provide jobs and sustainable resource use (Ravindranath, 2002). The largest seller of ERs is Asia with 45 percent of the total global trade; Latin America is second with 35 percent of the volume supplied . Africa as a whole has attracted a very negligible amount (Ellis et al., 2004) partly due to lack of awareness on climate change issues (Nabegu, 2009).

In Nigeria, most CDM projects were unilaterally initiated and are mostly gas to power e.g. Kwale oil-gas processing plant; Aba Clean Energy Carbon Project (ACECP) and the Sub -Regional Co-operation on Emission Reduction (WAGP)**,** a 681 km onshore and offshore pipeline project that will transport natural gas from gas fields in the Niger Delta region of Nigeria to Benin, Togo and Ghana (Ellis et al., 2004). This paper assesses the potential for implementing a CDM project in Kano, Nigeria. The objective is to evaluate the prospects of Nigeria taking advantage of this mechanism particularly in the municipal solid waste disposal sector in Kano metropolis. This is predicated by the fact that today solid waste generation is increasing as a consequence of rapid population growth and urbanization coupled with the fact that conventional management has not been efficient resulting in risks to human health and global environment. The data for this study were collected through questionnaire surveys and informal interviews conducted with senior officials of the agency responsible for waste management in Kano metropolis during which information on the existing solid wastes management practices, and status of landfill management were obtained. In addition, information in respect of the Kyoto protocols, relevant documents on UNFCC and Nigeria's communication to UNFCC were also used.

STUDY AREA

Kano is the largest city in the Sudan Region of Nigeria with a population of more than 6.5 million. It is located between latitude 12^{o} 25 to 12^{o} 40N and longitude 8^{o} 35N to 8^{o} 45E and has for centuries been the most important commercial and industrial nerve centre of Northern Nigeria attracting millions of people from all parts of the country and beyond. Unprecedented urban growth of 40%, natural growth rate of 3% and rapid economic growth of 8% nationally in Nigeria since 2005 is expected to continue to increase the population and waste stream in the years to come. Today Kano metropolis generates about 1, 080, 5000 tons of solid waste per year or approximately 3050 metric tons per day (Nabegu, 2008). By 2025, this figure is expected to increase to 1,825,000 tons per year, or 5000 metric tons per day. The climate of the study area is the tropical wet and dry Aw by Koppen's classification characterized by high temperatures with low mean variations throughout the year. Climatic factors play a crucial role in the municipal waste management of the study area as, during the wet season; heat and humidity cause the municipal solid waste to be of higher moisture content thus increasing the weight of the refuse. In addition, high humidity with heat causes the organic portion of the waste to decompose quickly leading to release of methane a potent GHG that has been identified as one of the most causative agent in global warming; this is particularly significant in Kano metropolis where waste disposal is predominantly in unmanaged landfills.

Clean Developement Mechanism (CDM)

The Clean development mechanism (CDM) is a market-based solution for addressing the problem of global warming. It is predicated on experience derived from various regional markets for atmospheric pollutants, such as the United States' experience with emissions trading under the Clean Air Act (Thornloe et al., 2002). However, unlike hitherto market based atmospheric contaminant programs, CDM is a project-based system that is based on individual projects that are validated by designated entities and registered with the CDM Executive Board (CDM EB), the mechanism's governing body, rather than an industry or sector-wide scale (UNFCC,2005). Each project wishing to participate in the CDM must prepare a Project Design Document ("PDD") that explains in detail how its future emissions reductions will be real, additional and not induce leakage. It must also prepare a monitoring methodology that explains in detail how it will monitor emissions reductions made by the project.

In order for countries to participate in the CDM they must meet some basic requirements such as; must have ratified the protocol and must establish a National CDM authority called the Designated National Authority (DNA). Industrialized countries in addition must have a national system for the estimation of a national registry and an accounting system for the sale and purchase of emission reduction among other things (UNEP, 2004).

The Protocol's conditions for prospective CDM projects must satisfy two criteria of additionality and sustainable development. Additionality according to the Kyoto protocol means that the CDM project must lead to 'certified emission reductions' (CERs) that normally wouldn't have occurred without the project. A CER refers to one tonne of avoided CO_2 that has been certified after validation by an independent third party. Sustainable development criteria simply restates the purpose of CDM in the first place which is to assist non-Annex 1 countries achieve sustainable development in the context of climate change (*ibid.*). The sustainable development criteria are further classified into social, economic and environmental criteria in conformity with conventional sustainable development objectives.

The main participants in a CDM project are the CDM Executive Board (EB), Designated National Authority (DNA), Designated Operational Entities (DOEs), and the Project Developer (PD). The CDM EB is appointed by the member states to the Kyoto Protocol. The EB generally oversees the operations of the CDM, approves baselines methodologies, and registers projects and issues CERs. The DNA is the host country's national authority charged with the responsibility of evaluating proposed CDM projects, determining whether the proposed project will result in sustainable development, issuing Letters of Approvals (LoA) and managing the local regulatory aspect of the CDM (UNFCC,1997).

The approval of the host country is required to register a CDM project with the UNFCCC. In Nigeria, the regulatory authority is the Special Climate Change Unit of the Federal Ministry of Environment (FME, 2003). The Project Developer (PD) is the project sponsor, the company or institution developing the CDM project, while the DOEs are independent third parties, accredited by the EB for the purpose of validating proposed CDM projects, verifying and certifying emission reductions resulting from the project to the EB (*Ibid*).

Developing a CDM project involves preparing a Project Idea Note (PIN), a feasibility study on the proposed project, obtaining an LoA from the DNA of the Host country for the proposed project and a written authorization from the Party to the Kyoto Protocol of the voluntary participation of the proposed Project Participants, drafting a Project Design Document (PDD), which contains a description of the project activity, the proposed monitoring methodology and baseline, project duration, monitoring plan, environmental impact assessment and stakeholders' comments, submission of the PDD to a DOE for validation, registration of the project as a CDM with the EB, operating the project in a way which reduces GHG, monitoring the ER based on the monitoring plan, review and verification of the ER by a second DOE, certification by the DOE of the ER resulting from the project to the EB and issuance of CERs by the EB. Relevant documentation includes the PIN, PDD and LoA from the DNA of the host country and the Emissions Reduction Purchase Agreement (ERPA) amongst others.

The ERPA is a purchase and sale agreement between a seller (usually the Project Developer) and buyer for the sale of the CERs resulting from a CDM project activity. The ERPA identifies the parties, their rights and responsibilities, nature of the contract, risks borne by the parties and risk mitigation strategies. Some of the risks include failure to obtain a license from the DNA, project failing to qualify for CERs and price risks amongst others. The ERPA must ensure that these risks are allocated and managed in such a way that will allow the value of the project to be fully maximized between the parties. It is advisable that parties involved in a CDM project involve their lawyers' right from the start of negotiations for the project to ensure that their rights are adequately secured. Ownership of the CERs to be generated by the CDM project activity must be clarified from the onset. In order to be entitled to the CERs, the PD must be able to establish title to the rights and benefits from the CERs. In the absence of any law to the contrary, the PD owns the CERs and is entitled to deal with them exclusively.

Municipal Solid Waste and Climate Change

Currently, the bulk of municipal solid waste still finds its way into solid waste disposal sites all over the world - 60% in the EU and a little less than that in the US (Bingemer and Crutzen, 1987; US EPA, 2002). In Kano metropolis, as indeed all Nigeria's major cities almost all municipal solid waste ends up in landfill. Ackerman (2000) identified five predominant ways in which solid waste management impacts on climate change: reduction in industrial energy use due to recycling and source reduction, landfill methane emissions, energy recovery from waste to displace fossil based electricity, carbon based sequestration due to decreased demand for virgin paper and energy used in long-distance transport of waste.

From a sustainability point of view, waste disposal is the least preferred option in waste management because it is essentially an end of pipe solution and it has the most impact on the environment (*Ibid*). Despite this fact, the proportion of municipal solid waste that goes to disposal sites is likely to be higher in the years to come in Kano metropolis because the recycling and reuse capabilities are rudimentary at best. Also the expenditure on collection systems and on improving recycling and reuse programs is meager. Such continued dependence on landfill disposal has its ramifications as they not only pose local health and environmental problems but global ones as well, in that, they serve as a significant source of GHG emissions especially methane. For instance an EU study showed that land filling accounts for about a third of total anthropogenic emissions of CH_4 in the region. A separate US study also reveals that landfills are the largest anthropogenic source of methane-CH_4 in the US. Globally waste is estimated to be responsible for anywhere up to 20% of global methane emissions with municipal solid waste representing about 90% of it (Bingemer and Crutzen, 1987). Hence the potential for reducing CH_4 emissions in the waste sector lies primarily with recovery of methane from landfills and dumpsites (Kumar et al., 2004).

POTENTIAL OF WASTE SECTOR AS A CMD PROJECT IN KANO METROPOLIS

GHG inventories of waste sector in Kano metropolis

Table 1 shows Nigeria's National Greenhouse Gas Inventory for 1994, the total CH4emissions from wastes sectors were 35.22 Gg, of which municipal solid waste disposal contributed 19.567 Gg of CH4 emissions. Similarly, the National Greenhouse Gas Inventory for 1998 based on Revised 1996 IPCC National Greenhouse Gases Inventory, had estimated the national total emission of CH4 as 14,152 GgCO2-e or 14,152,000tCO2-e (673.90 Gg CH4.

Table 1: Per Capita Sectoral and Gross Emissions for 1994

SECTOR	CO_2 (kg C/cap)	1994 CH_4 (kg C/cap)	specific N_2O (kg N/cap)	Emissions CO (kg C/cap)	NO_X (kg N/cap)	NMVOC (kg NMVOC/cap)
Energy	324.64	11.44	0.05	54.26	1.58	19.27
Industry	4.96	0.00	0.00	0.00	0.00	3.79
Solv.use	0.00	0.00	0.00	0.00	0.00	0.00
Agric	0.00	18.17	0.03	14.83	0.47	0.00
Luc	212.92	0.14	0.00	0.67	0.01	0.00
Waste	0.00	16.21	0.00	0.71	0.01	0.00
Total	542.54	45.97	0.08	70.46	2.07	23.06

Source: Nigeria's communication to UNFCC (2011)

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 fulfillment 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, shown in Table 2 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 CH4 emissions. 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. Interestingly, this is at variance with the general trends in other developing countries. In India for instance according to their own Initial National Communication to the UNFCCC, Municipal Solid Waste accounts for 53% of total methane emissions from the waste sector and in Malaysia and the Philippines, it accounts for 82% and 57% respectively.

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%).

Table 2: Gross National Emissions by Major Sector and Removal by Sinks in 1994

Source/sink categories	co_2	ch_4	(gg) n_2o	co_2	no_x	nmvoc
ENERGY	115109.45	1462.96	7.52	13124.90	499.30	1864.40
Fossil Fuels	115109.45	1018.24	4.32	9044.52	383.43	1864.40
Biomass Fuels		444.72	3.21	4080.38	115.87	913.30
INDUSTRIAL PROCESSES	1760.88	0.05	na		0.46	366.84
Iron/Steel		0.05	na		0.46	0.04
Inorganic Chemicals	260.09	Na	na		0.46	
Non-Metallic Minerals	1500.79	na	na		0.00	
Paint		na	na			274.97
Food/Beverages		na	na			3.07
Textiles		na	na			88.77
SOLVENT USE	260.09	0.05	na		0.46	0.04
Paint Applications		0.05				0.04
Degreasing/Dry-cleaning						
paper printing	260.09				0.46	
WASTES	1760.88	0.05			0.46	458.68
Municipal solid waste	1760.88	0.05			0.46	458.68
Waste water treatment	Na	na	na	na	na	Na
NET EMISSIONS	192484.7	5930.70	11.95	17045.4	658.28	2231.51

Source: Nigeria's communication to UNFCC (2011)

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. 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. Table 3 shows Nigeria's 20 and 100 year's projection of GHG projection.

Table 3: Cumulative GHG Emission in 1994 to Global warming in 20-years and 100-years Horizons

GHGemission by sector	1994 emission(ggghg)	GWP		CO_2equivalent (Gg-CO_2)		Contribution to warming	
		20 Yrs	100 YrS	20 Yrs	100 Yrs	20 Yrs	100 Yrs
CH_4							
Energy	1476.2	62	24.5	91525	36167	16.24	10.59
Industry	0.00			3	1	0.00	0.00
Solv.use	0			0	0	0.00	0.00
Agric	2344.2			145342	57434	25.79	16.81
Luc	18.5			1148	454	0.20	0.13
Waste	2091.7			129686	51247	23.01	15.00
Sub-total	5930.7			367703	145302	65.24	42.53
N_20							
Energy	7.5	290	320	2167	2391	0.38	0.70
Industry	0.0			0	0	0.00	0.00
Solv.use	0.00			0	0	0.00	0.00
Agric	4.1			1188	1311	0.21	0.38
Luc	0.1			37	41	0.01	0.01
Waste	0.3			74	81	0.01	0.02
Sub-total	11.9			3465	3823	0.61	1.12
TOTAL				563653	341610	100.00	100.00

Source: Nigeria's Communication to UNFCC (2011)

Waste characteristic and Methane emission in Kano metropolis

From the samples of solid wastes collected from different dump sites and sampled households in three different residential zones in Kano metropolis, eight different types of wastes were categorized. These are food scarp, paper, textile and rubber, plastic material, glass, metal, ash and dirt and vegetables. Table 4 shows the different categories of waste observed in the three residential zones of Kano metropolis.

Table 4: Waste characteristics in three residential zones of Kano metropolis

Categories	City	G.R.A.	Suburban
Food scrap	38	5	40
Paper	6	34	5
Textile rubber	7	10	4
Plastic material	10	17	6
Metal	5	20	3
Glass	7	12	1
Ash, dirt	18	1	20
Vegetable	9	1	21

Source: Fieldwork (2007)

Analysis of waste type shows that Kano metropolis's solid waste consists largely of organic and other biodegradable matter (65 %) - typical of low- income developing country. Kano metropolis produces about 1, 0805,000 tons of solid waste per year or approximately 3050 metric tons per day. By 2025, this figure is expected to increase to 1.825 million tons per year, or 5000 metric tons per day (Nabegu, 2013). These are estimates and the real values are probably more than these quantities, but what is certain is that the quantities will increase tremendously in the years to come as a result of population increase. Current management of waste in Kano metropolis is predominantly in unmanaged landfills where anaerobic degradation of organic material occurs, causing CH4 emissions. When organic waste is sent to open dumps as is the case in all Nigerian cities, it is buried under layers of dirt. Eventually, all oxygen is consumed and organic matter decomposes in anaerobic conditions. Anaerobic decomposition generates methane, a greenhouse gas that is 20 times more potent than CO2 in trapping the sun's heat. Garbage dumps and landfills generate about 11 per cent of anthropogenic emissions of greenhouse gases (Cointreau, 2008). Methane concentrations can reach up to 50% of the composition of landfill gas at maximum anaerobic decomposition (Cointreau, 1996). Also, Hoornweg et al. (1999) have shown that for every metric ton of unsorted municipal solid waste (containing 0.3 Mt carbon), 0.2 Mt are converted to landfill gases.

Thus the major GHG emission from wastes sector in Kano metropolis is methane (CH4), which comes from both solid waste and wastewater treatment and human sewage which are all mixed in the landfill in Kano. The estimation of methane emission done by this study followed the same procedure as the revised 1996 IPCC National Greenhouse Gases Inventory, and found 104.45 Gg per year which is equivalent to 2,193, 450 tCO2-e. The estimation was based on a total of 3,085 tons per day of wastes disposed through land filling. This estimation considered only the emissions from the currently operated sanitary landfills but not from the transfer stations, uncollected waste that is left on the street and yard all over the metropolis and old landfills.

The total generation of GHGs for Kano metropolis is low when compared to emissions from cities in developed economies. However, Nigeria's gross emissions may approach those countries if its population continues to grow at the current rate of 2.5% per annum since per capita emissions is also likely to increase. Apart from population growth, Kano metropolis as indicated earlier has been experiencing unprecedented urbanization over the last five decades. 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.

Based on waste composition and the amount of methane emission from the waste sector in Kano metropolis, an option that can be developed as a CDM project for mitigation of GHG emission from wastes sector in Kano metropolis and other Nigerian cities in general is the capture of methane from the solid waste disposal on land. However, other option such as, recycling was found to be very successful and effective in Kano (Nabegu, 2011). Also pre-treatment of wastes by applying Mechanical Biological Waste Treatment is another approach, which can reduce the significant volume of wastes.

Mitigating climate change through methane capture can be done by collecting emitted LFG from the disposal sites and either flaring it, or utilizing it as an energy resource for electricity production, a process referred to as Landfill Gas to Energy (LFGTE). It is worthy to mention the fact that according to some studies, when properly maintained will actually have a positive impact on the carbon balance. Unlike incineration for instance which results in the rapid oxidation of organic matter, landfills serves as sinks for the long- term accumulation of such materials, much like natural peat lands (Bramryd, 1997).

Despite the prospects, it is difficult to envisage any major flow in CDM projects in Nigeria due to several factors. First, Nigeria appears to have no real definitive climate policies. Climate change is not seen as a national priority in the face of more pressing needs for economic growth, but is rather treated sparingly from time to time. This situation, to a lesser degree, describes the position of many developing countries (UNEP, 2004). Secondly, Nigeria's approach to municipal solid waste has been directed at addressing only the most apparent and perceptible impacts of waste disposal, as its affects esthetics and public health. Thirdly, is the fact that energy prices in Nigeria are currently low, especially considering that natural gas, which is increasingly forming the major part of the fuel mix, is supplied at heavily subsidized prices. Nonetheless and despite these constraints Nigeria in general has the potential to attract investors to the country for CDM projects that can be initiated across all sectors of its economy and the waste sector of Kano metropolis can be an excellent project in the waste sector.

CONCLUSION

To achieve the potential of attracting CMD projects, Nigeria needs to implement a lot of reforms. At the most immediate and practical level there is the virtual non-existence of national priority on climate change and no clear adaption and mitigation plans for all the different ecological zones. Second, the NCA CDM authority should be involved in advocacy and awareness campaign to make itself known within and outside the country through intensive effort to acquire international recognition for CDM projects, while small -scale CDM projects spanning across all sector of its economy be encouraged for development. In addition, states and local authority CDM authorities should be created to discover potential CDM locally, and to aid the interactions between the state level Project Developer (PD) and the NCA. The NCA should provide capacity building to the state and local government CDM authorities, provide access to data, and support the dissemination of information to the public and other stakeholders. Third, subsidies should be provided by the government for CDM projects. Third, Nigeria should set up a carbon fund similar to what already exist for small and medium scale enterprises in the country; to encourage organizations to assist small- scale CDM project.

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