ECONOMICS OF WASTES MANAGEMENT IN LAGOS STATE NIGERIA (1980 – 2003)

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CERTIFICATION

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ABSTRACT

Solid wastes management in most states of Nigeria especially in Lagos State is unsatisfactory despite consuming a relatively high proportion of the State's budget. This tends to 'crowd out' other social amenities. Most of the attempts made to improve performance in the discharge of solid waste services have focused mainly on supply-side activities such as collection and disposal capacity which have failed to yield very desirable results. On this premise, this thesis therefore explored a different tool of waste management by considering the demand-side approach into the planning process. This analysis questions the initial assumptions that households and firms accord low priority to solid wastes management services as compared with other composite goods and are quite unwilling to pay for it. It also calls to question the command-and-control approach to solid wastes management.

To achieve our objectives therefore, the study investigates the relationship between waste generation per capita and its determinants in Lagos State which include among others, the socioeconomic variables such as income and urbanization, weather variables in the form of precipitation and temperature levels and; economic instruments such as price of recyclables (recycling incentive) and user fee.

The study also investigates the impact of weather variables and economic incentives above on waste generation at the commercial level in Lagos State. To accomplish our analysis, primary instruments were employed in generating the economic incentives in Lagos State and in addition to this, covariance analysis, ordinary least squares, generalized least squares as well as integrated autoregressive moving average (ARIMA) were employed in accomplishing the above analysis.

Among other things, the study found an inverse relationship between both the residential waste and household user fee. Income has a direct relationship with residential waste generation. Significant economies of scale were equally found in urbanization as per capita waste decline with increases in population density. Weather variables also exerted positive impacts on waste per capita. While recycling incentive relates positively

(contrary to theory) to waste per capita. For the commercial sector, commercial waste is positively influenced by recycling incentive and temperature level, while precipitation and commercial user fee relates inversely to commercial waste.

Based on our findings, we therefore recommend the use of variable user fee in Lagos State, encouragement of recycling and composting via some recycling incentives and strengthening of bodies involved in waste management among others. The study has contributed to knowledge by confirming the beneficial role of economic incentives as against the conventional property taxes and Government's subventions employed in waste management in Lagos State. It has also been able to determine the impact of socio-economic, demographic as well as meteorological variables influencing waste management among others.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The environment is seen as the outer physical and biological system, in which man and other organisms live and interact. Therefore, the application of economic instruments in solving its problems require an understanding of its components and, the need for positive and realistic planning that balances human needs against the potentials of the environment. This is why environmental issues have continued to form part of strategic thinking. More important is the fact that environmental imperatives cannot be isolated in the quest for sustainable development.

The rising concern for the environment can be attributed to the realization of the limited carrying capacity of the environment. Man, in his bid to further satisfy his needs and aspirations for further development and better living conditions exerted further influence on the environment in which he depends for survival. This causes further deterioration of his environment. This outcome is avoidable. Based on the report of Agenda 21, the success of efforts to eradicate poverty and manage the natural resource base for economic and social development depends upon fundamental changes in global consumption and production patterns.

Even though certain innovative production processes have been celebrated over the years, the environmental gains from these innovations are being offset by huge consumption. Excessive consumption is caused mainly by population pressure in the metropolitan centres and higher income status of individuals. The population problem is compounded by the fact that efforts towards improving the environmental quality and economic performance of products have been some incentives for consumers to consume more. This process negates the benefits of the original improvement in the environmental quality and economic performance (the rebound effect).

World consumption patterns pose formidable threats to the environment under two opposing grounds (excessive consumption and inadequate consumption). Consumption pattern has gone up dramatically due to expansion of the global economy and a corresponding explosion in standard of living. For instance, the global consumption expenditure has grown by an average of 3 percent annually since 1970. From 1973 to 1998, the World consumption in real terms has more than doubled to reach US 24 trillion dollars i.e. twice the 1975 level and six times that of 1950 (UNDP, 1998). According to the "State of the World 2004" report, the amount spent on goods and services at the household level has increased fourfold since 1960 and topped more than $20 trillion in 2000. The issue therefore is, what is wrong with increases in consumption pattern or growth in per capita consumption despite the fact that a sizeable portion of this growth in consumption is essential for human development?

What is wrong is that while per capita consumption has grown dramatically, there is no corresponding growth in consumption for everyone. Based on Brundtland reports (1994), the richest quintile of the World's population, accounts for as much as 86 percent of the total private consumption expenditures. This is against the 1.3 percent total private consumption expenditures of the poorest quintile. The problem of inequality of consumption as reported is not only an intra-country issue but also has inter-country dimensions. An average North American consumes almost 20 times as much as an average Indian or Chinese and 60-70 times more than an average person in Bangladesh. Human Development Report (1998) also finds that gaps between the world's richest and poorest people have been steadily widening, and that in Africa, the average household consumes 20 percent less than it did 25 years ago. In addition, growth in consumption has been attributable to wants rather than needs (a breakdown of this for the World in 1998 can be seen in Appendix N).

Secondly, while there is an unprecedented rise in world per capita consumption, a breakdown of it indicates that only a small proportion of it is essential for human development. Most of this spending has been for wants rather than on essential needs.

In Africa however, the story is different, while the industrialized and industrializing countries of the world are increasing their consumption on the average, the consumption of an average African household decreased by 20 percent (UNEP DTIE/ROA, 2000). While the per capita consumption is declining in Africa, there is a marked increase in per capita consumption of higher income people. This group has access to wider economic opportunities, wealth, privilege and political power while the lower income groups are further subjected to a decline in per capita consumption. The environmental consequence of under-consumption in this case is manifested in further poverty, lack of infrastructure, poor environmental management and further degradation of the natural environment among others.

Low income residents of urban centres therefore are the most vulnerable to exposures from environmental health hazards, the most susceptible when exposed to pollution, and above all, are the least able to cope with the consequences of environmental disasters when they occur. The reasons for the above are as follows. The households with inadequate income are less able to afford accommodation that shield them from environmental risks and are forced to occupy the ecologically fragile areas (usually slums/blighted areas). These fragile areas are without pipe-borne water, adequate provisions for sanitation, drains and garbage collections. This is so because they are priced out of safe, well located, and planned residential settlement with adequate investments in infrastructure to mitigate the impact of disasters when they occur. Other reasons include their undertaking environmentally dangerous work to meet their physiological needs, they also lack the political resistance to environmentally detrimental governmental decisions among others.

Urban environmental improvement can be an effective means of reducing poverty, moreso that the improvements enhance healthier living and working conditions for urban poor. Better health resulting from environmental improvement leads to healthy children that grow into healthy adults without excessive expenditures on medicines and health care. They also avoid the loss of income that can result from taking time of work due to illness or to nursing sick family members. They are less likely to lose their jobs and enter a vicious circle of poverty and destitution. National policy frameworks devised by countries in less developed countries therefore calls for the necessity of preventing poverty-driven environmental degradation in the context of rapid population growth and improving the environmental conditions of the poor.

Urban environmental problems must been given a propriety moreso that the world population is expected to grow by 3.7 billion over the next 40 years. Ninety percent of that rise will take place in developing countries, largely in cities, pushing population densities in many places to an extreme. World consumption of energy and manufactured goods will triple, even under more efficient patterns of use; for developing countries, the increase will be fivefold. If emission (and waste) per unit of output remains unchanged, tens of millions of people will die prematurely each year as a result of pollution. Water shortages will become intolerable, and tropical forests and other natural habitats will shrink dramatically. Fortunately, such an outcome is unnecessary (Ryan, 1992; see also Usoro, 1998).

Waste management is a part of system of material utilization in the overall economy. In order to fully appreciate and understand the connection between waste management and the economy, it is necessary to see the interconnection between the functioning of the economy and waste management. This is necessary because the viability of any activity such as recycling affects and is affected by, arrangements upstream in the supply of virgin materials from primary sectors and imports, and downstream in the options for disposing or on-selling materials once they are discarded.

The materials cycle is an open one because of the presence of international trade. New materials may enter the cycle as raw materials imported from other economies or as materials embedded in imported goods. At the other end, materials may move out of an economy as exports because the returns from doing so exceed the alternative local markets. Figure 1.1 that follows therefore shows the overview of this cycle and the associated role of waste management and recycling.

In figure 1.1, developing countries of the world obtain virgin materials needed for productive purposes either locally or as imported virgin materials of various components. They also obtain secondary materials as substantial part of their inputs in addition to some semi-processed and fully processed materials obtained through import for local production. These producers transform these materials and turn them out to consumers as commercial/industrial goods as well as individual consumables. The consumption activities of these sectors therefore create some refuse/residues which are either stored for onward collection by the waste service providers, recycled/reuse (which is hardly the case in Nigeria) or dumped in the streets.

The waste service providers therefore process the waste and transport to the disposal sites (incinerators and/or landfill) or sort the waste for material recovery where it finds its way back to the local producers.

The major import of the material cycle in less developed countries (LDCs) is that dumping and disposal is always the final destination of waste in an open-loop system of material cycle. In such a system, the logic of economic growth implies that the more the level of consumption (both at domestic and commercial levels), the more will be thrown away as waste. The only exemption to this is a re-orientation towards closing up the loop in material cycle. A viable alternative for developing nation like Nigeria is the adoption of a natural model of "closed-loop" system of materials cycle characterized by circular flow of materials and multiple uses of materials.

Practically, a hundred percent closed-loop is not achievable, but economic growth and environmental well being are maintained in the balance where resource conservation in waste management revolves around embracing the '3Rs' (reduce, reuse, and recycling). This approximates to an ideal practicable closed-loop system with the sole objective of diverting as much as possible waste from landfill to productive uses and waste minimization which is the main concern of this study.

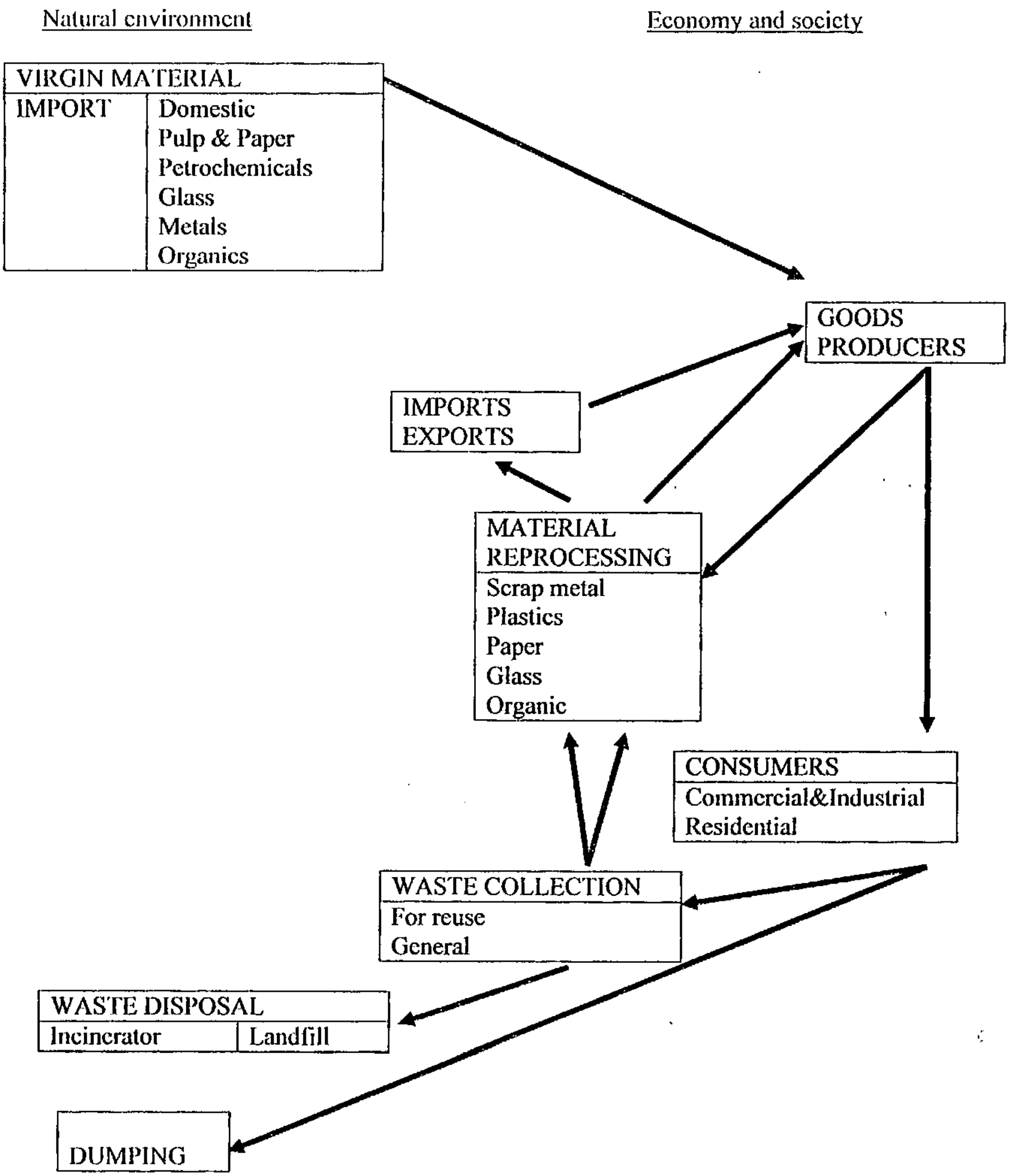

Figure 1.1 Material use cycle

Source: New Zealand Institute of Economic Research (INC.) – 1999.

Relating waste management to the study area requires a brief description of overall basis of policy of the state and Nigeria. Nigeria has an area of 923,768km^2 with population density of 95.8 persons per square kilometre, with predominant population in the urban area (based on the NPC 1991 figures). Nigeria has a fast growing population rate which is expected to hit 152.2 million marks by the year 2010 and 216.2 million by the year 2025 (See the figure 1.2 and appendix C).

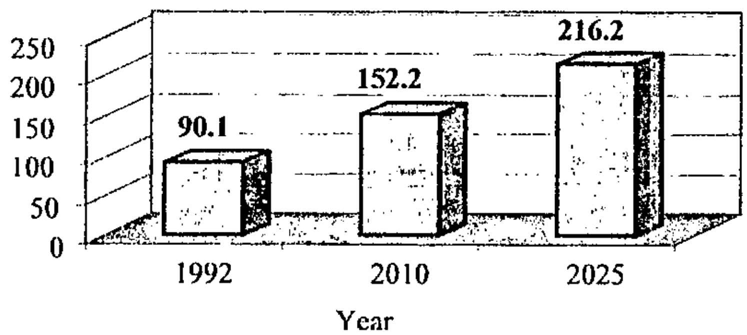

Figure 1. 2: Projected population growth (in millions) in Nigeria.

Source: Figure based on Haub, C., and Yanagishita, M. (1992) World population Data sheet, Washington, D.C.; Population Reference Bureau, 1992.

The process of human agglomeration in multi-functional settlements of relatively substantial sizes called urbanization (with its concomitant commercial and industrial activities) could produce a number of problems in any nation and the most threatening problem of urbanization is social-malfunctioning which can appear in various ways ranging from overcrowding of areas and homes, paucity of social and health services, --- to inadequacy of waste management. Solid waste is a major disutility of urbanization in Nigeria as rapid urbanization combined with industrialization in Nigerian cities have created greater concentration of wastes that these cities' systems can possibly assimilate (See the figure below and appendix H) and one state where this problem is most severe is Lagos State.

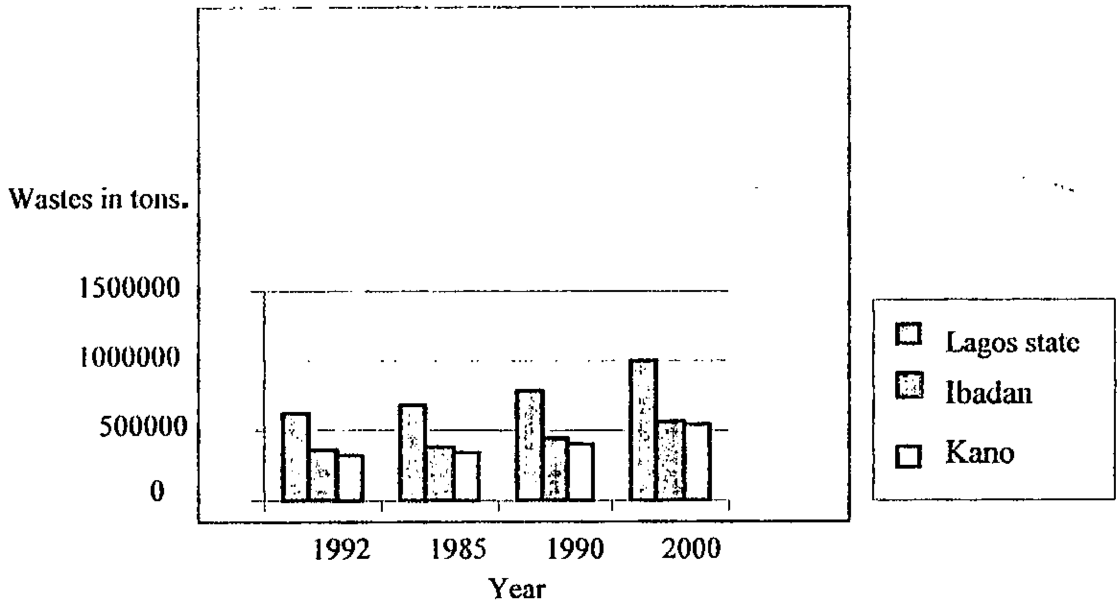

Figure 1.3: Comparative chart of projected and estimated waste tonnage in Lagos state and other states in Nigeria.

Source: Figure based on extract from Federal Ministry of Housing and Environment. The state of the Environment in Nigeria, Monograph series, No.2. Lagos (Undated). Adopted from Umoh (1997; 268).

Study Area

Lagos state has a landmass of 3,577 Square Kilometres which represent 0.4 percent of Nigeria's territorial landmass and is the smallest state in the federation. The physical environment of Lagos State is composed of about 83% of landmass and 17% of water bodies. Natural factors such as flat topography of the state, its high water table, the swampy nature and its intensive rainfall contribute to the problems of the environment and the location of the state makes it possible to receive pollution loads from migrants, rivers and streams from hinterland states. The size of the state, coupled with the other factors identified above act as potential threat to the limited carrying capacity of the Lagos environment.

The state also has been 60-70% of Nigeria's total industries. The high population and large concentration of industrial, commercial and trade activities in the state exposed it to various environmental pollution, unsanitary disposal of solid wastes (some of which are toxic or hazardous) and ecological problems.

Kofoworola (2006) tactically presented Lagos problem well when he commented that, --- Lagos, the largest city in Nigeria, increased seven times from 1950 to 1980 with a current population of over 10 million inhabitants. The majority of the city's residents are poor. The residents make a heavy demand on resources and, at the same time, generate large quantities of solid waste. Approximately 4 million tones of municipal solid waste (MSW) is generated annually in the city, including approximately 0.5 million of untreated industrial waste. This is approximately 1.1kg/cap/day---.

Ojikutu (2006) also corroborated the above point as he remarked that, the population of Lagos, which is 13 million, grew from about 290,000 in 1950 and it is expected to exceed 20 million by 2010. This makes it the most urbanized state in Nigeria and one of the fastest growing cities in the world. Over 50 percent of industries in Nigeria are located in the state, contributing about 70% of the national gross industrial output (Oke *et. al.* 2001). The state accommodates about 6.2 percent of the total population of Nigeria and its annual population growth rate is over 9 percent. The average population density in Nigeria is 85 persons per square kilometer while that of Lagos state is about 1,308 persons per square kilometer. In some areas density is over 20,000 people per square kilometer. The share of Lagos state in international trade in Nigeria is above 70 percent and it is responsible for about 50 percent of the total value added by the manufacturing sector in the country. The state employs about 40 percent of the skilled manpower in Nigeria.

Based on the above facts, it is clear that Lagos state holds the key to Nigeria's industrial survival and its carrying capacity is seriously threatened and urgent measures must be taken to address the problem facing the city. Since the aesthetic states of a place has a bearing on its economic survival, and waste has been recognized as the number one problem facing the state despite the predominant use of command-and-control instrument in waste management over the years. It is therefore worthwhile to look at the potency of economic instruments employed in solid waste management so as to secure a cleaner environment conducive to investment growth. On this ground the research topic is justified.

In summary, Lagos state is chosen as a study area because of its position as the most urbanized state in Nigeria and because it houses about one tenth of Nigeria's population (Ojikutu, 2006). The scenario in the state is such that natural environment is being over-stretched, there is serious pressure on water resources, land is being overexploited, air quality is constantly abused, noise pollution is on the increase and the general aesthetics of the state is threatened. It must be realized therefore that, the environment is nothing but a public good of common heritage of mankind essential for economic survival, and social development. The preservation and management of the environment and of renewable and non-renewable natural resources are therefore a matter of public utility and social interest for the good of the community if the sustainability of human existence is to be realized.

1.2 Statement of the Problem

The health status of our environment is either being threatened by the expansion in the scale of consumption and production activities or is being threatened by the ineffectiveness and inefficiency of the public sectors put in place to manage the environment. It is not clear which of the above or a combination of it is jeopardizing the realization of sustainable development, but what is however clear is that the cost of environmental degradation in Nigeria is assuming a colossal height. For instance, in 1990, the socio-economic profile of Nigeria (1996) made a huge annual sum of five billion United States' dollars as the estimate of the long term economic losses from just the top eight environmental problems facing Nigeria. This is a large percentage of Nigeria's Gross Domestic Product (GDP); therefore, this is a huge loss of resources for Nigeria.

Specifically, there are four cities in Nigeria with the highest production and consumption activities (See Appendix H and I). Lagos stands out of the lot based on the fact that it houses over sixty percent of Nigeria's industrial activities including 300 industries in 12 industrial estates (World Bank, 1995) and as such turns out more wastes and emission. This was confirmed by the World Bank (1995) as it concluded that the state has the greatest industrial activities/pollution in Nigeria as it turns out the highest level of emission which is in the realm of 8,000 tonnes of hazardous waste per year (World Bank, 1995).

The large volume of waste generation in Lagos metropolis is a huge problem because waste represents an enormous loss of resources both in terms of materials and energy. For example, quantity of waste is a problem because it is a product of inefficient production processes, low durability of goods and unsustainable consumption patterns.

Waste generation has been increasing in Lagos State over the years and an amount of about 3 million tonnes of solid waste is currently being turned out by households, manufacturing sectors, commercial premises, construction and demolition activities etc (Adeogba, 2000).

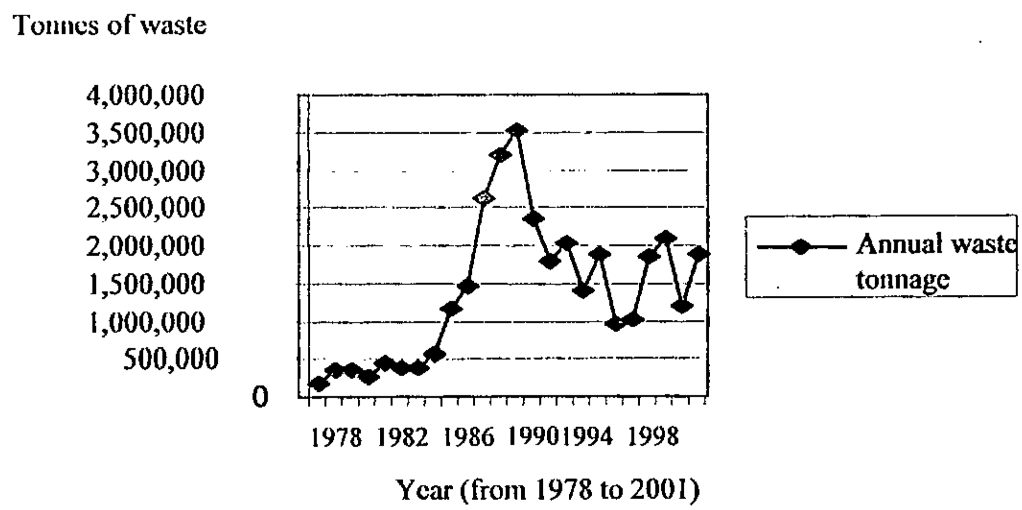

Figure 1.4: Residential wastes turnout in Lagos State from 1978 to 2001

Source: Figure based on LAWMA Landfill Gate Records (Undated)

In addition, waste management exerts significant pressures on the environment in the following ways:

i. Increased transport and the environmental impact of such land transport can be enormous and are usually in the form of significant energy consumption and air pollution since the transport distances from points of waste generation to landfill are much.

ii. Air and water pollution and secondary waste streams from recycling plants pose serious problem to the life support system. Ground or surface water pollution occurs, because of the shallow aquifer, and permeable soil types in Lagos. Liquid wastes, leakages from accumulated solid wastes could readily percolate down to the groundwater and cause pollution.

iii. Also related to the above is the fact that pollution of rivers and seas due to excessive solid waste generation and unsuitable instruments of controlling wastes results in extensive fish kills. It also leads to the destruction of other forms of aquatic life due to an increased organic load and the concomitant depletion of dissolved oxygen in the water. When fish or other aquatic organisms are not immediately killed, they accumulate pollutants, which are eventually transferred to man via the food chain. Airborne pollutants and noxious gases produced from refuse dumps contribute to the increase in pulmonary diseases among the populations near dump sites (Ajiwe *et. al.*, 2000; Sundaresan, 1977).

iv. Landfills in Lagos are unsanitary and they destroy the aesthetic appeal of the environment as they harbor flies, fleas, mosquitoes, rats, and other disease vectors. Some of the diseases carried by rodents and insect vectors from landfills include lassa fever, malaria, filariasis, yellow fever, typhoid fever, diarrhea, cholera, hepatitis, hook worm infestation, skin diseases, *etc.*

v. Great demands for land in the creation of landfills and the landfills represent a permanent loss of resources. Moreover, the need to control the pollution impacts of landfills/dumpsites lead to increasing public expenditure for monitoring and clean-up operations.

vi. Leaching of nutrients, heavy metals and other toxic compounds from landfills are not only dangerous to the present generation but has significant consequences on future generations.

vii. Emission of greenhouse gases from landfills and treatment of organic waste has a daring consequence on the life support ecosystem.

Adeogba (2000), remarked that total waste generation in Lagos is expected to increase due to rapid rate of rural-urban migration. This in effect means that the limited carrying capacity of Lagos will be overstretched. At present, waste management "crowd out" public investments because the opportunity cost of financing solid waste services (SWS) through public funds is the social infrastructure foregone. The present landfills have been congested and mismanaged and the cost of setting up new sites would be enormous. Therefore, if present annual growth rate in population of 6-8 % (LAWMA) is to be sustained, there should be an urgent need to de-link economic activities from environmental degradation via an efficient waste management strategy that focuses on waste minimization among others. On this ground, this research work is justified.

Moreover, economic instruments have been embraced as a potent instrument in the pollution control and waste management worldwide. Recently, the use of economic instruments in pollution control and waste management has been well embraced as it introduces more flexibility, efficiency, and cost-effectiveness into pollution control measures. These instruments act as incentives to polluters to choose their own means of pollution control. When economic instruments are properly administered, it can yield the following benefits:

i. Promotion of cost-effective means of achieving desirable level of pollution/waste.
ii. Stimulation of the development of pollution control/waste minimization technology and expertise.
iii. Provision of revenue base for the government to support pollution control/waste management programme.
iv. Provision of flexibility in pollution control technology.
v. Lastly, it eliminates government's requirement for detailed information in order to determine the most feasible and appropriate level of control of each plant or product (Bernstein, 1993; Oates, 1999; Kolstad, 2000, Jerome, 2001).

To what extent the employment of economic instruments in waste management in Lagos state has been able to modify consumers' and producers' behaviour and reduce waste generation thereby avoiding all the negative impacts/costs of excessive waste generation on the environment is a researchable topic. This research is therefore a justifiable one, as it will determine the future choice of optimal environmental instruments in the state.

1.3 Objectives of the Study

Consequent to the foregoing, the broad objective of this study is to evolve a policy framework for optimizing waste management in Lagos state by coming up with more economically relevant instruments than currently being applied and evolving a basis for future policies and policy reforms.

In addition, the specific objectives of the study are to:
i. Estimate the average user charges for solid waste and the average prices of various recyclables in Lagos state using household and firm surveys for the purpose of formulating sound waste management policies.
ii. Determination of the impacts of the average user charge and the prices of recyclables on waste generation in Lagos state.

iii. Analyzing the impacts of other socioeconomic variables (income, population density, etc), weather variables (level of precipitation and the mean maximum temperature) on waste generation.

iv. Assess the impact of user charges (residential and commercial) on refuse dumping in Lagos state and to project the welfare impact of increasing the average user charge above a baseline.

1.4 Research Questions

Generally, the major questions this research seeks to answer are:

1. What are the nature of the previous policies and instruments for wastes management?
2. What are the best economic policy instruments that can potentially address the excessive waste generation in Lagos state in particular?
3. Do the socioeconomic variables (income, population density, household size, *etc.*) and seasonality factors have any bearing on waste generation?
4. What is the welfare impact of economic instruments above other instruments of solid waste management?

1.5 Research hypothesis

We therefore formulated the following null hypotheses relating to the commercial sector.

Commercial Level

i. Quantity of commercial waste generated has no relationship with the commercial/industrial user charge. In other words, commercial user charge does not affect the quantity of commercial waste generated in Lagos.

ii. Quantity of commercial waste generated has no relationship with the price of recyclables, level of precipitation and the temperature level.

Household Level

The hypotheses tested are as follows:

i. Residential waste per capita is not affected by the variation in the cost of residential solid waste disposals (user fee) in Lagos. In other words, there is inefficiency of residential user charge in influencing the quantity of waste set out for disposal in Lagos.

ii. Household income, price of recyclables, population density, level of precipitation and, temperature level have no impact on waste generation per capita.

iii. The user charges (both commercial and residential) have no significant influences on the volume of waste generation and dumped in Lagos state.

1.6 Scope of the Study

This research covers the entire Lagos state (with its total area of 3,577 square kilometers) and all economic related issues of waste management in the state from 1996 to 2008. It also analyzes the waste management strategies in Lagos state. Even though the study reviews issues between 1980 and 2003, data analysis covers the period 2000 to 2003. This is due to the short period economic instruments were applied. In addition, the data are weekly and monthly, from January 2000 to December 2003. The main instruments of concern in the study are economics instruments. The variables included in the study include user fee (both residential and commercial), price of recyclable, socioeconomic variables as well as meteorological variables (such as inches of precipitation and, temperature level). In order to achieve our objective, we will differentiate the analysis of the household from that of commercial.

1.7 Limitations of the Study

The employment of economic instruments in pollution control and waste management in the study area has been for relatively shorter period of 1st January 2000 to mid 2004. Based on this, this study is highly constrained on the data length. Using weekly and monthly data however, we believe that the data length problem was not serious enough to impact negatively on the results.

Also related to the above is the fact that data were not kept (by the environmental agencies) of some important variables of interest. This study however overcame this through direct survey. In the course of the survey however, response rate was generally low but not low enough to distort the magnitude of the needed information. Another issue also related to this is that most respondents could not be tracked down at home but in their places of work and we cannot really say that we have strict adherence to our stratification.

CHAPTER TWO

BACKGROUND TO ENVIRONMENTAL POLICY AND WASTE MANAGEMENT STRATEGIES IN LAGOS STATE

2.1 Introduction

Lagos is the most populous city in Nigeria. It is a mega city of dominant economic importance in the West Africa sub-region with a population estimate of about 17,552,942 (Office of Central Statistics, 2006). It has an annual population growth rate of 6 – 8 %. Lagos is, by most estimates, one of the fastest-growing cities in the world. It is currently experiencing a population increase of about 275,000 persons per annum. In 1999, the United Nations predicted that the city's metropolitan area, which had only about 290,000 inhabitants in 1950, would exceed 20 million by 2010 and thus become one of the ten most populated cities in the world (Wikipedia, 2008). The metropolitan area, an estimated 300 square kilometers, is a group of islands endowed with creeks and a lagoon. (United Nations Cyberschoolbus, 2008). After the Nigerian civil war, migration to the city, coupled with huge waves of refugees and migrants from other African countries, produced a population boom that has continued to torment the state till the present day.

Lagos is the commercial and industrial hub of Nigeria, with a GNP triple that of any other West African country. Lagos has greatly benefited from Nigeria's natural resources in oil, natural gas, coal, fuel wood and water. Light industry was prevalent in post-independence Nigeria and petroleum-related industry dominated in the 1970's, directly affecting the rapid growth of Lagos (United Nations Cyberschoolbus, 2008).

Oil production, of the 1950's, increased seven-fold between 1965 and 1973, while world oil prices skyrocketed. By 1978, the metropolitan area accounted for 40% of the external trade of Nigeria, containing 40% of the national skilled population. The world recession in 1981, which caused a sharp fall in oil prices, sent Lagos reeling into debt and runaway inflation that persists at present. As a result, a massive programme of infrastructure and social services expansion came to an abrupt halt.

Energy and water access, sewerage, transportation and housing have all been adversely affected by haphazard development of a geographically disjointed city. Despite the region's endowment of water, the city suffers from an acute and worsening water supply shortage. With congested bridges, traffic congestion is a daily problem in Lagos, and it takes an average of two to three hours to travel 10-20 kilometres. Since 1985, state urban renewal plans have concentrated on upgrading the environment of slum communities by building roads and drainage channels and providing water supply, electricity, schools and health clinics (Cyberschoolbus, 2008).

Nwankwo (1994) indicates that growing population, rising incomes, and changing consumption patterns combine to complicate environmental problems (especially the solid-waste problems) in Nigeria of which Lagos state is one. Thus, the population has a direct consequence on waste generation with generation per capita (GPC) which is put at 0.5 kg/person/day. The city of Lagos generates about 9,000 metric tonnes of waste daily. The problem of adequate solid-waste management in Lagos has reached mammoth proportions and the situation must be addressed.

This chapter therefore examines the content of environmental policy of Lagos State and the strategies recommended towards achieving certain environmental targets. In addition, it investigates the historical emergence of the main waste management institutions in the state, outlined their functions, method of operation, financing of waste management and factors militating against its operation. The activities of other complementary bodies in the waste management structure in Lagos state are highlighted while a summary of waste management related legislations and penalties are included.

2.2 Background to Environmental Problems of Lagos State

Environmental policy

Since the convening of the United Nations Conference on Environment and Development in 1992, over 100 countries have adopted national sustainable development strategies or national environmental action plans (division for sustainable development agenda 21/natlinfo. May 2000). These processes have focused on setting national environmental priorities, devising the best private-public intervention mixes in relation to those priorities and involving the public. According to the World Bank Report (2001: 24), "these processes have largely focused on setting national environmental priorities, devising the best private-public intervention mixes in relation to those priorities and involving the public. Although policy implementation has been lagging behind policy formulation, as evidenced by the large majority of country reports prepared for the first quinquennial review and appraisal of the Agenda 21, national environmental policy instruments provide a unique framework within which to obtain a sense of population, of the salience of population issues in the context of environmental policies".

Despite the availability of a National Policy on Environment, Lagos State has also an ambitious environmental policy. The Lagos State environmental policy goals are tailored towards the promotion of economic, social and physical development in the state and the welfare of its citizenry.

Specific policy goals include the alleviation of poverty, hunger, disease and the adverse impacts of these problems on the environment; ensuring that every person in the state had the right to enjoy healthy environment; promotion of rational use and conservation of natural resources for the present and future generations as a means of promoting sustainable social and economic development; development, use, restoration, preservation and enhancing the land, water, air and other natural resources of the state in a manner consistent with the purpose of the policy; mitigation and prevention of pollution of the natural environment; promotion of awareness of the citizen of the state on the need to balance environmental management with development; cooperation and collaboration with all tiers of government and agencies on environmental matters.

Based on the above, the strategies for realizing the above goals centre on integrated and holistic view of environmental issues. The envisaged actions will be systematic and will establish and/or strengthen; environmental legislations, environmental regulations, environmental research, environmental monitoring and evaluation, environmental legislations and enactment of necessary amendments; the establishment of adequate environmental guidelines and standards; monitoring and evaluation of the state of the environment in Lagos State; collection, documentation and dissemination of relevant environmental data; determination of environmental impacts of proposed activities and auditing of those in existence, the impacts of which may affect the environment or the use of natural resources.

In the area of environmental management, the government will pay special attention to environmental pollution, coastal zones management, issues of public health, infrastructural management, conservation of natural resources, and waste management.

Environmental pollution: This has a number of strategies among which is the regulation of polluting activities: every economic activity must be conducted so as to minimize the pollution of the environment, control of the ecosystem degradation, sustainable production, distribution and utilization of all energy sources, proper regulation of oil/gas activities, compulsory installation of pollution abating technology in all modes of transportation, encouragement of alternative modes of transportation apart from road transport with a view to abating noise pollution.

Coastal zones management: The strategies involved here include the preservation and protection of coastal zones and surface water systems from any alterations with adverse environmental effects, regulation of planning and development of the coastal zones and the identification and protection of bio-diversity of the coastal zones.

Public health has agenda such as the promotion of the highest level of sanitation, promotion of a wholesome and conducive workplace environment for all workers, compliance with the national policy on population growth, relocation of human population through carefully implemented new town development without jeopardizing the master plan and the regular monitoring of the state of environment.

Infrastructural management: Continuous studies into cost effective, manageable, cost efficient appropriate technology for service delivery in the areas of water supply, sewage and drainage systems, road network, upliftment of blighted areas, eradication of squatter settlements, control of street tradings and alleviation of level of poverty and destitution and the circulation of results to agencies and local government councils in the state for implementation.

Waste management: proper classification of waste for effective management, submission of study and certification for proposed landfill, engineering design of any treatment plant and waste disposal method, implementation and monitoring of cleanup mechanism for abandoned landfill sites, establishment of alert system against toxic, radioactive, hazardous wastes and illegal dumps and the discouragement of raw sewage into surface waters.

Natural resources conservation: the strategies to be utilized here include the regulation of all mining activities; the promotion and encouragement of prudent use of the mineral resources in the state through conservation, regulation and agricultural land use and allocation; maintenance of a register of up-to-date approved agrochemicals guidelines for their use; regulation of the production, use, storage, transportation, marketing, sales of agrochemicals; setting up of guidelines and regulations for land reclamation and the submission for certification the Environmental impact Assessment (EIA) Report; the development of relevant capacity and procedure to monitor, procure and conserve bio-diversity of the ecosystem; classification of water bodies and regulation for utilization and prevention of pollution of surface, ground water and well; assessment and regulation of the current rate of water abstraction and continuous studies on energy sources in the state so as to promote the use of renewable energy.

The environmental management framework of the policy shall centre on the Lagos State Advisory Committee on the Environment and the Lagos State Environmental Protection Agency (LASEPA) with the responsibility for overall environmental planning, protection and management of the environment. Empowering LASEPA to stipulate procedures and regulations, establish guidelines and procedures for the conduct and submission of EIA and Audit Reports for new and existing facilities. Promotion of cooperation, collaboration and consultation among tiers of government for overall environmental planning, protection, monitoring and enforcement, harmonize and review of existing environmental legislations and enactment of necessary amendments among others.

In the area of environmental funding, the State Government shall fund environmental programmes, projects and management, set aside one percent of the State's Annual Budget as Environmental/Ecological Fund for the emergency relief measures, it shall encourage, donations, grants and gifts from agencies, governments and friends of the environment. It shall also encourage the establishment of an "Environment Endowment Fund". Lastly, it shall empower LASEPA to create avenues for revenue generation.

In the area of environmental education, the Government will introduce environmental education into school curricular both at Primary and Secondary; Support LASEPA to produce and circulate newsletters on environment; ensure the organization of an annual seminar on environment in the state; promote the organization of seminars, conferences, workshops, symposia on matters affecting the environment; empowering LASEPA to develop environmental training programmes for officers, tiers of governments, police, the military, and para-military personnel among others.

2.3 History of Waste Management in Lagos State

The history of waste management in Lagos State dated back to the 70's when Lagos was tagged as the "Dirtiest City" in the World. This was the time the Local Government Councils, in pursuance of their constitutional roles were vested with waste management. These councils however lack institutional and financial capabilities to effectively manage waste in the state thus necessitating for a centralized system under the name – Lagos

State Refuse Disposal Board. This was the time the Local Government Councils, in pursuance of their constitutional roles were vested with waste management. These councils however lack institutional and financial capabilities to effectively manage waste in the state thus necessitating for a centralized system under the name – Lagos State Refuse Disposal Board. This is to facilitate some perceived economics of scale through the establishment of a single Authority within a large metropolitan area under the management of a foreign firm of Messrs. Powell Duffern Pollution Control.

The organization was responsible for the collection, transportation and disposal of domestic waste in metropolitan Lagos, especially Lagos Island and Mainland.

In 1979 however, the organization was renamed as the Lagos State Waste Disposal Board (LSWDB) with added responsibility for commercial/industrial waste operations, cleaning and maintenance of primary and secondary drainage facilities in February 1, 1980. In August, 1981, it commences the "Emergency Flood Relief Operation" during the rainy seasons. The collection and disposal of Scraps and derelict/abandoned vehicles was added to its functions in December, 1984, a Task Force on Environmental Sanitation/Removal of illegal structures erected on the required setback from the roads or those impeding the clearing of drains or drainage channels was set up. There was the commencement of world Bank Assisted Loan for waste collection Equipment and Manpower Development in 1987.

In 1988 however, the primary and secondary drain collection services were taken over by the Ministry of the Environment and Physical Planning. In 1991, the Board was renamed as the Lagos State Waste Management Authority (LAWMA) and was consequently commercialized. January, 1996, it decentralized and deployed domestic waste collection with complementary personnel, to all the Local Government Council Areas in the State. Domestic and industrial waste collection was recentralized in April, 1997. In December, 1999, LAWMA was designed as the only authority permitted by law to undertake commercial, industrial and trade waste collection services in Lagos State while the decentralization and deployment of domestic waste collection was given to the private sector participants (PSP) under the supervision of the Local Governments. In the year 2000, the Highway sanitation exercise was handed over to the Highway Managers Limited.

LAWMA is now charged with the collection and disposal of industrial/commercial waste, with complementary role to the PSP operators, Highway Managers and the Local Government Councils.

In a nutshell, the role of LAWMA in solid waste management in Lagos State can be summarized as follows:

i. Collection and disposal of industrial and commercial waste.
ii. Complementary service to Highway Managers Ltd. and, the Local Government Councils, and PSP operators in domestic waste collection, and
iii. Management of landfill sites and waste Transfer Loading Stations (TLS).

2.3.1 Solid Waste Management System (SWM)

According to Adebisi (2000), the solid waste management system outlines the processes involved in the management of solid waste from the source of generation down to the disposal site.

Theoretically, the following stages are recognized:

a. Generation
b. Storage
c. Collection
d. Transportation/Transfer
e. Treatment/Recycling
f. and disposal

In actual practice, most especially in developing countries especially in Nigerian cities, we have the following stages:

a. Generation

b. Separation of re-usables by sweepers
c. Storage at waste bins
d. Collection
e. Transportation
f. Scavenging by vehicle crews/drivers
g. Disposal/Sales of recovered items
h. Scavenging and reuse at dump site by resident scavengers.

Since the objective of an efficient waste management system is to collect, transport, treat, and dispose wastes in a hygienic, aesthetically pleasing and environmentally acceptable manner at the lowest cost possible, it is important to look at the waste management problem facing LAWMA as evidenced by its waste collection activities.

The three main methods of waste collection in Nigeria are: House-to-House collection, collection from centralized points or communal depots and collection from kerbsides. House-to-House-Collection is practiced in residential areas and other well-planned areas of Lagos City especially in high income low density residential areas, waste bins and bags are usually provided by the Government or the private sector participants (PSP) who would have signed agreement with each household as per the cost as well as the suitable time of collection. In this arrangement, collection crew enters each premise to collect the refuse on regular basis.

Collection from centralized points or communal depots involved placing communal waste storage facilities mainly by the side of the road or other areas with vehicular access and high population density and households just discharge their wastes into the depots where refuse collection vehicles visit these sites at frequent interval to collect these communal wastes.

Collection at Kerbsides is popular where depots are not in use or non-existent but waste generation is high. Roadsides and open spaces are usually used for depositing bins and bags of refuse from where they are emptied.

2.3.2 Waste Disposal Methods in Lagos

A safe disposal of solid waste is a must in effective waste management, the existing methods in use in Lagos State depicts some defects as residents discharge off their refuse in unauthorized places, open spaces, gutters and streams. Others burn their refuse openly while some dump in open dumpsites.

Dumpsites are usually disused pits, valley or ditch where wastes are dumped without treatment, grading or placement of a layer of inert materials to prevent the breeding of files, mosquitoes and disease carrying vectors. Lagos has 32 approved dumpsites as observed by the UDBN Survey (1997).

Sanitary landfill involves disposing wastes on land without creating nuisance or hazards to public health and safety. It utilizes the principle of engineering to confine wastes to the smallest possible level. The waste is covered with a layer of earth at the conclusion of each day's operation or at a specified interval. Their operational stages can be classified under – site investigation; design and engineering, excavation and construction, liner systems, Disposal and final cover.

Presently, there are no sanitary landfills in Lagos state, but there are three major dumpsites in Lagos State with average depth of 18 metres each and sizes of 42.0, 10.5 and 9.3 hectares respectively (see appendix J). incineration is another disposal method which involves waste processing technique by which solid, liquid and gaseous combustible matter is converted to a residue and to gasses by refuse burning and the residue in form of ashes is left as an end product. The main incineration plant in Lagos State was the Oshodi Incineration Plan which has been converted to a transfer station because of the releases of obnoxious gases such as carbon-monoxide, nitrogen oxides, acid gases etc as end-products as against the modern incinerators which are safer with by-products used as a source of energy.

Other method of disposal is the composting which is a biological decomposition of wastes of organic origin under controlled circumstances to a condition sufficiently stable for nuisance-free storage and for use in agriculture.

2.3.3 Financing of Waste Management in Lagos State

In Lagos State, waste management is regarded as a municipal function and as such it is expected to be borne by the state governments. The bulk of the revenue comes from state subvention, Local Government deductions, other source of finance is through property tax, which is based on the value of the property. This is usually revalued every 5 years. A percentage of the property value is determined as property tax, from which a determined percentage is passed on for waste management.

With the commercialization of LAWMA Services, the Board derives additional funding from internally generated revenue from industrial waste collection (user charges). As at mid 2001, a total of about 260 industrial premises were serviced by LAWMA and revenue accruing from such is put at an average of ₦10 million per month.

2.3.4 Private Sector Participation (PSP) Scheme

In December 1999, the PSP programme was set up in a bid to effectively manage the large volume of municipal waste generated daily in the state (see appendix I on waste generation). This programme was made in the area of domestic waste management in which consumers (domestic households) pay an agreed user's fee so as to enjoy the services of the PSP under each Local Government of operation. The details of the successes achieved in the implementation of the programme in the various Local Governments are in appendix K.

2.3.3 Factors Affecting Waste Generation and Effective Management:

Massive importation of manufactured and industrial goods and the consequent change in consumption and standard of living of urbanized Lagos have given rise to a geometric increase in the daily tonnage of waste generation. An average of 5,500 metric tones of refuse is generated daily in the state as a result of the following; rapid urbanization/urban growth, high rate of commercial activities, high rate of industrial production and growth, high rate of supply and consumption of agricultural products, high products/incidents of no compliance with town and country planning regulations – indiscipline among the populace, high incidence of non-compliance with existing laws e.g. Environmental Sanitation Edict, Town and Country Planning Laws, and the new Lagos State Environmental Sanitation Edict. High rate of property development, and geometric population growth. Other factors include pattern of consumption, level of economic activity, climate, cultural habits, population, size of personal income.

All the above points put together hinder effective waste management in the following ways:

a Lack of adequate physical planning, functional drainage system and proper housing condition.

b Environmental pollution resulting from high industrial activities.

c Illegal development and squatter settlements

d Poorly planned road network resulting in perpetual traffic congestion.

e Illegal conversion of designated open spaces.

f Lack of public toilets and baths

g Lack of adequate parking spaces

h Inadequate sewage system *etc.*

UNCHS Habitat (1984) cited by Cointrean-Levine (1994) also showed that World Bank study for 30 Countries showed that per capita waste generation for low income countries (Nigeria inclusive) is as high as 0.4 to 0.6kg/capita/day which is less than the 0.7 to 1.8kg/capita/day of the industrialized countries which surely portray a difficult situation for a rapidly urbanized city such as Lagos as can be seen in its historical pattern of waste generation in appendix I.

2.4 Lagos State Waste Management Institutions

Waste management in Lagos has been adversely affected by large volumes of waste generation and inadequacy of disposal systems. This has caused a constant review of waste management strategies that could minimize waste generation and improve the level of efficiency of waste management institutions.

The following agencies were established or re-organized to improve on the performance of its predecessors.

a The Sanitary Board of Health for Lagos Colony of 1899.

b The Municipal Board of Health for Lagos Municipal of 1917.

c The Water Division of the Ministry of Works of 1967.

d The Sewage and Drainage Division of Ministry of Works of 1977.

e The Lagos State Refuse Disposal Board of 1978.

f The Lagos State Waste Disposal Board of 1979 created through the State Edict number 9 of 1977. Then the amended Lagos State Waste Disposal Board Law No 8 of 1990.

g The Lagos State Waste Management Authority (LAWMA) created by the Lagos State Waste Management Board Edict of 1991.

Other agencies offering complementary roles in waste management in the State are as follows:

Ministry of Environment and Physical Planning:

This Ministry was created first in 1979 as the Ministry of Environment. In 1989, the Ministry was merged with the Physical Planning Division of the State Ministry of Works to become the Ministry of Environment and Physical Planning. These two Ministries merged together had two offices under two Permanent Secretaries and they are responsible to the Commissioner for the Environment and Physical Planning.

Based on the Edict that established it, the Ministry has a total of 59 functions being co-supervised by its eight Departments. The functions fall under: ensuring proper planning of the physical environment and the protection of the environment so as to promote a clean and healthy environment and the protection of the environment so as to promote a clean and healthy environment conducive for sustainable, social and economic development. In the Office of the Environment, there are five Professional Departments and three parastatals and these are:

a Environmental Services Department
b Sewage and Water Department
c Drainage Department
d World Bank Assisted Project Directorate and;
e The Finance and Administration Department.

Parastatals:

a Lagos State Waste Management Authority (LAWMA).
b Lagos State Environmental Protection Agency (LASEPA).
c Lagos State Water Corporation (LSWC).

Other active players in the environmental management in Lagos are as follows:

Lagos State Environmental Pollution Control and Technical Committees:

There are twin Committees with various administrative and technical members. These Committees were established under the Edict 46 of the Lagos State Laws and Regulations. These Committees are the Advisory Sub-Committee with wide range of experts in the area of environmental issues.

The functions of these Committees include;

a The formulation of state policies on pollution control, environmental sanitation, conservation issues and environmental control programmes.
b The examination and suggestion of waste management strategies for the state.
c Examination and recommendation of acceptable methods of collection and disposal of both hazardous and toxic wastes in the state.
d Looking into other environmental issues facing the state and;

e Recommending of standards for solid, liquid, gaseous, toxic or hazardous waste management in the state.

Task Forces, Police and Special Tribunals:

In order to ensure an aesthetically clean environment, the Lagos State Government set up some series of ad-hoc task forces and special tribunals. These include the Lagos State Environmental Sanitation Task Force, and Lagos State Environmental Sanitation Corps. They derived their powers respectively under the Edict no 3 of 1992 and 1998. Their memberships are spread through a broad spectrum of professions with experience and relevance in environmental enforcement. Other relevant implementation bodies in the state include LASEPA, Committee on illegal conversion of uses, Town's Planning Authority, LSWC and Lagos State Urban Renewal Board.

The Governor has powers to set up Special Offences Tribunal when the needs arise and the Court can sit anywhere any time to pronounce judgement on environmental matters.

According to Soneye (2000) and LAWMA (Undated), the state Edicts on environmental management in the state include:

i Street Trading and Illegal Markets (prohibition) Edict no 1, 1984.

ii Sand laterite and Gravel Spillage (prohibition) Edict No 4, of 1984.

iii Removal of Abandoned Vehicles Edict of 1984.

iv Town and Country Planning Law of 1984.

v Environmental Sanitation Edict No 12, of 1985.

vi Road Traffic Law cap 124 Laws of Lagos State and other Amendment including Road Traffic (Amendment) Edict of 1984 which stipulates that:

a. Failure to cover vehicle carrying sand or literite or gravel with tarpaulin attracts a penalty of ₦50 fine or 3 months imprisonment.

b. Negligent spillage of sand or literite or gravel on any highway or road in Lagos State shall attract a penalty of ₦100 fine or 6 months imprisonment.

c. Discharge of sand, literite or gravel on the roadside or highway in Lagos State shall attract a penalty of ₦50 or 3 months imprisonment.

d. It is an offence to abandon any vehicle on the highway or road and failure to report incidents of abandoned vehicles to the nearest police or complaint center shall attract a penalty of ₦100 or 3 months imprisonment.

e. The Environmental Sanitation Law, of 1984 mandates the occupier of any tenement to keep his surroundings, including drains clean, desist from burning refuse inside the Waste Disposal Board bins.

Other Edicts include:

i. Town and Country Planning Edict No 1, 1986.

ii. Lagos State Water Corporation Edict No 25, 1986.

iii. Environmental Pollution Control Edict No 13, 1989 – This edict has the responsibilities and powers to enforce the following.

a. That residents should keep their environment and gutter clean at all times using leak-proof dustbins and/or sanitary bags.

b. That every commercial vehicle should carry a litter basket.

c. That obstructions that constitute public nuisance should be demolished or impounded.

d. That refuse should be properly disposed and should not be burnt or icinerated.

e. That open spaces should not be abused and;

f. That drains, sewage and tanks should be adequately maintained in every neighbourhoods.

Local Government Authorities:

This tier of Government also participated in waste management especially between 1994 and 1996. They were given the responsibility to manage waste within their domains. The Departments of public health in the relevant LGAs were also empowered to maintain the existing sanitary landfills in their domains. These duties were referred back to LAWMA due to non-performance.

The private sector participants (PSPs) also partake in waste management in Lagos. The details can be found under solid waste management system. Other actors include the

Non-Governmental Organization (NGOs) and Community-Based Organizations, Social Groups and Clubs.

Lagos State Environmental Sanitation Law 2000:

This is an important law for managing the environment in Lagos and it has the following stiff provisions:

i. No pedestrian shall dispose of any scrap paper, newspaper, candy (biscuit) wrapper, fruit skin and similar refuse anywhere except in litter bins.

ii. No person shall use litter bins for household refuse, Commercial or industrial waste.

iii. Every Commercial vehicle in the state shall carry a litter bin for use of the passengers.

iv. No passenger shall throw any litter, fruit skins, scrap paper or other (waste) items onto the road from any vehicle.

v. All sidewalks shall be free from obstruction to allow free flow of Pedestrian traffic.

vi. All streets shall be free from obstruction and from construction or demolition materials.

vii. No person shall use another person's dustbin in front of his or another's building far or near from where he resides or works.

viii. No person shall dump indiscriminately any domestic, industrial, commercial waste, or discarded vehicle spare parts or tyres along highways, roads, channels, gorges, land directly or through private operators except at designated refuse disposal sites.

ix. No person shall dispose off domestic refuse or waste except through a private sector participation operator.

x. No person shall paste any handbill, poster, notice, sign or advertisement that bears the name of his organization or business on sidewalks, trees, bridges, public dustbin hydrant, highway or any street without the permission of the appropriate authority.

xi. No person shall construct or put any structure on roads, rail tracks, footpaths or on the required road setbacks.

xii. No person shall organize or hold social parties or religious activities on any major road; and

xiii. No person shall allow cattle, goats, sheep or other animals to roam on the road or any open space.

xiv. Enforcement is to be executed by Environmental Sanitation Corp and the police while special offences courts will be established.

Penalties:

Based on the provisions, a company or corporate body which carries the highest penalty shall on conviction, be liable to a fine of ₦100,000 while the least fine that would be imposed for failing to clean sidewalks is ₦500 against an individual.

In addition, the obstruction of any authorized enforcer of the provisions carries a ₦10,000 fine or six months imprisonment. Enforcers have also been empowered to serve a notice or prevent recurrence of environmental nuisance whenever any is noticed.

2.5 Assessment of Past Policies

As good as the earlier waste management methods look on paper, they are mired with a number of problems ranging from duplication of waste management bodies with overlapping responsibilities, non-enforcement of appropriate environmental laws, to overwhelming waste generation and indiscriminate dumping of refuse.

The operations of LAWMA itself have been met with a number of difficulties among which we have the financial crunch. LAWMA is hardly paid regularly for the services it delivers to government institutions or its agencies. In addition to this, the cost of providing specific charges for waste management services by individuals and commercial sectors were not gazetted properly. Agency did not have a fixed amount of charge, and costs of hiring equipment at the waste management authority were not appropriately set. Moreover, records of operational activities and transactions were not kept properly by this waste management agency (Soneye, 2000).

Another major problem facing the operations of waste management bodies in Lagos State is the institutional framework in which waste management is being operated. There was no clear-cut decision on who is responsible for the operation of the waste management. For instance, in the 70's, the local government was bestowed with the waste management responsibility, but their inability to cope with it led to the setting up of the Lagos State Refuse Disposal Board in 1978. In 1985, the Local Government of Mainland and Ikeja were given the responsibility of waste management as a pilot test project aimed at ascertaining the readiness of Local Governments to take up their constitutional responsibility. Their failure to discharge these duties efficiently and effectively led to the takeover of this duty by the Lagos State Waste Management Authority (LAWMA). In 1994 again, the waste management duty was decentralized to Local Government Councils and again was reverted back to LAWMA in 1997. The import of the foregoing is that the instability brought about by the constant change in bodies discharging waste management services will not permit proper long term planning.

An important issue for consideration in the discussion of waste management strategies in Lagos State is the issue of waste management funding. Urban waste management requires huge capital and the waste management authority with its lean financial resources are finding it difficult to bridge the ever expanding gap between huge waste management financial needs and the low financial base. Among other things, this has prompted a number of questions without answers. These questions include what the actual current cost of efficient waste management should be, who should bear its cost, should public or/and private sector bear this cost? Other questions raised include, whether the payment for waste services should be direct or indirect, if indirect, should it be a component of tenement rate? If the Government should bear the cost, which tiers of Government should be responsible?

The waste management authority in trying to answer these questions concluded that waste management services cannot be free, and therefore people must pay directly or indirectly. The authority therefore decided to be deducting the cost of waste services indirectly from the tenement collected from property owners. The annual tenement was usually set at between 2 to 5 percent of property value. The proportion of this that is set aside for waste management service fee is however uncertain. Apart from the above, the waste management board had been enjoying Lagos State subventions and subsidy.

Another mode of financing waste services came into being in Lagos State in August 1991 under the commercialization programme. The authority was expected to generate enough money to offset its expenditure and even repay the World Bank's US$56 million solid waste management loan within 15 years. The commercialization of domestic waste services therefore entails charging a minimum monthly tariff of ₦25 per dwelling house not more than two floors and additional sum of ₦10 for each additional floor. Also as part of the commercialization of waste, the authority equally took over the operations of

the private industrial waste contractors' services. In effect, it decentralized its operations to cover industrial/commercial waste collection and maintenance of landfill sites while domestic waste service was handed over to the various Local Governments. So, until this commercialization of waste services, the Authority had been operating solely on subventions from state and Local Governments since its establishment in 1977.
The Authority did not achieve much as a number of tenements, Local Governments, State Government and Federal Government and some industries and private residence did not pay up their expected charges.

Apart from finance, some major problems also came up under the commercialization arrangements. Some contractors manipulated the system by bribing some Lagos State Waste Disposal Board (LSWDB's) refuse collection crews designated for private service to collect their refuse for them. In the same manner, some contractors fraudulently obtained spare parts from the LSWDB's inventory for maintaining their private owned trucks. Lastly, some private haulers resorted to clandestine dumping. All the above factors killed the system and led to the abandonment of private sector participation (PSP) in 1991 and the LSWDB did not only revoke the private contractors' licenses but also declared monopoly over service delivery.

In Lagos State, Institutions at all levels of governance have not set up effective pollution control and waste management programmes which incorporates State-specific problems, nor have they the capacity to adequately develop and implement standards, regulations, and charge systems. Where they exist, some constraints have been affecting the implementation of regulatory and economic instruments among which we have inadequate expertise, funding, equipment, lack of political will, limited public support and participation, unclear, overlapping and uncoordinated Institutional responsibilities and above all, lack of effective financial management for collecting charges among others.

Recently, the PSP programme was set up again so as to effectively manage the large volume of municipal waste generated daily in the state (see appendix I on waste generation). They operated through the use of economic instruments (between 2000 and 2004) in the area of domestic waste management in which consumers (domestic households) pay an agreed user's fee so as to enjoy the solid waste services (SWS) of the PSP. The State also operated in the commercial sector through its agency, Lagos State Waste Management Authority (LAWMA) for the same period. The detailed data of the successes achieved in the implementation of the programme in the various Local Governments are in appendix K. from January 2000 to 2004, the economic instruments were fully employed in waste management. To what extent this has been able to achieve cost-effectiveness, efficiency and desirable behaviour is therefore the driving force of this research.

CHAPTER THREE
REVIEW OF LITERATURE

3.1 Introduction

In this survey, effort is made to describe sustainability and the role of environment in achieving sustainability as seen by various schools of thought. In the second part, effort is concentrated on theoretical derivations on waste management vis-à-vis the role of economic instruments in influencing waste generation. This is followed by empirical findings on waste management. Lastly, the experience of developing countries like Nigeria was covered in the last part. This is to achieve a review of policy and the perceived gap in policy so as to establish a basis for this research.

3.2 Sustainable Development

Every nation strives after development because it is an important panacea for sustaining the well-being of its people. Human development is a broad and comprehensive concept. It is as much concerned with economic growth, its distribution, basic human needs with variety of human aspirations and with distress of the rich countries, and with the human deprivation of the poor. Development therefore should be perceived as a multi-dimensional process involving the re-organization and reorientation of entire economic and social systems. Professor Dudley Seers (1969: 3) best posed the basic questions about the meaning of development when he stated thus:

> *"The questions to ask about a country's development are therefore: what has been happening to poverty? What has been happening to unemployment? What has been happening to inequality? If all three of these have declined from high levels, then beyond doubt this has been a period of development for the country concerned. If one or two of these central problems have been growing worse, especially if all three have, it would be strange to call the result 'development' even if per capita income doubled".*

Seers' (1969: 3) statement suggests that if there is a reduction in poverty, unemployment and inequality, then development can be said to be occurring. Sachs (1979) took a step further from where Seers stopped. He described ecodevelopment as an approach to development with the aim of fulfilling social and economic objectives, incorporating ecologically sound management, and solidarity with the future generation. The term solidarity with the future generation used by Sachs was similarly emphasized later as "without compromising the ability of future generations" in the (WCED, 1987). Later, Riddel (1980) philosophically outlined attributes of macro principles of ecodevelopment as the attainment of international parity, hunger and, poverty alleviation, eradication of disease-misery, proximity to self-sufficiency, balancing human numbers with resource, conservation of resources and the protection of the environment.

The Brundtland Commission or WCED (1987) defined sustainable development as the "development that meets the needs of the present generation without compromising the needs of future generations". The report highlighted the need to simultaneously address developmental and environmental imperatives. Subsequent attempts have been made to develop operational measures of sustainability especially in relation to the environment and the following approaches have been outlined.

The Neoclassical View

The Neoclassical view sees sustainability in the context of man-made capital or economic growth measured as the conventional Gross Domestic Product (GDP) where capital and labour play very important roles. According to Neoclassical economists, when resources become scarcer, their prices rise, demand is constrained and the search for substitutes and more resource-saving technologies is stimulated. However, the ecosphere is finite and bounded. Material-intensive economic growth would therefore not be sustainable in the long-run. The implication of the above are: price mechanisms will fail due to imperfections, underlying natural system will collapse and shortages and price increases would destabilize markets and gaps in economic development could result. Sagof (1995) and technological optimist Simon (1981) with the Neoclassical Economists such as Nordhaus (1992) tend to discount the existence of environmental destruction and its negative impacts on human welfare and they believe that new technology will allow the economy to expand without damaging the environment, these technological innovations will enhance substitutions of scarce natural resources for other resources and recycling of wastes generated in the production and consumption processes. Victor (1991) outlined the Neoclassical indicators of sustainability as – maintenance of man-made capital stock, resources substitutability, technological innovations, change in relative cost and price index and, level of economic efficiency.

The Economic-Ecological View

Another sustainability school of thought is the economic – ecological view which is also similar to the Neoclassical school but it calls for the incorporation of ecological considerations into the mainstream of economics or the resource economic framework. The sustainability criteria of this concept include: the utilization of renewable natural resources at a rate equal to regeneration rate. Generation of wastes at a rate equal to or less than the absorptive capacity of the environment. Optimization of efficiency through technological progress which substitutes renewable for non-renewables in an optimal manner (Pearce *et al.*, 1990; Daly, 1996).

The Ecological School

The other school of thought is the ecological school which opined that economic growth portends a threat to sustainable development. The indicators of ecological sustainability according to Dover *et. al.* (1987) include soil quality, ecological efficiency, agro-ecosystem stability, species diversity, sustainable yield and assimilative capacity of the ecosystem.

Ecological-Economics' School

Ecological-Economics' school is another view to the concept of sustainability. According to this group, expansion in human economy and environmental quality are related to each other and the concept of limits must be recognized. The idea is that there are biological and physical limits to economic growth beyond which both ecological and economic growths' collapse would occur. (Daly, 1979, 1996: Costanza, 1991). The sustainability criteria of this school include; limiting human scale to optimal or carrying capacity, a through-put efficiency enhancing technology rather than throughput quantity increasing, use of renewable resources in such a way that they will not be over-utilized beyond regeneration capacity or sustainable yield, the generation of wastes less or equal to the renewable assimilative capacity of the environment and, for renewable inputs, harvesting must be less or equal to the rate of regeneration and for non-renewable inputs harvesting must be less or equal to the rate of creation of renewable substitutes.

The Green/Brown Agenda

All the above schools of thoughts can be tactically coined under the 'green' and the 'brown' agendas for environmental improvement. The green agenda for environment focuses on reducing the impact of urban-based production, consumption and waste generation on natural resources and ecosystems and, ultimately, on the world's life support systems. The brown agenda on the other hand emphasizes the need to reduce the environmental threats to health that arise from poor sanitary conditions, crowding, inadequate water provision, hazardous air and water pollution and local accumulations of solid waste.

Many of the urban poor of the world are threatened by environmental health problems with short timing, local in scale and inaccessibility to basic facilities such as environmental services thus making the brown agenda more appealing to cities of the south. There is however, a complementarity of the two agendas as cities that have the capacity to address their own local environmental problems efficiently and equitably are more likely to be able to respond to the green as well as the brown agenda hence the bulk of our study will follow the brown agenda except for the study on user fees to curtail excessive waste generation and encourage recycling.

Some lessons of interest can be learnt from the foregoing. A sustainable school is right if it preserves the integrity of an ecosystem and wrong if it does not. There is almost a unanimous agreement by the various approaches on the existence of 'real' or 'hypothetical' limit of the biosphere, and sustainable growth involves recognizing this. Even the Neoclassicals agree on the existence of a hypothetical limited carrying capacity of the biosphere, but their insistence is that we will never get there because of substitutions of 'scarce natural resources' for other resources (man-made resources) and recycling of waste due to production and consumption activities. The major oversight of this theory is that the carrying capacity of the environment is a scarce natural resource without any substitutes.

It is not our intent to join in the environment-growth debate, but rather must recall a resolution of this debate as presented by Gardiner (1999). According to him, less-than-optimal outcomes result for both the economy and the environment when decision makers adopt an either/or model of the economy-environment interaction. The key issues in achieving environmental protection and economic progress simultaneously is clean technology and management practice. This work just as price and institutional reforms encourage reductions in all polluting emissions per unit of industrial output. The development and diffusion of environmentally safe technologies can therefore alter the production and consumption processes of goods and services and also become beneficial to human welfare.

According to Toman (1999), others, notably the ecologists Paul and Anne Ehrlich and the economist Herman Daly, believe that the scale of human pressure on natural systems already is well past a sustainable level. They point out that the world's human population likely will at least double before stabilizing, and that to achieve any semblance of a decent living standard for the majority of people the current level of world economic activity must grow, perhaps fivefold to tenfold. They cannot conceive of already stressed ecological systems tolerating the intense flows of materials use and waste discharge that presumably would be required to accomplish this growth."

The "low hanging fruit" in sustaining the carrying capacity of the ecosystem is the employment of economic instruments. Employing these instruments require that economic growth and environmental well-being are maintained in the balance where resource conservation in waste management revolves around embracing the '3Rs' (reduce, reuse and recycle). In order to reduce waste generation, on this premise, the study reviews the practical usefulness of economic instruments in achieving waste reduction.

3.3 Empirical Applications of Constructs on Waste Management

3.3.1 User fee

In an attempt to find the relationship between waste discarded and users' fee, Wertz (1976) made use of two data points of discarded waste per capita (699 Pounds) in a volume-based user fee in the city of San Francisco in 1970, and the quantity of waste discarded per capita (937 Pounds) in all urban areas of the US in the same year. All urban areas in the US were paying property taxes to finance waste services in which case the marginal cost of disposal above the required level is zero or simply put, the price of disposing additional pound of refuse is zero. With these figures, Wertz (1976) calculated the arc elasticity of waste with respect to the price of solid waste services (SWS) as – 0.15 meaning that a 100 percent rise in user fee will bring about a 15 percent fall in the quantity of waste discarded.

The above result suggests that user fee is potent in reducing waste disposal, but Wertz's (1976) distinctive oversight is the area of waste generation and waste discarded. His theory analyzed waste generated while his empirical work focused on waste discarded. The importance of this distinction has a great impact on the harmonization of his theory and empirical work (Jenkins, 1993).

Also related to the above is his failure to address the difference between waste generated and waste discarded. For instance, he failed to analyze the impact of user fee on refuse dumping so as to find out the net benefit of such fee. This is a major flaw of his work. For instance, is the difference in waste generated and waste discarded caused by more composting, recycling, illegal dumping of refuse or refuse burning?

Lastly, he was criticized for disregarding waste generated through other means apart from consumption. The meager or limited data used coupled with the neglection of other important determinants of household waste and lack of disaggregation of waste into its components are some major problems with this method. This is not to underrate his effort in discerning the effect of users' fee on waste discarded.

Fullerton and Kinnaman (1996) explored the effects of using economic incentive in the form of unit pricing programme on the weight of garbage, number of containers, the weight per can and the amount of recycling in Charlottesville, Virginia a University town with a population of 40,341 in USA following the introduction of a unit charge of $0.80 sticker per 32-gallon bag or can of residential garbage collected as from July 1, 1992. Prior to this time, residential garbage collected was financed by the use of property tax.

Data was collected before and after the implementation of the unit pricing programme based on weight per can of garbage and recyclable materials of 75 households. Voluntary curbside recycling requires the city to provide a free recycling container to each household in which to place glass, tin, newspaper, aluminium and certain plastic etc. The 75 households were those who voluntarily agreed to participate in the exercise and with full data out of the 400 initially invited. Some demographic data were collected through questionnaire to each of the 75 households.

Data was collected for four weeks in May and early June before the commencement of unit pricing and again over four weeks in September following the implementation of the programme. Holiday was excluded and the observations in those two days it rained were excluded. Other minor adjustments were made to the data and a control for seasonal and other effects were verified because the change in garbage from May to September might not all be due to a change in price. Seasonal and other effects were verified first by comparing these data with the aggregate in Charlottesville (excluding the University of Virginia) between 1986-1991 and 1993-1994 (excluding 1992).

Secondly, by comparing with the 25 cities in Virginia between May and September 1992. Thirdly, by comparing their observations with those of Richardson and Havlicek (1974). The result shows that the three estimates of seasonal effects are close to one another, but their standard errors are high because commercial and residential wastes are combined.

The variance is large so the observed change in Charlottesville is not statistically different from changes in those of other cities. The Authors noted that the difference in estimates may be as a result of the inclusion of yard waste, inclusion of the households on vacation and other reasons which they tactically corrected.

Their results under what they termed as direct measures show that an average person in their sample reduced the weight of garbage from 10.90 to 9.37 pounds per week (14 percent decrease). By applying Fisher-Sign test, this change is statistically different from zero at 5% level. The arc-elasticity of demand is – 0.076 at mean levels price and weight.

On the volume result, average individual reduced volume from 0.73 to 0.46 per container per week or a 37 percent decrease in volume which is statistically significant at 1 percent. The arc-price elasticity of demand is -0.226 at mean levels of price and volume.

The density (pounds per can) increased from 15.04 to 21.49 per can or an increase of 43 percent meaning that residents stomped on refuse. The possibility of dumping was explored by fielding respondents with survey questions which explored "all" the legal options of disposal and the "other" means to reduce garbage. 8 of the 75 households or 10.7 percent of respondents indicated "other means" as one of their waste reducing strategies.

The methods used to actually compute illegal dumping was to look first into those that indicated 'others' and second into those whose garbage fell to zero during the measurement period. Using the first method indicated that 4 of 75 (5.33%) dumped refuse of an average of 13.38 pounds per person per week or 28% of total reduction in curbside garbage. The second method indicates that 7 of 75 households (9.33 percent) or 43 percent of total reduction in garbage at the curb were due to illegal dumping.

On the overall, 38% reduction in waste was accounted for by more recycling, 28% by dumping, 34 percent due to more composting, less packaging demanded at stores and other methods.

Fullerton and Kinnaman (1996) concluded that households' response to unit's pricing was in the form of reduction in the number of bags but not on the actual weight of their garbage. Household therefore stomped on their garbage to reduce their costs. There was also an increase in recycling weight. Though, refuse weight declined by 14 percent at the curb, after accounting for dumping (using the lower estimate) the actual reduction in garbage is only 10 percent.

They went further to explore the possibility of applying a one-bag minimum as the solution to waste management problems in Charlottesville. The one-bag minimum requires communities to pay property taxes or monthly fees to finance one-bag waste disposal per household weekly and additional bags would require the purchase of stickers. They made a few assumptions that households that dump all their refuse would not dump only the excess over a bag, that their regular garbage would increase by the quantity not dumped and that others presenting up to a bag of garbage (33 percent) are unaffected by unit pricing. They discovered that dumping reduced substantially by 83 percent (0.42 to 0.07 pounds per person weekly) but this will result into undesirable changes in garbage (for example, garbage weight increased by 1.04 instead of 1.54 pounds per week, volume increased by 0.21 instead of 0.27 cans per week) and recycling (rose from 0.50 to 0.58 pounds per week).

They went further by applying a simple cost-benefit comparison into the analysis. The demand for garbage collection is assumed to be the marginal benefit (MB). The social marginal cost (SMC) of Charlottesville was found to be equal to $1.03 per bag (Repetto *et. al.*, 1992) and a price of zero is capable of leading to too much wastes generation since Charlottesville charges only $0.80 per bag of garbage, without illegal dumping, the net gain per person yearly is $3.59. When there is a mild dumping in which individuals dump into firm's dumpsters, the welfare gain is $2.67 or $2.17. The same benefit was computed in the case of a one-bag minimum. The 'threshold' costs per bag that will yield a zero net gain was computed for each situation.

When the estimated administrative costs to the government (this includes cost of stickers, commissions to area merchants, employees payments *etc.*) were computed per bag, these estimates were greater than any threshold values. Consideration of illegal dumping makes the benefits smaller while at the same time added to social costs of disposal. Based on this, they concluded that the incremental benefit of unit pricing is small and in our simple comparison, the social benefit does not cover the administrative cost.

Fullerton and Kinnaman (1996) is commendable as they focus on the impact of weight-based unit pricing which is more relevant in the consideration of the city's garbage and expenditure on disposal. The inclusion of only the household units make this research effort appealing, but the first loophole of the research is in the area of selection of the 75 households. These households no doubt are of the educated and environmentally conscious background. We might as well state that the sample suffered from a self-selection bias which may have a dire consequence on the results of the entire research.

Another sampling problem even identified by the Authors which has the same consequence with the self-section bias is the over-sampling of the home-owners, married couples and full time workers in the analysis. The sample also has a higher than average income and education. This will no doubt make the sample an untrue representation of the entire population moreso that it excluded dormitories and all multifamily dwellings which together make up the 31 percent of housing in Charlottesville.

Moreover, in the determination of who dumped what refuse and the quantity of garbage reduction that are accounted for by dumping, the use of questionnaire which requested each household to state whether they did not attempt to reduce garbage, recycled more, composted more, demanded less packaging at stores or used "other means" to reduce garbage, they assumed that "other means" referred to the possibility of illegal dumping activity alone. This may not be so as respondents were not even asked whether they engaged in reuse. "Other means" for instance may be interpreted to mean reuse or other legal methods of reducing waste by respondents. The consequence of this is that illegal dumping figures might be over stated thus reducing the incremental benefit of unit pricing. It is even possible for respondents to avoid stating that they engaged in other means of reducing gargage even when they actually dumped garbage leading to the derivation of overstated marginal benefit of unit pricing.

Jenkins (1993) derived the equation that explains the quantity of waste discarded by household and firms. For the household, he relates the quantity of residential waste discarded per capita to the user fee charged. The commercial equation relates quantity of commercial waste per employee to price which is the user charges for commercial waste services.

The results of the empirical analysis indicate that the demand for solid waste services is sensitive to user fees in both the residential and commercial demand. He estimated the price elasticity of residential demand for solid waste services of -0.12 and -0.29 for commercial demand. They also concluded that the extension of local landfill sites' lives can be accomplished first by imposing user fees rather than the flat fees for solid waste services and secondly by increasing the user fees for commercial solid waste services.

Jenkins (1993) has provided a useful kit and tool for analyzing household's responses to solid waste services. The inclusion of the necessary economic and socioeconomic variables and the verification of the robustness of estimates indicate the thoroughness and usefulness of his estimates. However, the analysis of commercial waste per capita is out of place and the omission of an important dependent variable (average capacity utilization) which affects industrial/commercial waste generation can bias the estimate especially if the omitted variable is collinear with any of the included independent variables.

Goddad (1995) has researched into the appropriate intervention tools to control the size and composition of solid wastes flow. According to Goddad (1995) the most dramatic of the intervention tools is the adoption of high recycling targets for specific factions of the waste streams and special measures to deal with packaging wastes in some European countries. Goddad's (1995) paper therefore reviewed published literature and concluded that the conceptual and empirical basis on which to predicate efficient and effective solid waste management policy is still incomplete. The major basis for public interventions thus far established in the economic literature is that user fee is effective for waste management at the household level. The paper therefore analyses the role of user fees or user charges in rationalizing investments in waste management technology. He however found that the user charges are not rightly set as the waste management institutions have failed to focus on the role that user fees can play in motivating source reduction at the consumer or household level.

The contributions of Goddad (1995) no doubt is commendable, his methodology however is based mainly on reviewing literature on economic incentives which is not thorough enough for serious meaningful conclusion. In addition, the focus was mainly on firm's behaviour at the generation level to the neglect of household behaviour and the roles of incentives in bringing about manageable waste quantities. This gap our study hopes to cover.

Xavier and Pieter (2007) analyzed the instruments for reducing the quantity of waste generated. These instruments were grouped into three categories. The first is what they called pecuniary incentives (unit-based pricing), the second is the service level and the third is the measurements stimulating prevention and waste reduction incentives. They evaluated the applicability of literature results from other studies on Belgium (Flemish region). Factors that have greatest impact on household solid waste generation as well as the municipality specific characteristics were analyzed using a multiple regression model.

They found a positive impact of income on waste generation. They estimated an income elasticity of 0.326. They also found pecuniary incentives as effective instruments in reducing waste. They equally estimated the price elasticity of -0.139. The general conclusion is that a higher percentage of direct costs, directly attributable to waste services, borne by households reduce waste generation.

Xavier and Pieter (2007) no doubt contributed in no small manner to the economics of solid waste, the analysis of the determinants of waste generation is broad in outlook, but the neglect of weather factors in their analysis places an important limitation on their analysis. In addition, such a study is based on developed country with higher level of income, and their results may not necessarily be identical with that of a developing country like Nigeria. Therefore, there is a need for conducting a research based on the peculiarity of a State like Lagos.

3.3.2 Income

In the empirical validation of his theory, Wertz (1976) collects cross-sectional data for 10 Detroit suburbs that deliver refuse to a common disposal authority based on their characteristics and similarities in wastes collection for 1970. He used the ordinary least squares method to estimate a linear regression model. He estimated parameters in an equation that simply relates annual pounds of refuse collected per capita to the annual income per capita and obtained the results:

W	=	888 + 0.0753y	$c^2 = 0.459$
		(6.24) (2.61)	(t – statistic)
		(<0.01) (0.02)	(P – value)

Using these results, he went further by computing the income elasticity of waste as 0.279 at the sample mean of those variables. Meaning that, when a consumer's income rises by 100 percent, his waste will increase by 27.9 percent. Wertz (1976) went further by including six additional Detroit suburbs with similar service characteristics with the earlier ten suburbs and then estimated a regression result of:

W	=	913	+	0.0574y	
		(5.61)		(2.100)	(t statistic)
		(<0.01)		(0.05)	(p value)

He estimated the income elasticity as 0.272 meaning that a 100 percent rise in income will lead to a 27.2 percent rise in waste generation. The similarity of these estimates made Wertz (1976), to conclude that there is a slightly positive relationship between income and waste generation.

Wertz's (1976) income effect generally cannot be resolved by analysis alone, but the uncommon nature of inferior goods creates a presumption that residential refuse quantities will increase when real income increases.

Most research mentioned income as a determinant of quantity of waste, but there is no uniform conclusion (regarding sign and significance). Some researchers have even concluded that the income and waste components' relationship can be non-uniform (Richardson and Havlicek, 1978) depending on the type of waste. The majority of studies however found a positive relationship between aggregate waste and income (Wertz, 1976; Fullerton and Kinnaman, 1996; Jenkins, 1993; Xavier and Pieter, 2007). Investigating this under a different environment would be worthwhile.

3.3.3 Population density

Since population is assumed to be the extent of urbanization, population density has been hypothesized to be influential in the determination of a community's consumption pattern and consequently the quantity of waste generated.

There are however mixed findings on the relationship between urbanisation and the quantity of waste generated. There is an indication that changes in population density also lead to changes in the refuse types. In fact, some types of refuse might be reducing while others might be increasing. The fact however remains that the changes in waste composition brought about by changes in population density do counteract one another and thus affect the result of analysis calling for more empirical analysis under different environments.

3.3.4 Average household size

This is a measure of the economics of scale within the household. This is to ascertain whether or not there is a positive relationship between the average number of members of a household in a community and the waste per capita. For instance, if there is economies of scale within the household, as the household size goes up, the waste per capita reduces.

There are reasons to believe in economies of scale within the household. There is the tradition of handing down items and materials form one member of the family to the other as the size of the family goes up. There is the inclination of bulk purchases (which reduces packaging) as the family size goes up. Moreover, large families share some goods like newspapers and yard space (Jenkins, 1993). Richardson and Havlicek (1978), Fullerton and Kinnaman (1996) agree to the presence of economics of scale while Jenkins (1993) disagrees with the presence of economics of scale within the household.

3.3.5 The age distribution of population

The implication of age distribution on waste quantities has been described by Richardson and Havlicek (1978). The consumption bundle of individual changes over his lifetime. Total waste generated is low in early age, it increases with age, thereafter in old age it declines. Jenkins (1993) represented the active age of consumption to be between 18 and 49 years and his empirical work validates the expectation of a positive correlation between age distribution and waste generation even though Richardson and Havlicek (1978) could not validate the active year's positive and significance result calling for more empirical evidence especially in a different setting.

3.4 Policy Issues

The nexus between environmental conditions and development is a clearcut one. Deforestation, soil erosion, water pollution, air pollution, water hyacinth expansion, urban decay, industrial pollution are some of the environmental problems which if unchecked can lead to colossal ecological and economic losses which can hinder further economic growth, impair human health and environmental quality. A sustainable development therefore is impossible in an environment that does not enhance the health status and the general well-being of the people.

Umoh (1997) aptly put the nexus between the environment and human development in Nigeria well when he stated thus:

"All countries, whether underdeveloped, developing, or developed are always striving to meet the basic needs of its citizenry. In the quest for development in Nigeria, human activity and technology have greatly impaired the natural ecosystem by undermining its viability to such an extent that it has become diminished in terms of biodiversity, bioactivity and biomass making it less able to withstand shocks. Such deterioration of the environment is responsible for the pervasive level of poverty in Nigeria and has had a far-reaching negative impact on the environment upon which man depends for survival. It further suggests, that to improve the conditions of living for people in the immediate term and safeguard the standard of living for the future generations, the balance of the natural ecosystem must be enhanced and protected. There is the need to stop the degradation of land and forestry assets and restore the ecological balance".

The socio-economic profile of Nigeria (1996) corroborated the statement of Umoh (1997) in its estimates made in 1990 in which the long-term losses for only the top eight environmental problems in Nigeria was put at over five US billion dollars annually except mitigative actions are taken.

The realization of the need to initiative mitigative measures so as to curtail the adverse effects of environmental degradation on sustainable development necessitated the Nigerian government to promulgate Decree number 42 in 1988 in response to the Koko toxic waste episode which involved the importation and dumping of hazardous waste into Nigeria and later the Federal Environmental Protection Agency (FEPA) Decree number 58 of December 1988, which gives the agency overall responsibility for formulating and implementing a national environmental policy and to set a national guideline, criteria and standards for water quality, effluent limitation, air quality and atmospheric protection, noise control and the discharge of hazardous substances was initiated. The Decree also set out appropriate penalties for non-compliance with its provisions. Following this is the

National Policy on Environment which was launched in November 1989 to provide the framework for the pursuit and realization of the aims and objectives of the FEPA Decree and the summary of it is well documented in the work on Onwiodukit (1998). The policy has a goal of achieving sustainable development in Nigeria. Specifically, it is aimed at:

i Securing for all Nigerians a quality of environment adequate for their health and well-being.

ii Conserve and use the environment and natural resource for the benefit of present, and future generations.

iii Restore, maintain and enhance the ecosystems and ecological processes essential for the functioning of the biosphere so as to preserve biodiversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems.

iv Increase public awareness and nurturing the understanding of essential linkages between environment and development and to encourage individual and community participation in the environmental improvement efforts.

v Promote cooperation with other Countries, International Organizations, Agencies so as to achieve optimal use of trans-boundary natural resources and effective prevention or abatement of trans-boundary environmental pollution.

vi In the area of energy production and use, the policy states that as energy consumption increases with increase in industrialization, it is essential to ensure a balanced mix of various energy type which will be compatible with sound environmental practice, and the reduction of the negative impact of energy production and use on the environment.

The strategies designed to achieve the above include:

i Encouraging the use of environmentally safe and sustainable energy forms.

ii Promoting safe and pollution-free operation in energy production and use.

iii Monitoring and controlling the level of noxious by-products of energy production and use such as CO, NO_x, SO_2, CO_2 and non-methane hydrocarbons, thereby reducing the "green house" effects.

iv Setting up of stringent standards of safety in all energy production processes.

v Monitoring of oil spill contingency plans including national, corporate and company level plans.

vi Ensuring an effective monitoring and assessment of environmental protection programmes in upstream and downstream sectors of the petroleum industry.

vii Establishing standards for the control of fuel additives with respect to trace elements especially pb, s, va, Ni, Cr and zn.

viii Encouraging re-injection and utilization of produced gases to prevent the adverse environmental impact of gas flares.

Plausible and commendable as some of the efforts made so far to arrest environmental degradation in Nigeria may seem, the fact remains, however, that environmental problems in the country rather than abate are increasing in number, complexity and magnitude. For instance, 80 percent of industries in Nigeria discharge solid, liquid and gaseous effluent directly into the environment without any treatment. Both the World Bank and the erstwhile Federal Environmental Protection Agency (FEPA) have observed that degradation of environmental quality is most severe in four states (Lagos, Rivers, Kano and Kaduna) that house 80 percent of the nation's industries (Osae-Addo, 1992. Adopted from Magbagbeola, 2000). This therefore demands a more aggressive, irrevocable and all embracing approach towards tackling the gamut of environmental problems currently plaguing Nigeria (Oluocha, 2000).

3.5 Waste Management in Developing Countries

All Nigerian major Cities like Abuja, Benin, Enugu, Ibadan, Kano, Kaduna, Lagos and Port-Harcourt are desirous of cost-effectiveness and ecosystem-sustaining regime of municipal solid waste disposal. This is so because households in these states generate about a tonne of Municipal waste annually and the trend is expected to skew upward in the future due to Urbanization trend (Adeogba, 2000).

Durotoye (1998) tactically coined the refuse problem in urban Nigeria as follows: "Bad refuse disposal schemes characterize most Nigerian urban areas. Increasing population density doubtlessly implies greater generation of solid wastes and trash. Refuse moulds and dumps are common features of our town landscape. Often in desperation, people dispose of their refuse in gutters, drains, streams and rivers which become clogged up and cause flooding in the raining season. Consequently, road failures occur with the formation of potholes". According to Durotoye (1998), refuse generated in urban town may pollute water supply of smaller communities living downstream of the town.

Olokesusi (1998) also remarked on the deplorable condition of waste management and its attendant problems when he commented that, "the indiscriminate and improper management of solid wastes in the country can be regarded as serious enviro-social problem which has been causing a lot of psychological and emotional disturbance to the people. -------- very few people are not affected by the present and expanding mountains of solid wastes in all our urban centres, especially at bus stops and markets." In a nutshell, improper solid wastes management may result in one or more of the following:

i. Uncollected wastes encourage the breeding of flies, cockroaches, rats and other rodents which transmit plagues, diseases, rabies and other health hazards.
ii. It may lead to the pollution of underground water due to the percolation caused by rain water and in landfill areas. Ground water is the major source of water in our urban areas, its pollution is of great concern.
iii. It could cause flooding in areas where it is being dumped in streams which might cause a lot of damage to lives and properties e.g Ogunpa flood disaster at Ibadan in 1981 (Olokesusi,1998).

Olori (2003) cited Alo on the beneficial role of environment, and the need for its proper management as follows. "The environment is a sustainer of life and if we do not manage it well we are reducing our lifespan, we are damaging our health and there are factors that are unseen. We want to say take care of our environment so that we can have something to live behind for the coming generation."

Lagos is the largest producer to Municipal solid waste in Nigeria as it generates an average of 7,500 metric tonnes minimum per day, yet it is the smallest of Nigeria's 36 states with an area of 3,345 square kilometers (1292 square miles) which represents about 0.36 percent of Nigeria's land mass of 923,768 sq. kilometers but with a population of

5,725,116 which was 6.4 percent of Nigeria's population as at 1991. The current Commissioner for Environment, Mr. Tunji Bello during the inauguration of waste management society of Nigeria (WAMASON) held at Muson centre stated that: almost 9,000 to 12,000 metric tonnes of refuse are being generated daily. He went further by stating that, at present, the state spends nothing less than ₦400 million per month to manage waste. This is not enough. This in effect means that waste management 'crowd-out' public investments necessitating for a new approach to financing solid waste services in the state.

Bello's (2008) remark above is a confirmation of the earlier picture presented of the state. The population was projected to rise to 7,877,810 by the year 2002 (Nigerian state and local Government Area Demographic Profile 1999-2010). It has a population density of 1712 per square kilometer based on the population Census of 1991 (Population Census of the Federal Republic of Nigeria Analytical Report at the National level NPC 1991). This density figure was estimated to be 2,355 persons per square kilometer by 2002 (computed by the author based on the projected 2002 population). It houses the Nigeria's largest chief port, and principal economic an cultural centre (Microsoft Encarta Encyclopedia, 2000). Lagos has about 17 percent water bodies and over 41 blighted/slum settlements – a fall out of premature and spontaneous urbanization. It has a flat topography, a high water table, endemic perennial flooding and it is swampy (Adeogba, 2000). All these combined constrain waste management.

Moreover, household income in the state has been rising over the years. Despite the increases in income, pollution and waste management problems have assumed a predictable upward trend in conformity with the anti-growth theorists in a dynamic world where the pro-growth view holds sway. For instance, Dosunmu (1998) concluded that the emission inventory in Lagos shows a progressive increase. Waste generation too is also on the increase and the average waste generation per capita a day in the city was 0.55kg. while the least waste generated per day in the state was 7,500 metric tonnes. Out of the total waste generated, only about 73 percent actually got to the final disposal site (LAWMA, undated).

The above situation portrays the inadequacy of waste management strategies which has the potential of adversely affecting the economic and social life apart from posing risks to the health of the people of Lagos state since the visual quality of an urban environment contributes to the residents' self identification with their neigbourhood. It also determines the potential of the particular area for fleas, home out-door oriented recreation and thus contributes significantly to the well being of the citizens.

In the same vein, a pleasant appearance of a city attracts private investors and revenue generating enterprises and, therefore, promotes economic well being of a neigbourhood. An unpleasant appearance on the other hand as it is in Lagos presently contributes to the exact opposite effects i.e. withdrawal of higher income investors, public negligence and accelerated deterioration of physical, economic and social living conditions.

The current trend in solid waste management strategy therefore is to divert as much waste as possible from going to disposal sites or by discouraging the consumption of goods with high waste content through imposition of an optimum disposal tax on solid waste services. This involves reducing the quantity of waste produced, such as by inducing consumers to avoid the purchase of disposable and over-packaged goods, and by industries changing production processes to generate fewer unusable by-products. Alternatives to disposals are being identified (recycling, reuse and composting among others) depending on waste composition. Waste is fast becoming a resource and not a "waste". Alo (2008) also commented on what the ideal situation should be regarding solid waste and its management when he stated that waste minimization for example, is an excellent strategy and an effective way of waste management for Lagos and Nigeria since its objective of reducing operating cost through the elimination of or reduction in waste treatment and disposal is not only achievable but desirable.

One way in which waste minimization can be achieved is through recycling. Recycling (and reuse) result in material being returned to production processes, either as closed loop process (where the material is made into the same, or similar product from which the material arose) or in processes where the waste material is fashioned into something completely different. The main benefits of recycling for the economy as a whole arose from the reduced need for primary extraction, and hence the reduction in the environmental effects from the production, processing and transport of the raw material. Another benefit is in the diversion of waste (as well as its associated cost of disposal) away from the dumpsites.

In other words, recycling (and reuse) also known as the circular waste management option reduces the rate at which primary resources are run down, and reduces the disruption of land surface and water pollution caused during the extractive process for the economy as a whole. Olori (2003) cited Alo (2008) on the beneficial impact of recycling and the need for its adoption when he stated that; "People can make money from waste. People should think of setting up recycling plants for wastes and packaged water nylon sachets. The wrappers are recyclable and they can be used again after being cleaned and recycled to make another set of wrappers," he says. Alo (2008) suggests that incentives be given to users of packaged water who return the wrappers to the producers. "For example, a 100 pieces of used wrappers could fetch 20 naira (two U.S. cents) and if you return 1,000 you get 100 naira (one U.S. dollar). If we do this, our cities will be rid of pure water wrappers".

"Recycling will ensure that the gutters and drainages are not blocked and our homes are not flooded when it rains," he commented. The import of this is that with the necessary incentives, recycling can be made beneficial and waste ending up at the disposal sites can be reduced considerably.

Recycling on the other hand has its associated environmental impacts. Consumption of energy in the separation, transporting, cleansing and processing the recycled materials to the point at which it is combined with the primary material stream are detrimental processes to the environment: Greenhouse gases and particulate emission as well as dioxins are released into the atmosphere in the process of recycling. The general approach or strategy in the adoption of recycling option is, if the process of primary production is more energy intense than secondary production, recycling reduces the rate of energy consumption. Otherwise, recycling is more energy intensive and may be undesirable.

The decision as to which option is best therefore include the trading off of the different pros and cons of the approaches through economic valuation of the different effects. Coopers and Lybrand *et. al.* (1997) reported that the following factors were considered to be important for determining external costs associated with waste management options.

a. Composition of waste stream
b Size of the disposal site or facility
c Physical characteristics of the disposal site
d Age of the disposal sites, or facility
e Spatial location of the disposal site
f Level of pollution abatement in a facility.

The external costs (and benefits) estimate in Pound Sterling per tonne of solid waste (in 1999 prices) was estimated by Cooper and Lybrand *et. al.* (1999) and the table below gives the summary.

Table 3.1: External costs and benefits of different waste management options.

WASTE MANAGEMENT OPTION	EXTERNAL COST ESTIMATE, £ PER TONNE OF WASTE, 1999 PRICES
Landfill	-3
Incineration (displacing electricity from coal-fired power stations)	+17
Incineration (displacing average-mix electricity generation)	-10
Recycling	+161
Ferrous metal	+297
Non-ferrous metal	+929
Glass	+196
Paper	+69
Plastic film	-17
Rigid plastic	+48
Textiles	+66

Source: Adopted from Coopers & Lybrand *et. al.* (1997)

In table 3.1, the positive options indicate a benefit per tonne of waste while the negative represents net disbenefits/cots. For instance, landfilling can bring about $3s net cost to the society. Recycling has net environmental benefits over incineration and landfill. However, these estimates seem to exclude the costs of leachates from landfills, all disamenity costs and some of the environmental costs of processing for recycling.

The above estimates preclude disamenity cost which could be significantly high. This study also suggests that urban incinerations with energy recovery may produce net external benefits amounting to £15.20 per tonne to a net environmental cost of £4.10 per tonne (in 1999 prices). This estimates of cost and benefits must be interpreted with caution due to uncertainty in quantification and valuation of impacts. External costs and benefits per tonne of waste may vary based on location and waste quantity sent out to each option (Waste Strategy 2000 for England and Wales). CSERGE (1993) suggests that existing rural landfill sites without energy recovery may have net external costs of between £1.09 and £10.90 per tonne (1999 prices).

Coopers and Lybrand (1997) went further in their analysis by ranking waste management options by specific criteria. This classification is very relevant in the study of economics of waste management in Lagos State.

Table 3.2: Ranking of waste management options by specific criteria

Rank	TOTAL NET ECONOMIC BENEFIT
1	Source reduction
2	Recycling
3	Landfill
4	Incineration
5	Municipal composting

Source: Coopers and Lybrand *et. al.* (1997)

The import of table 3.2 is clear, source reduction is most beneficial viewed from environmental costs and total net economic benefits' angle. The second best option is recycling after which landfilling follows. The main problem with the ranking table is the placement of municipal composting as the least choice option. The environment in which the research was conducted must have been responsible. In an environmental where the overwhelming waste streams are in the form of biodegradable, composting is as attractive as recycling.

Having passed remarks on Cooper and Lybrands's ranking table, it is better to analyze the waste management options. Source reduction, recycling and composting can be encouraged through the use of economic incentives of which user charges and recycling incentives are mostly favoured. Landfilling and incineration were the most traditionally favoured management options in Nigeria and some other countries of the world. Waste collection was viewed as the role of the municipal governments and people were not expected to pay for waste management services.

After decades of waste management by the Governments and its Agencies, waste management was decentralized and waste management was broadened to incorporate Private Sector Participants. The issue here is, have they fared so well in waste management? How effective and efficient are the waste management strategies? The solution to the above problem is the main concern of this research.

CHAPTER FOUR

THEORETICAL FRAMEWORK AND EMPIRICAL METHODOLOGY

4.1 Introduction

Our theoretical framework and literature review and the analytical framework provided the justification for empirical models of this study. Studies such as of Wertz (1976), Richardson and Havlicek (1978), Fullerton and Kinnaman (1996), Jenkins (1993) have formulated relationship between waste volume on one hand and the average user fee and income on the other hand. However, the issue is far from being resolved as mixed results were obtained. In addition, these studies were conducted in developed economies, this therefore established justification for this study in a less developed economy.

Urbanization and weather variables were justified in Jenkins' empirical analysis as exerting substantial influences on waste generated per capita, in order not to overlook this fact, this study incorporated urbanization into the household sector model while the weather variables were incorporated into the household and commercial sectors as done by Jenkins.

Justification for price of recyclables (both commercial and residential) were based on Jenkins' theoretical and empirical derivations, while the justification for disaggregating of waste to residential and commercial were also based on Jenkins'(1993).

Although, this research shares in common with earlier researches the use of regression analysis, it differs in its thoroughness in the use of econometric packages such as the stationarity test and the elimination of spurious relationship, use of ARMA term and the filtering of data to achieve a white noise among others.

Following from our survey in chapter three, this study adopted the Jenkins' (1993) household decisions on solid waste services' model, which was based on disaggregated household decision on waste services. The model is relevant in formulating policy on solid waste management. On the other hand, wastes were disaggregated into units which are very relevant in formulating policy on the environment. The analytical framework of this research was divided into two major parts. The first part was based on household's decision regarding solid waste using the household production function (Langham, 1972, Jenkins, 1993). The second part was on a firm's decision on solid waste generation using the conventional firm's production function (Jenkins, 1993).

4.2 Willingness to Pay (WTP) and User Fee: a Theoretical Construct

Economists have a distinct definition of value based on the ideals of rationality and consumer sovereignty. Since an individual consistently knows what he or she wants and needs (rationality) and is best able to make choices that affect his or her own welfare (consumer sovereignty), rationality requires that if an individual prefers clean environments to a filthy one he or she must consistently rank clean environment over a dirty one. If a change occurs such that the person believes she is better off in some ways, she may be willing to pay money to secure this improvement. This willingness to pay (WTP) reflects her economic valuation of improved environmental services (Harley, Shogren and White, 1997).

Alternatively, if the change makes her worse off, she might be willing to accept compensation (willingness to accept compensation – WTA) to allow this deterioration. These are the two general measures of economic value for an environmental service.

Considering individual's economic problem, we assure that an individual derives utility from both environmental quality (Q_0 and all other market goods and services ($x = x_1, x_2, \ldots, x_n$) such that $U = u(x, Q_0)$. The individual's choice is however constrained by fixed monetary income, M. The problem becomes: maximize $U = f(x, Q_0)$ subject to $M = Px + P_oQ_o$. Where, P is the vector of market goods' prices and P_o is the willingness to pay for environmental good.

Since the economic value of environmental services (such as solid waste service) is not reflected by direct market prices, consumer surplus measures are used to capture the value of changes in these services.

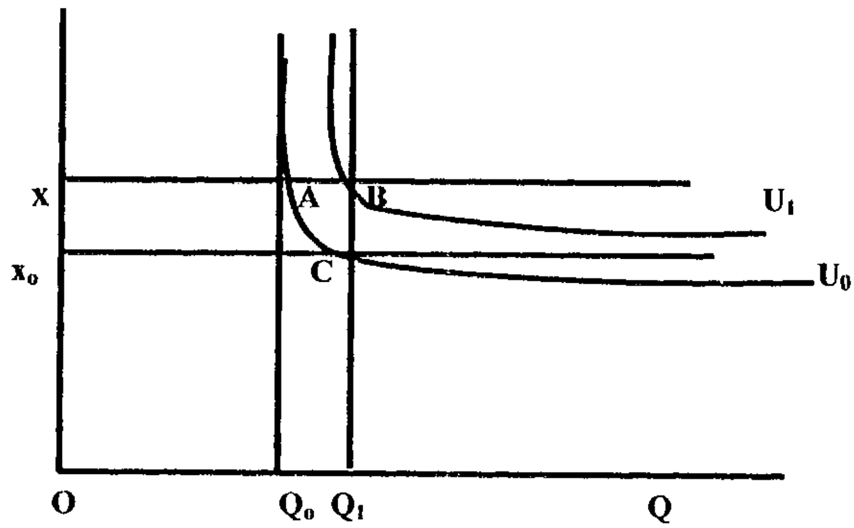

Figure 4.1 Willingness to pay for improved environmental services

Figure 4.1 above illustrates the basic ideas of consumer's surplus for quantity changes in an environmental service. Point A represents the utility level, U_0, and composite market good, x. If we increase the level of environmental services to Q_1 from Q_0 keeping x fixed, the individual's utility increase to U_1 from U_0. The question therefore is what is the maximum he or she is willing to pay (WTP) to secure this change to Q_1 from Q_0? The answer is, the individual would give up the composite market goods until he or she reached his or her original utility level, that is, the move to point C from point B.

This maximum willingness to pay is called the Hicksian compensating surplus (after Sir John Hicks). Based on the foregoing therefore, individuals would be willing to pay for solid waste services and give up some composite goods until his maximum willingness to pay is just equal to the amount that would return him to his original level of utility.

Most households pay a flat fee to have their refuse collected. In this case, household's payment is fixed regardless of the quantity of refuse discarded. Households therefore face a marginal or incremental cost of refuse disposal equal to zero and thus may be disposing of greater than optimal quantities of waste (Jenkins, 1993). Depicting the fee household pays for refuse collection (including transportation and disposal) as the household's demand for solid waste services (SWS), user fee is potentially beneficial in providing incentives for households and firms in the following way.

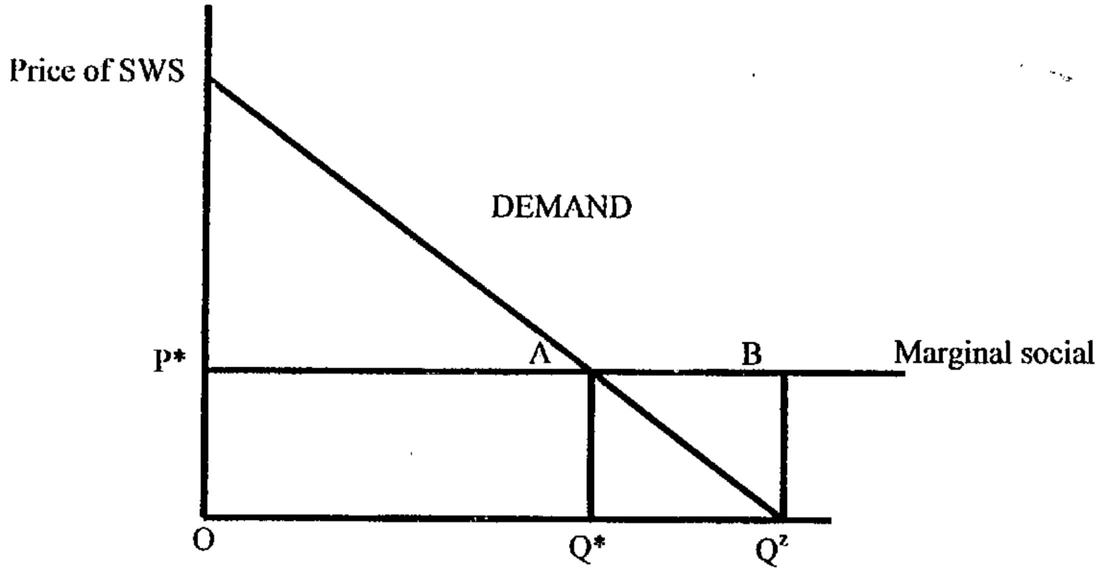

Figure 4.2 the demand curve for residential SWS (adopted from Jenkins 1993).

Consider the demand curve for SWS shown above in figure 4.2, the implication is that as price declines, demand for SWS (which equals the quantity of waste discarded) increases. However, in many cities in Nigeria, price per unit of SWS is zero and the quantity discarded is Q^z which is more than the quantity that would have been discarded with a positive price. If P* were charged per unit of SWS (which could be a 32-gallon container) the quantity of SWS demanded would decline to Q^*. For the quantity of waste not only to decline but also to be optimal, the price charged for SWS should reflect the social cost of such services (Jenkins, 1993). The efficacy of the user fees in affecting waste generation is reviewed theoretically below.

User Fees

Wertz (1976) investigated the direct effect of a positive volume based users fee on residential demand for solid waste services (SWS). He focused on the development of a formal theoretical model of the demand for SWS. Wertz (1976) postulated that individual's purchases are assumed to be guided by the maximization of individual's utility U;

$$U = U(X_1, \ldots, X_n, A)$$

Subject to:

$$\sum P_i X_i + tw - y = 0$$

Where t is the weight-based refuse collection fee, X_i denotes the quantity of good i purchased, P_i its price and y income, the variable A represents the refuse that accumulates on one's premises between collection stops, multiplied by the distance(S) through which the refuse must be transported before the public agency will collect it. While w is the total weight of the refuse which is a linear combination of goods chosen (i.e. $w = K\sum_{ri} X_i$) and $r_i \geq 0$ represent a constant, unit refuse weights and K stands for a shift parameter.

Wertz formulated the Lagrangean of the form:

$$L = U(X_i, \ldots, X_n, A) - \lambda(\sum C_i X_i - y)$$

With an initial problem of choosing X_i and λ to maximize the Lagregean.

According to Wertz (1976), for optimal decision to be made, an individual must maximize his utility which is a function of quantities of goods (composite goods) consumed subject to the waste services he received which is the cost of solid waste services (SWS) in the form of user fee. Wertz (1976) derived first-order conditions for utility maximization and a comparative static analysis from which he derived the direction of relationship between the quantity of wastes a household generates and the cost of SWS in the form of the weight based user fees.

Wertz's analysis implies balancing positive utility from consumption against the negative utility (disutility) from resulting refuse. The conclusion of Wertz (1976) is that consumption of refuse generating goods will vary inversely with both users' fee and the absolute refuse disutility. Theoretically, Wertz (1976) implied that the quantity of waste generated varies negatively with user's fee.

Wertz's theoretical analysis though provided a starting point for further analysis but can easily be flawed on the ground of his myopic view of the factors that influence waste generation. There are other factors that influence waste generation than those suggested by Wertz's theory. Perhaps, the most theoretical oversight of Wertz is the lack of distinction between waste generated and waste discarded. His empirical work considers the latter while his theory relates to the former and this distinction is very important when recycling is incorporated (Jenkins, 1993). Jenkins also criticized Wertz for disregarding any waste generated by actions other than consumption such as yard waste and when this is incorporated, Wertz's earlier conclusions might be affected. Jenkins also criticized Wertz's empirical analysis as necessarily limited by the meager data on which it is based and he did not control for variations across urban areas in income or weather conditions or numerous other influential factors affecting demand for solid waste services which he oversimplified.

Another attempt on solid waste services was that of Choe and Fraser (1999). According to Choe and Fraser, a comprehensive waste management policy should target four sequential goals of reduction, reuse, recycling and disposal. However, most existing studies fail to provide a comprehensive framework within which to provide policy recommendations. For instance, Wertz (1976), Dobbs (1991), Dinan (1993), Morris and Holthausen (1994), and Jackus *et. al.* (1996) focused on waste management at the consumption and disposal stages alone while Copeland (1991), Palmer *et. al.* (1997), and Conrad (1997) concentrate on the production stage alone. Choe and Fraser referred to Fullerton and Wu (1998) in which they stated that waste management policy aimed only at source reduction in the production stage ignores subsequent household behaviour such as waste reduction effort like reuse and recycling, as well as a waste collection charge on the household which can lead the household to demand products with less waste content, thereby affecting production decisions as well.

According to Choe and Fraser (1999), a firm produces consumption good with cost function $C(q,k) - (c+k)q$ where q is the quantity of the good produced, $c > 0$ is the marginal cost incurred in reducing the amount of waste intrinsic in the goods produced. $\alpha(k)$ is the amount of waste intrinsic in the goods after production and it ranges between zero and one.

Choe and Fraser now introduced two policy instruments into what they called a second-best option. That is, the monitoring of illegal waste disposal of the household and imposition of fines on illegal waste disposal by the monitoring regulator. There is a probability variable of catching illegal waste disposal and per unit penalty (which is assumed to be exogenously determined is imposed). It also assumed that the penalty for illegal waste disposal is higher than or equal to the marginal environmental cost of illegal waste disposal. Legal or illegal waste disposal depends on the relativity of inducing legal disposal to the resultant benefits.

They made two propositions. First, that an optimum waste management policy based on second-best option is characterized by a positive environmental tax on the firm, a waste collection charge on the household set between the private cost of illegal waste disposal and the social cost of legal waste disposal and the monitoring probability necessary to support the two instruments to induce household compliance with legal disposal.

Second, a higher monitoring cost makes legal waste disposal costly, and must be made up by a reduction in the waste collection charge. This induced waste collection charge must be made up by an increase in environmental tax on the firm (The rate of penalty for illegal waste disposal has an opposite effect as the monitoring cost).

The second-best optimal problem is stated mathematically as the solution to the maximization of surplus $s(t, \tau)$ in :

$$\text{Maximize}_{(t,\tau)}\ S(t,\tau) \equiv U[q(t,\tau)] - V[e(t,\tau)] - [c+k(t,\tau)]q(t,\tau) - \gamma\{\alpha[k(t,\tau)]q(t,\tau) - \rho e(t,\tau)\} - m(\tau-\delta)/\phi$$

Subject to $\delta \leq \tau \leq \delta + \phi$ and $(t+\tau)\alpha'\ [k(t,\tau) + 1 = 0$ where k denotes equilibrium, ϕ is the penalty for illegal dumping, ρ is the waste reduction benefit from household effort and m is the cost of monitoring illegal waste while other variables are as initially represented.

In all, the second-best policy option is a combination of a strictly positive waste collection charge on the household, explicit monitoring of illegal waste disposal, a strictly positive environmental tax on the firm.

The first problem with Choe and Fraser's second-best option is the assumption of a single representative individual with a private cot of illegal disposal. When this is extended to individuals, there is bound to be a different private costs of illegal disposal to each of them even if all other conditions hold, households with lower private cost of illegal disposal whose private costs of illegal disposal are lower than the threshold will still dispose waste illegally while the rest may comply with the legal disposal. Monitoring cost will now determine the optimal policy. Since monitoring cost is an exogenous factor, the second-best approach may not lead to an optimal decision.

Another flaw of this approach was recognized by he Authors themselves which is the issue of coordination. Environmental taxes are exogenously determined by the National government, waste disposal by municipal governments and monitoring and penalizing illegal waste by the environmental protection or law enforcement bodies. There is bound to be a cost of coordination failure to be borne and this will add to the cost of waste management (Jenkins, 1993).

Jenkins (1993) developed a utility maximization model which relates utility positively to the quantity of goods consumed subject to a number of constraints among which we have the user change for solid waste services.

Jenkins (1993) modeled the household and firm. His household model is based on utility maximization framework of the well known household production model. He assumed that household utility is a function of the quantity of time the household spends enjoying leisure t, and of course, he obtains hourly wage rate s and sT wage per day in addition to the non-wage household income V and total revenue derived from recycling$P_R R_1(t_1)$.

His maximization problem in Lagragean form becomes:

$$L=U(X_1 \ldots X_n, t_L) + \lambda \{sT + v + P_R R_1(t_1) - \sum_{i=1}^{n} P_i X_i - s(t_L + t_1 + t_2) -$$

$$P_W [\sum_{i=1}^{n} \sum_{j=1}^{j} W_{ij} X_i + Z - R_1(t_1) - R_2(t_2)]$$

Where P_i is the market price of good X_i, P_W is the weight-based user-fee, W_{ij} is the weight of jth type of waste associated with one unit of good i (following Wertz, 1976) while Z is the weight of waste created by non-market goods such as garden waste etc. ti is the number of hours per period spent recycling marketable waste(R_1) while t_2 is the number of hours per period spent recycling waste of which household receives no payment for (R_2). Differentiating the Lagrange with respect to $X_{1,\ldots,}X_n$, t_L, t_1, t_2 and λ gives some first order conditions which we shall briefly mention.

His result suggests that as long as the household is paying a positive user fee, the cost of a good to the household will increase with the quantity of waste associated with that good. Jenkins (1993) also modeled the commercial demand for waste services within a profit maximization framework in which the demand for commercial solid waste services is a function of the prices of factors of production and the commercial user fee and his result is analogous to that of household outcome. Firms will find inputs that generate a lot of waste more expensive as the commercial user fee increase thus creating incentives for both firms and households to purchase goods with less waste contents.

The theoretical construct of Jenkins (1993) is more appealing as it introduced a more comprehensive approach to decision regarding solid waste services. This is no doubt a great improvement over Wertz's analysis.

Recycling

Jenkins (1993) developed a utility maximization model which relates utility positively to the quantity of goods consumed and negatively to the amount of recycling subject to a number of constraints. He also in this utility maximization model of household decision on solid waste services viewed the impact of an increase in user fee on time devoted to recycling. He then concluded that as the user fee on sold waste service is raised, individuals will devote more time to recycling. The import of this is that as user fee is raised, more recycling will be done by the household. In the like manner, the firm will commit more labour to recycling as the commercial user fee for solid waste service is raised.

4.3 Framework of Jenkins' Model on Household's Decision Regarding Solid Waste

In the consumption activities of individuals, waste is generated as a by-product of consumption. They therefore tend to maximize utility subject to the relevant budget constraint. Individuals therefore determine their level of recycling, the quantity of waste to dispose by allocating their time among these competing activities including leisure.

Assuming that a household wishes to maximize utility from the consumption of some quantities of market goods (X_1, ---, X_n) and the quantity of time devoted to leisure activities (t_L), this can be formulated as

$$U(X_1, ---, X_n, t_L)$$

$$U_i > 0, i = 1, ---, n; \; U > 0 \qquad (1)$$

Where U(.) represents the utility function and subscript U's denote partial derivatives of utility with respect to the market goods and leisure.

Since each unit of i th good consumed has its associated fixed component of waste (Wertz, 1996), if we denote this fixed component of waste measured in weight as W_i, and we assumed that W_i can further be broken down into J types of waste. For instance, a cow slaughtered will have the bowel waste, the bone waste and the hoof components waste etc. If W_{ij} is therefore the weight of the j^{th} type associated with a unit of good i, then,

$$W_i = \sum_{j=1}^{j} W_{ij}; \; i = 1, ---, n \qquad (2)$$

Apart from wastes generated from market goods, non-market goods' waste enter individual's decision. If yard waste is represented by Z which is recyclable but for which payment is not received and the weight of all waste components (which comprises of waste associated with all market and non-market goods) is denoted by W, then;

$$W = \sum_{i=1}^{n} W_{ij} X_i + Z \qquad (3)$$

In the j type of waste, three types are relevant to the consumer's utility maximization{j=(1,2,3) where j=1 j_1 j=2 j_2 j=3 j_3}: Recyclable waste for which household receives payment (J_1); recyclable waste for which household receive no payment (J_2); and the non-recyclable waste (J_3).

$$W = \sum_{i=1}^{n} \sum_{j=1}^{3} W_{ij} X_i + Z$$

If the total weight of J_1 type of waste is denoted by W_{R+M}, then:

$$W_{R+M} = \sum_{i=1}^{n} \sum_{j=1}^{j1} W_{ij} X_i \qquad (4)$$

If the total weight of J_2 type of waste is denoted by W_R, then:

$$W_R = \sum_{i=1}^{n} \sum_{j=j1+1}^{j1+j2} W_{ij} X_i + Z \qquad (5)$$

It must be noted here that the inclusion of Z indicates the addition of the garden waste which is recyclable without payment received.

Denoting the total weight of the non-recyclable waste (J_3) by W_{NR};

$$W_{NR} = \sum_{i=1}^{n} \sum_{j=j1+j2+1}^{j1+j2+j3} W_{ij} X_i \qquad (6)$$

Households do not recycle one-hundred percent of their recyclable waste because recycling involves huge investment of time and this investment of time has an opportunity cost in the form of reduction in wages (as less time will be available for work) and reduction in leisure activities.

Representing the quantity of J_1 waste that is recycled by R_1 and the time spent on recycling them by t_1 and for J_2 type of waste, represent the recycled material by R_2 and the time spent on them by t_2 . Therefore, R_1 and R_2 are positive functions of the time that the household devotes to recycling them. In other words, as the time devoted to recycling each of the waste component increases, more of each waste component is recycled (see equation 8).

$$R_1 = R_1(t_1),\ R_2 = R_2(t_2); \qquad (7)$$

$$\frac{dR_1}{dt_1} > 0,\ \frac{dR_2}{dt_2} > 0; \qquad (8)$$

$$\frac{d^2R_1}{dt_1} < 0,\ \frac{d^2R_2}{dt_2} < 0 \qquad (9)$$

Intuitively, it appears that the easiest recyclables for the household to recycle are first recycled and the marginal productivity of time is positive giving rise to equation 8. However, the second derivatives of quantities of waste recycled with respect to time spent recycling them are negative meaning that as the quantities of waste recycled increased, marginal productivity per unit of time is negative (see equation 9).

Furthermore, a consumer has limitation on the maximum recycling of both marketable and non-marketable waste. He cannot recycle more than the waste generated. This is represented by equation (10).

$$R_i \leq \sum_{i=1}^{n} \sum_{j=1}^{j1} W_{ij}X_i;\quad R_2 \leq \sum_{i=1}^{n} \sum_{j=j1+1}^{j1+j2} W_{ij}X_i + Z \qquad (10)$$

Based on the above therefore, an individual wishes to maximize his utility subject to some constraints which are; the productivity or income of the household, non-wage household income and the revenue from recyclables. Given that;

P_i = the price of good i:

P_w = the price per unit weight of residential SWS (a weight based user fee).

P_R = The payment received for recycling W_{R+M}

V = non-wage household income

S = The hourly wage rate earned by the household

T = Individual's time endowment per day (e.g. 24 hours a day)

t_s = The number of hours the household spends working for wages.

The resulting maximization problem in Lagrangean form is as follows:

$$L = U(X_1,...,X_n, t_L) + \lambda \{sT + v + P_R R_1(t_1) - \sum_{i=1}^{n} P_i X_i - s(t_L + t_1 + t_2) - P_W[\sum_{i=1}^{n} \sum_{j=1}^{j} W_{ij} X_i$$

$$+ Z - R_1(t_1) - R_2(t_2)] \qquad (11)$$

Differentiating the Lagrangean with respect to each of the variable produces a number of first-order conditions which will be briefly discussed. Their implications are derived through forming firstly, a ratio between U_i and U_n which yields:

$$\frac{Ui}{Uh} = \frac{P_i + P_w \sum_{j=1}^{j} W_{ij}}{P_h + P_w \sum_{j=1}^{j} W_{hj}} \qquad (12)$$

In the result above, price of good i is P_i and price of good h is P_h. The other component respectively denotes the SWS price for waste on good i and h. The sum of these two components is the marginal social cost of goods i and h. The ratio in the right-hand depicts the marginal social cost of good i over good h. Equation 12 therefore explains houschold's reaction to an increase in waste associated with a good. Since P_w is the price per unit weight of SWS, it is a weight-based user fee for SWS which is not zero. Other things being equal, the houschold will respond to an increase in quantity of waste associated with good i by reducing its consumption relative to good h. Consumers therefore will increase the consumption of a good (in the presence of a non-zero user fee) in response to a decline in waste associated with the good and this provide incentive to manufacturers to reduce waste associated with their products:

Also, given that λ is the marginal utility of income and S is the marginal income of time spent working;

$$U_{tL} = \lambda S \qquad (13)$$

Optimum houschold will set the marginal utility of time spent at leisure equal to the marginal utility of time spent working. From the first-order results and solving for S ;

$$S = \frac{dR1}{dt1}(P_R + P_W) \qquad (14)$$

$$S = \frac{dR2}{dt2} P_w \qquad (15)$$

Equations 14 and 15 implies that household will continue to recycle until the value of the marginal product of time spent recycling (marketable in equation 14 and non-marketable in equation 15) equals the wage rate. Further manipulation of 14 and 15 produces:

$$\frac{dR_1}{dt_1} = \frac{S}{P_R + P_W} \qquad (16)$$

$$\frac{dR_2}{dt_2} = \frac{S}{P_W} \qquad (17)$$

The above equations suggest other things being equal that the number of hours spent recycling is positively related to the cost of waste disposal or user fee for solid waste services (SWS). The optimizing household will respond to an increase in user fee, P_W by reducing the marginal products of both t_1 and t_2 (through an increase in hours spent recycling both marketable and non-marketable waste). If the time spent recycling marketable waste is equal to the time spent recycling non-marketable waste, then the quantities of marketable waste and non-marketable waste recycled are equal. Equations 16 and 17 however suggest that the household will recycle a greater quantity of marketable waste than non-marketable waste making $R_1 > R_2$. Since the marginal product of time spent recycling non-marketable is the wage rate divided by the price of SWS only while the marginal product of time spent recycling marketable good is the wage rate divided by the sum of the price of SWS and the price received for recyclables, it therefore follows that the marginal product of t_1 is less than that of t_2 implying that t_1 is greater than t_2.

Lastly, if we assume that all the first-order conditions can be solved for X_1,---,X_n; t_1 and t_2. their solutions will be functions of the parameters of the system of equation 11.

$X_i = G_i(S, V, P_1,\text{---},P_n, P_R, P_w, W_{11},\text{---},W_{nj}, Z)$,

$i = 1,\text{---},n$;

$t_1 = Gt_1(S, V, P_1,\text{---},P_n, P_R, P_w, W_{11},\text{---},W_{nj}, Z) \qquad (18)$

$t_2 = Gt_2(S, V, P_1,\text{---},P_n, P_R, P_w, W_{11},\text{-----},W_{nj}, Z)$

If the demand for SWS = $W^d = W - R_1 - R_2$ and substituting earlier notations into them produces the equation:

$$W^d = \sum_{i=1}^{n} \sum_{j=1}^{j} w_{ij}\, G_i(.) + Z - R_1[Gt_1(.)] - R_2[Gt_2(.)] \qquad (19)$$

Based on set of equations in (18), it is clear that the demand for SWS is a function of household's wage rate, non-wage income, prices of goods consumed, price received for recyclables, the price of residential SWS or the user fee, the waste components of all goods consumed and the quantity of waste generated by non-market goods.

4.4 Framework of Jenkins' Model on Firm's Decisions Regarding Solid Waste

The representation used in this model is as follows:

Q = The quantity of output produced

P_q = The price per unit of output, Q.

I_i = The quantity of non labour input:

r_i = The price per unit of input:

L_p = the number of utilized productive hours by the firms

L = The total number of labour used by the firm (in hours)

S = The hourly wage rate earned by the firm.

W^c = The weight of commercial waste

w_i = The weight of waste associated with a unit of ith input.

P^c_W = The price paid by the firm per unit weight of waste (a commercial Weight-based user fee for SWS)

P^c_R = The price received by the firm per unit weight for recyclables.

K_1 = Type of waste (marketable)

R^c_1 = Quantity of waste recycled

L_1 = Number of labour hours devoted to recycling marketable waste.

K_2 = Other recyclable waste which are not marketable but are recycled to avoid disposal costs

R^c_2 = The quantity of non-marketable waste recycled by the firm.

L_2 = The number of hours spent recycling non-marketable waste.

W^c_{R+m} = Marketable waste

W^c_R = Non marketable but recyclable waste

W^c_{NR} = Non recyclable waste.

Firms are into productive activities so as to produce goods and as such maximise profit from their productive activities. In maximising profits therefore, several factors tend to constrain their profitability one of which is the solid waste services' costs (SWS) just like the inputs' cost which must be deducted from their revenue. Recycling on the other hand affects firms by drawing labour away from the real productive activities. When the recycled materials are marketable, they can affect direct sales. On this ground, recyclables are divided into two components of marketable materials which include materials re-used within the firm. The second component is the non marketable materials which are recycled in order to avoid the disposal costs.

The input aspect of the firm can further be broken down into labour inputs (L_p) and non-labour inputs (I_1---I_m). Assuming that a firm that produces just a good with labour and non-labour inputs is given as:

$$Q = f(I_1,\text{---},I_m, L_p); \qquad (1)$$

$f_i > 0$, $i = 1,\text{---},m$; $f_{Lp} > 0$:

Given the production function above, output is a function of these two components of inputs mentioned above. The weight of commercial waste is a function of a subset of non-labour inputs ($W^c = W^c(I_1,\text{---},I_{m\text{-}j})$ but instead of using the functional form above, we simply adopt a stronger assumption that commercial waste is a linear combination of such inputs.

$$W^c = \sum_{i=1}^{M} W_i I_i \qquad (2)$$

Since wastes can further be broken down into types and if we assume K types of waste, the formular (2) above translates to:

$$W_i = \sum_{k=1}^{k} W_{ik} \quad i = 1,\text{---},M \qquad (3)$$

Assuming that K_1 represents the marketable waste, therefore

$$W^c_{R+m} = \sum_{i=1}^{M} \sum_{k=1}^{k1} W_{ik} I_i \qquad (4)$$

The quantity of the marketable waste actually recycled (R^c_1) will depend positively on the number of labour hours devoted to recycling them.

$$R^c_1 = R^c_1(L_1);\ \frac{dR^c_1}{dL_1} > 0 \qquad (5)$$

If the easiest recycling is first done and the difficult is done later so that as more labour is devoted to recycling. The productivity of labour falls off,

$$\frac{d^2Rc_1}{dL^2_1} < 0 \qquad (6)$$

Equation 6 is enough to satisfy the second-order condition for profit maximization of the firm-given in equation (11). It is necessary to say that the quantity recycled can never be greater than the total quantity of marketable waste generated by the firm. i.e.

$$R^c_1 \leq \sum_{i=1}^{M} \sum_{k=1}^{k1} W_{ik}I_i \qquad (7)$$

The next waste group is the non-marketable waste (W^c_R) which firms recycle so as to avoid disposal costs. This is denoted by K_2 type. The labour hours spent on recycling this waste is L_2.

$$R^c_2 = R^c_2(L_2);\ \frac{dR^c_2}{dL_2} > 0; \qquad R^c_2 \leq \sum_{i=1}^{M} \sum_{k=k_1+1}^{k_1+k_2} W_{ik}J_i \qquad (8)$$

Equation (8) subjects a linear and direct relationship between recycled non-marketable waste and labour hours spent recycling them. By assumptions, as more and more labour time is spent recycling this kind of waste, the productivity of that time diminishes (see equation 9).

$$\frac{d^2R^c_2}{dL^2_2} < 0 \qquad (9)$$

Apart from K_1, K_2 types of waste identified, The K_3 type of waste comprises of virtually non-recyclable (W^c_{NR}) and are always some solid waste residues which must be disposed off completely.

Equation (10) shows the mathematical representation.

$$W^c_{NR} = \sum_{i=1}^{M} \sum_{k=k_1+k_2+1}^{k_1+k_2+k_3} w_{ik}I_i \qquad (10)$$

Given the above, the firm wishes to maximize revenue (P_qQ) minus the cost of non-labour inputs, minus the cost of labour, minus the cost of commercial weight-based solid waste services on residues, plus revenue from recycling activities.

When the maximization problem is formulated into a Lagrangean function we have:

$$L = P_qQ - \sum_{i=1}^{M} r_i I_i - S(L_p + L_1 + L_2) - P^c{}_w [\sum_{i=1}^{M} \sum_{k=1}^{k} W_{ik} I_i - R^c{}_1 (L_1) - R^c{}_2 (L_2)] + P^c{}_R$$

$$R^c{}_1 (L_1) + \lambda[f(I_1, \text{------}, I_m, L_p) - Q] \qquad (11)$$

In a perfect market, maximization of (11) with respect to each of the variable gives some first-order conditions. The implications of a first-order condition when P_q is substituted for λ is that, a profit maximizing firm chooses each non-labour input so that the value of the input's marginal product equals its marginal cost. The marginal cost of input i includes input price of i as well as cost of disposing wastes associated with the input.

From the first-order results, taking the ratio for inputs i and h gives a condition a profit maximising firm must fulfill.

$$\frac{f_i}{f_h} = \frac{r_1 + P^c{}_w \sum_{k=1}^{k} W_{ik}}{r_h + P^c{}_w \sum_{k=1}^{k} W_{hk}} \qquad (12)$$

The above suggests that the firm will set the marginal rate of technical substitution between two inputs equal to the ratio of marginal costs of those inputs (which include the market price of each input plus the cost of disposal of waste associated with the use of the input). In order words, a positive user fee for commercial SWS implies that inputs that generate high quantities of waste are, other things being equal, less desirable to the firm. The incentive effect is that a firm will seek out low waste inputs which, in turn, gives manufacturers of the inputs incentive to lower the waste associated with their products. The effects of an increase in the commercial user fee for SWS can be seen from the result below.

$$\frac{dR^c{}_1}{dL_1} = \frac{S}{P^c{}_w + P^c{}_R} \qquad (13)$$

$$\frac{dR^c{}_1}{dL_2} = \frac{S}{P^c{}_w} \qquad (14)$$

The meaning of this is that more labour will be devoted to recycling in response to an increase in the commercial user fee for SWS (P^c_w).

Lastly, if the first-order conditions are solved for I_1,---,I_m L_1 and L_2, in equation 11;

$$I_i = H_i\ (r_1,\text{---},r_m,\ s,\ P^c_R, P^c_w\ W_{11},\text{---},W_{mk})$$

$$i = 1,\text{---},m$$

$$L_1 = HL_1\ (r_1,\text{---},r_m, s, P^c_R, P^c_w\ W_{11},\text{---},W_{mk}) \qquad (15)$$

$$L_2 = HL_2\ (r_1,\text{---},r_m, s, P^c_R, P^c_w\ W_{11},\text{---},W_{mk})$$

The firm's demand function for SWS = $W^c_d = W^c - R^c_1 - R^c_2 = \sum_{i=1}^{M} \sum_{k=1}^{k} W_{ik}\, H_i\,(\cdot) - R^c_1$

$[H_{L1}\,(\cdot)] - R^c_2\,[H_{L2}\,(\cdot)]$

From the above therefore, $W_c^d = f^c\ (r_1,\text{------},r_m, s, P^c_R, P^c_w\ W_{11},\text{----},W_{mk})$

In conclusion, the firm's demand for SWS is a function of non-labour input costs, the wage rate, the price received for recycling (price of recyclables), the commercial user fee for SWS, and the waste associated with each input.

In conclusion, the theories just presented in sections 4.3 and 4.4 brought out some important determinants of quantity of waste generated by the household and the firm, it is incomplete in a sense as they did not include all the determinants of waste in the model. For instance, the impact of weather variables in the determination of both the household and commercial sectors' waste cannot be rule out. Literature has revealed that weather variables are very important in the determination of waste generation. For instance, Jenkins (1993) found significant impact of weather and demographic variables on waste generation, however, his theory failed to incorporate this.

In addition, the theories have been able to show the direction of relationships between both residential as well as the commercial waste quantities and their determinants. It has however failed to give regional specific estimates of magnitude of relationship. Viewed from these angles therefore, we say that these theories alone are inadequate to provide a total guide in this study and there is a need to complement with empirical analysis which we believe will be able to overcome the shortcomings of these theories.

4.5 Methodology

4.5.1 Model specification and estimation procedures

To determine the strength of relatedness or level of association between waste generated per capita and user fee on one hand and waste per capita and other explanatory variables (like level of precipitation, temperature, household income, density, prices of recyclables) on the other hand, the study utilized regression tool to ascertain causal relationships existing between variables.

Residential model

$$Wpc = \beta_0 + \beta_1 \text{ Rinc} + \beta_2 \text{ Popden} + \beta_3 \text{ Rain} + \beta_4 \text{ Temp} + \beta_5 \text{ Rprecy} + \beta_6 \text{ Rusa} + \varepsilon_{it} \quad (1)$$

The commercial model analyzed in this study is hereunder stated:

Commercial model

$$Qcom = \alpha_0 + \alpha_1 \text{ Rprecy} + \alpha_2 \text{ Rain} + \alpha_3 \text{ Temp} + \alpha_4 \text{ Rusfcom} + \varepsilon_{it} \quad (2)$$

Incremental contributions and stepwise regression of dumping

Choe and Frazer (1999) in their theoretical analysis confirmed the role of dumping when the solid waste services' charges are increased. This study is following up on this in this empirical investigation of dumping. Incremental contribution is an important one in this situation. In this empirical investigation; one is not completely sure which of the user charges (apart from the cartpusher's charge) is worth adding as explanatory variable in the dumping model. Our intent here is to exclude variable that contributes very little towards error sum of squares (ESS). In the same manner, we do not want to exclude explanatory variable(s) that substantially increase ESS. To accomplish this, this study used the analysis of variance (ANOVA) or F-test. We utilized the latter tool.

In this method, one proceeds either by introducing the independent variables one at a time (stepwise forward regression) or by including all the independent variables in one multiple regression and rejecting them one at a time (stepwise backward regression). The decision to add or drop a variable is usually made on the basis of the contribution of that variable to the ESS, as judged by the F-test. We adopted the stepwise forward regression procedure and the F-test utilized the following formular.

$$F = \frac{(R^2_{new} - R^2_{old}/df}{(1 - R^2_{new}) / df} \quad (3)$$

Where:

R^2_{old} is the R^2 of the old model (if the old model has one independent variable, R^2 equal to R^2 of this model).

R^2_{new} equal to R^2 of the new model (say new model with another independent variable added).

df numerator is the number of new regressors added.

df denominator is (n-number of parameters in the new model)

Note that since the dependent variable (dumping) is the same under new and old model, the above formular can be used, otherwise we have to use another version of F-test which we need not include here.

The models analyzed are:

$$\text{Dumpsm} = \alpha_0 + \alpha_1 \text{ Rcarprsm} + \varepsilon \quad (4)$$

$$\text{Dumpsm} = \alpha_0 + \alpha_1 \text{ Rusasm} + \varepsilon \quad (5)$$

$$\text{Dumpsm} = \alpha_0 + \alpha_1 \text{ Rusfcosm} + \varepsilon \quad (6)$$

$$\text{Dumpsm} = \alpha_0 + \alpha_1 \text{ Rcarprsm} + \alpha_2 \text{ Rusasm} + \varepsilon \quad (7)$$

$$\text{Dumpsm} = \alpha_0 + \alpha_1 \text{ Rcarprsm} + \alpha_2 \text{ Rusfcosm} + \varepsilon \quad (8)$$

$$\text{Dumpsm} = \alpha_0 + \alpha_1 \text{ Rcarprsm} + \alpha_2 \text{ Rusasm} + \alpha_3 \text{ Rusfcosm} + \varepsilon \quad (9)$$

Where:

Househsiz = mean household size in Lagos

Popden = Population per square kilometer (population density)

Rprecy = Average monthly price of recyclables (deflated

by the consumer price index) corresponding to time t.

Qcom = weekly/Monthly tonnes of commercial/industrial solid waste

Wpc = weekly/Monthly waste per capita

Rain = Average monthly level of precipitation in Lagos corresponding to time t.

Rinc = Monthly household income (deflated by the CPI) corresponding to time t.

Workpop = Percentage of population between 15 and 49

Rusa=Average monthly residential user charge (deflated by CPI) corresponding to time t.

Rusfcom = Average monthly user charge for commercial/industrial waste (deflated by the CPI) corresponding to time t.

Temp = Average mean temperature in Lagos

Dumpin = monthly quantity (in tonnes) of waste dumped in Lagos Streets

Carprice = Cart pusher's average monthly charge

Dump = Quantity of waste dumped in Lagos in time t.

Rcarpr = Monthly real cart pusher's charge corresponding to time t.

SM added at the end of variables means that they have been smoothed using the Holt-Winters smoothing technique.

Since data for the study are time series, we conducted a unit root test so as to eliminate the possibility of a spurious regression by applying Augumented Dickey-Fuller (ADF) test on all variables (both weekly and monthly) and then applied the needed differencing in the regression analysis. Our inability to obtain a white noise process further compelled us to add autoregressive-moving average (ARMA terms).

In addition to this, we ran regression on Holt-Winters' filtered data (the justification for smoothing data and for adopting Holt-Winters' procedure is provided in the next subsection). In order to obtain the best estimate of models, we equally ran Ordinary Least Squares (OLS) regression and the Generalized Least Squares (GLS) regression on models at levels so as to obtain the best estimates of models. The justification for applying GLS when OLS shows autocorrelated disturbances were provided by Greene (1997), who stressed the problem posed by autocorrelated disturbances and a way of dealing with them when he stated that the model with autocorrelated disturbances is a generalized regression model, and we should expect least squares to be in-efficient. This problem can be seen when we know the disturbance process and the process generating the independent variables. The efficiency of least squares falls to less than 10% if the autoregressive root (ρ) is close to 1. Judge *et. al.* (1985) also agreed to the loss of efficiency but differ on the severity of the problem (see also, Hill, Griffith and Judge, 2001). Based on the foregoing, we applied the generalized least squares (GLS) on series at levels and Holt-Winters' filtered data.

Data filtering or smoothing

Filtering techniques provide a means of removing or at least reduce volatile short-term fluctuations in a time series. Filtering is a series procedure, which may be used to generate new series that are based upon the data in the original series. Filtering enhances the generation of series with white noise. Smoothing may be done to make the time series easier to analyze and interpret. Smoothing also may be done to remove seasonal fluctuations. That is, to deseasonalize or seasonally adjust a time series. Lastly, filtering techniques do produce optimal forecasts in certain conditions, which turn out to be intimately related to the presence of unit roots in the series being forecast. In addition, other approaches produce optimal forecasts only under certain conditions as well, such as correct specification of the forecasting model. We must stress here that all our models are approximations, any procedure with a successful track record in practice is worthy of serious consideration, and filtering techniques do have successful track record in the situations mentioned above.

Hodrick-prescott filter (HP)

Hp smoothing method is widely used for macroeconomic analysis to obtain a smooth estimate of the long-term trend component of a series.

Technically, Hp filter is a two-sided linear filter that computes the smoothed series S of y by minimizing the variance of y around S, subject to a penalty that constrains the second difference of S. In other words, Hp filter chooses S_t to minimize:

$$\sum(y_t - S_t)^2 + \lambda \sum [(S_{t+1} - S_t) - (S_t - S_{t-1})]^2 \qquad \textbf{(10)}$$

In the above function, λ stands for the penalty parameters which controls the smoothness of the series S_t. In our analysis, we used the E views default values of:

$$\lambda = \begin{cases} 100 \text{ for annual data} \\ 1600 \text{ for quarterly data} \\ 1400 \text{ for monthly data} \end{cases}$$

It must be stressed that the larger the λ, the smoother is the S_t. As λ tends to $\propto$, S_t approaches a linear trend. This is a major problem that is encountered in the use of Hp-filter which led to the spurious regression obtained, hence the study considered other filtering method (Holt-winter's technique).

Perhaps, it is pertinent to review some of the theories and literature relating to Hodrick Prescott and other appropriate filter so as to be guided in the choice of filters. Ahamuda and Geragnani (1999) in their abstract summarized some of the shortcomings of Hodrick-Prescott filter thus; "Hodrick-Prescott filter has been the favourite empirical technique among researchers studying "cycles". Software facilities and the optimality criterion, from which the filter can be derived, can explain its wide use. However, different shortcomings and drawbacks have been pointed out in the literature, as alteration of variability and persistence and detecting spurious cycles and autocorrelations.---"

According to Ahamuda and Geragnani (1999), Cogley and Nason (1995) observed that there are possibilities of obtaining "spurious cycles" when filtering "difference stationary data" (like a random-walk representation). Cogley and Nason's (1995) observation above was confirmed in this analysis. Harvey and Jaeger (1993) extended the analysis to show the possibility of "spurious sample cross correlation" between spurious cycles. They even put a warning to the "uncritical use of mechanical detrending".

King and Rebelo (1993) also showed cases in which persistence, variability and comovement of (simulated and actual) economic series are àltered (after filtering with Hodrick-Prescott) in comparison with those raw data. Another serious criticism of Hodrick-Prescott filter was raised by Nelson and Plosser (1982: 158) when they stated that, "Hodrick-Prescott strategy implicitly imposes a component model on the data without investigating what restrictions are implied (a difficult task in their model) and whether those restrictions are consistent with the data".

One major problem with the Hodrick-Prescott filtered data which is related to the above is that it shows more serial correlation than first-differenced data and this is evident in our OLS and GLS estimates derived earlier and based on this, an appropriate smoothing method for data has to be derived and the next issue is, how can the study evolve a suitable filter that is compatible with our data?

Although there are numerical indicators for assessing the accuracy of the forecasting technique, the most widely used approach is using visual comparison of several forecasts to assess their accuracy and choose among the various forecasting methods. In this approach, one must plot on the same graph the original values of a time series variable and the predicted values from several different forecasting methods, thus facilitating a visual comparison (Ahamuda and Geragnani, 1999).

Visual comparison of forecasting power of smoothing techniques indicated that Holt-Winters' filter is the most appropriate of them all. In the study series, seasonal variation was so strong as it obscures any trends or cycles, which are very important for the understanding of the process being observed. Winters' smoothing method has the potentiality of removing seasonality and makes long term fluctuations in the series stand our more clearly. Holt first suggested it for non-seasonal time series with or without trends. Winters' generalized the method to include seasonality, hence the name Holt-

Winters' method. One appealing feature of Hot-Winters' filter is that it can be used for less-than-annual periods or data. This special feature also makes this filter appropriate for the study's weekly and monthly series unlike the Hodrick-Prescott filter which uses quarterly, monthly and yearly data penalty parameters for controlling the smoothness of series.

Holt-Winters' filter

Holt-winters' smoothing is a form of exponential smoothing in which forecasts from exponential smoothing methods adjust based on past forecast errors. The study therefore used the Holt-winters method with no seasonal and with two parameters.

This method is appropriate for series with a linear trend and no seasonal variation. This method is a parsimonious one. Two smoothed series $\hat{Y}_t$ of y_t is given by:

$$\hat{Y}_{+k} = a + bk \quad (11)$$

Where,

a	=	permanent component (intercept)
b	=	trend

These two coefficients are defined by the following recursions:

$$a(t) = \alpha y_t + (1 - \alpha)[a(t-1) + b(t-1)] \quad (12)$$

$$b(t) = \beta [a(t) - a(t-1) + (1 - \beta) b(t-1) \quad (13)$$

Where $0 < a, \beta < 1$ are the damping factors. Forecasts are derived by $\hat{Y}_{T+K} = a(T) + b(T)$ K. (Eviews).

Estimation procedures

In order to get the best estimate for both household and commercial models, three estimation techniques were employed:

i Models were estimated at levels using unfiltered data (raw data estimation).

ii In order to avoid high autocorrelation and spurious regression results associated with method one, stationarity was tested using the Augumented Dickey-Fuller (ADF) test and based on order of integration, we applied the needed differencing before running our regression.

Also, following Greene (1997), not in all cases can differencing alone produce a white noise series. Addition of autoregressive moving average (ARMA) in correcting autocorrelated errors is appropriate. Pindyck and Rubinfeld (1998) suggest that time-series analysis and regression analysis can be combined to produce a better forecast than would be possible with the use of either of these techniques alone. A regression model would have the dependent variable explained by all the independent variable(s) and an additive error term. The additive error term accounts for unexplained variance in the dependent variable. However, one source of forecast error of this regression model would come from the additive error (noise) term whose future values cannot be predicted. One effective application of time series analysis is the construction of ARIMA model for the residual series μ_t of this regression. We would then substitute the ARIMA model for the implicit error term in the original equation. The ARIMA model provides valuable information about what future values of ε_t are likely to be. In other words, it helps to explain the unexplained variance in the regression equation. The resultant model is likely to provide better forecasts than would the regression equation as it combines both the structural (economic) explanation of part of variance of dependent variable and the explanation of the structurally unexplained variance of the independent variable. This model is referred to as transfer function model or multivariate autoregressive-moving average model (MARMA).

Further justification of ARIMA was provided by Greene as he commented that in trying to obtain the BLUE, it is not so easy to know which procedure is the correct one. It is however obvious that most economic time series data are strongly trended. Taking incorrect approach will not necessarily improve matters. As an example, differencing may produce a white noise series, but differencing may trade trends for autocorrelation in the form of an ARMA process (Greene 1997).

The ARIMA model however is defective due to its inability to predict accurately sharp downturns and upturns in models thus limiting its value for forecasting (Pindyck and Rubinfeld 1998).

iii One of the important issues for consideration in the analysis of time series is the outlier consideration.

A mathematical reason to adjust for such occurrences is that the majority of forecast techniques employed in data mining are based on averaging and, arithmetic averaging is very sensitive to outlier values. Therefore, some alteration should be made to the data before modeling and one approach to this is data smoothing/filtering.

Then, which smoothing method do we adopt?

Our visual comparison of forecasting power of smoothing techniques (as recommended by Ahamuda and Geragnani, 1999) indicates that Holt-Winters filter is the most appropriate of them all as it did not alter persistence variability and comovement of (simulated and actual) series.

Generally, for the three procedures, ordinary least squares were first fitted and in most cases, autocorrelated disturbances were found, and taking a clue from Greene (1997), Judge *et. al.* (1985), Hill, Griffiths and Judge (2001), we applied the generalized least squares technique.

Estimated Generalized Least Squares (EGLS) – The Cochrane-Orcutt iterative procedure

In a regression model with AR(1) errors given by:

$Wpc = \beta_0 + \beta_1\,Rprecy + \beta_2\,Rain + \beta_3\,Temp + \beta_4\,Rusa + \beta_5\,Rinc + \beta_6\,Popden + \mu_t$

Where $\mu_t = \rho\,\mu_{t-1} + v_t$ $(-1 \leq \rho < 1)$ and v_t is an uncorrelated error term. If the coefficient of ρ is known, the autocorrelation can easily be solved. However, the theoretical value of ρ is not known, Cochrane-Orcutt devised an iterative procedure for its "best" estimation.

According to this method, if the Wpc model above is true in time t, then, it is also true in time (t-1) so that;

$$Wpc_{t-1} = \beta_0 + \beta_1\, Rprecy_{t-1} + \beta_2\, Rain_{t-1} + \beta_3\, Temp_{t-1} + \beta_4\, Rusa_{t-1} + \beta_5\, Rinc_{t-1} + \beta_6\, Popden_{t-1} + \mu_{t-1}$$

Multiply through by ρ on both sides, we have;

$$\rho Wpc_{t-1} = \rho\beta_0 + \rho\beta_1\, Rprecy_{t-1} + \rho\beta_2\, Rain_{t-1} + \rho\beta_3\, Temp_{t-1} + \rho\beta_4\, Rusa_{t-1} + \rho\beta_5\, Rinc_{t-1} + \rho\beta_6\, Popden_{t-1} + \rho\mu_{t-1}$$

By subtracting model ρWpc_{t-1} from model Wpc, we would have;

$$(Wpc - \rho Wpc_{t-1}) = \beta_0\,(1\text{-}p) + \beta_1\,(Rprecy - \rho Rprecy_{t-1}) + \beta_2\,(Rain\text{-}\rho Rain_{t-1}) + \beta_3\,(Temp\text{-}\rho Temp_{t-1}) + \beta_4\,(Rusa\text{-}\rho Rusa_{t-1}) + \beta_5\,(Rinc\text{-}\rho Rinc_{t-1}) + \beta_6\,(Popden\text{-}\rho Popden_{t-1}) + \varepsilon_t$$

Where, $\varepsilon_t = (\rho\mu_{t-1} + v_t)$. ε_t satisfies the usual OLS assumptions. We can apply OLS on the transformed model;

$$Wpc^* = \beta_0^* + \beta_1^*\, Rprecy^* + \beta_2^*\, Rain^* + \beta_3^*\, Temp^* + \beta_4^*\, Rusa^* + \beta_5^*\, Rinc^* + \beta_6^*\, Popden^* + \varepsilon_t$$

Where,

$Wpc^* = (Wpc - \rho Wpc_{t-1})$; $Rprecy^* = (Rprecy - \rho Rprecy_{t-1})$;

$Rain^* = (Rain\text{-}\rho Rain_{t-1})$; $Temp^* = (Temp\text{-}\rho Temp_{t-1})$; $Rusa^* = (Rusa\text{-}\rho Rusa_{t-1})$;

$Rinc^* = (Rinc\text{-}\rho Rinc_{t-1})$ $\beta_0^* = \beta_0^* = (1 - \rho_{estimated})$; $\beta_1^*\ \beta_1$; $\beta_2^* = \beta_2$; $\beta_3^* = \beta_3$;

$\beta_4^* = \beta_4$; $\beta_5^* = \beta_5$; $\beta_6^* = \beta_6$.

Cochrane-Orcutt's implementation procedures involve the estimation of the original Wpc model utilizing the OLS and obtaining the residuals (μ). The estimated residual is then used in running the AR(1) regression of the from; $\mu_t = \rho\mu_{t-1} + v_t$. The estimated 'rho' is then substituted into the generalized difference equation. Since beforehand, it is not known if the estimated 'rho' obtained is the best, we continue a process of obtaining the best estimate of 'rho' (that is, iteration).

The revised parameter estimates, β_1^*, β_1^*, β_2^*, β_3^*, β_4^*, β_5^*, and β_6^* obtained in the generalized difference equation are then substituted into the original regression model to obtain a new residual μ_t^*.

$$\mu_t^* = Y_t - \beta_0^* - \beta_1^* \text{Rprecy}^* - \beta_2^* \text{Rain}^* - \beta_3^* \text{Temp}^* - \beta_4^* \text{Rusa}^* - \beta_5^* \text{Rinc}^* - \beta_6^* \text{Popden}^*.$$

This can be computed since all the right-hand variables are known. Having known the values of μ_t^*, this residual again is then used in running another regression of the form;

$$\mu^*_t = \rho^* \mu^*_{t-1} + w_t.$$

The above is the second-round estimate of 'rho'. This process continues until we are almost sure that the best 'rho' has been obtained. In other words, the iterative process can be continued for as many steps as desirable. The guiding principle is, stop the iterations when the new estimates of 'rho' differ from the old 'rho' by less than 0.01 or 0.005 (there is convergence) or after 10 or 20 estimates of 'rho' have been obtained (Pindyck and Rubinfeld 1998).

Since 'rho' estimate is used instead of the true 'rho', this procedure is known as feasible generalized least squares (FGLS) or estimated generalized least squares (EGLS) method (Gujarati 2003). Although, there are various iterative methods of finding 'rho' (for instance, Hildreth-Lu scanning or search procedure, Durbin two-step procedure *etc.*) so as to estimate GLS, Cochrane-Orcutt iterative produce seems the most popular and the most preferred. It has a special additional value of being capable of estimating higher-order autoregressive process. The above reasons therefore informed our choice of this GLS procedure.

GLS is also very useful in correcting heteroscedasticity. According to Greene (1998), "The problems for estimation and inference caused by autocorrelation are similar to (although, unfortunately, more involved than) those caused by heteroscedasticity. As before, least squares is inefficient, and inference based on the least squares estimates is adversely affected. Depending on the underlying process, however, GLS and FGLS estimators can be devises that circumvent these problems."

GLS estimates based on Holt-Winters' filter showed more robustness compared with ARMA estimated models and we presented our results based on the GLS estimates of both household and commercial (weekly model). In addition to the above, the study also employed the covariance analysis to determine the direction of relationship between our variables.

4.5.2 Data Description and Source

Primary data

There are two sets of primary instrument used in this study. One set was administered randomly on big manufacturing firms in Lagos State to obtain information like their monthly average recyclable costs/prices from January 2001 to December 2003. In all, 100 companies were surveyed out of which about 41 responded positively to the questionnaires. Out of the 41 that responded, only 21 companies actually stated the prices of their recyclables and these recyclables include metal/iron scraps, plastics/rubber waste (including nylon pellets), aluminium and paper waste. The average of these prices was used as the prices of recyclables – having deflated by the consumer price index (CPI). These figures were used alongside our secondary data in our regression analysis.

The other two aspects of this company's instruments have first, an area in which companies were expected to check in on options in an eight-question matrix, which seeks to find out their perception of what an efficient and effective waste management should entail. In other words they tick one of: I strongly agree (5 points). I agree (4 points) it depends (3 points) I disagree (2 points) and I strongly disagree (1 point).

When each of these companies makes its choice, any item of the eight question matrix that does not make a mean of at least 4 marks is removed from the ranking scale of the fourth part of the questionnaires. In other words, for an item to be considered as a component of efficient and effective behaviour, respondents must at least agree that such an item is important for inclusion.

The third part of the questionnaire requires the respondent to rank their waste service providers on their efficient level in each of the eight-item scale in part 2. The ranks and scores are: excellent (5 points), good (4 points), fair (3 points), poor (2 points) and very poor (1 point).

Each waste services provider will be ranked on overall based on items selected as meeting the criterion under part 2 above. Any waste service provider that makes an overall average of 3.5 points on all the included items in the third part will be categorized as efficient and effective.

The second sets of questionnaires were administered in a stratified random sampling process on the household sector. 1,000 questionnaires in all were given out, out of which 504 were returned. The stratified sampling technique involved giving out 50 questionnaires each to the 20 Lagos State Council areas. The major problem with this sampling technique is that respondents could not be tracked down at home and as such, questionnaires were administered on respondents mainly at their working places and in this case, there was no assurance that the strata stipulations was strictly followed as many people are not residing even close to where they work. Categorization of our data based on those zones could not be accomplished because some respondents did not disclose their address. However, we feel that this sampling technique may not necessarily lead to high sampling error. The distributions of the 1,000 questionnaires are hereunder given;

Table 4.1: Presentation of Survey Instruments

Description	Quantity	Percentage
Household surveyed	1000	100
Total questionnaires returned	504	50.4
Badly completed questionnaires	41	4.1
Did not state service providers	25	2.5
Self disposal	24	2.4
Cart pushers patrons	220	22.0
Total PSP patrons	194	19.4

Source: author's fieldwork, 2004.

The other two parts of the questionnaire are similarly structured like that of the commercial instrument and as such, their analysis and interpretation will follow same pattern as those of commercial/industrial instruments.

This analysis also tried to investigate why people patronize the cart pushers who incidentally cause substantial dumping in Lagos metropolis as opposed to the conventional PSP. We therefore compared the mean income of patrons of PSP with those of their cart pusher's counterparts. We also compared the mean user charger of the two residential solid waste service providers utilizing the difference of two means approach.

We tested the hypothesis of no significant difference between the mean charges of PSP (X_1) and that of the cart pushers (X_2) of course. It is expected (no matter the income level) that an individual will patronize the cheaper of these two service providers provided the individual does not have a personal reason not to follow this line of thought.

In carrying out this test, null hypothesis of no significance difference between the population mean (μ) charges were formulated. In other words, the null hypothesis states that:

H_0: $\mu_1 - \mu_2 = 0$

As against the alternative hypothesis of;

H_A: $\mu_1 - \mu_2 \neq 0$

The Z formular utilized for testing the difference of two means is:

$$Z = \frac{X_1 - X_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where:

X_1 is the mean value of prices charged by the private sector participants (PSP)

X_2 is the mean charge of the cartpushers.

S_1^2 is the variance for the PSP sample

S_2^2 is the variance for cartpushers' sample

n_1 is the number of PSP patrons in the sample

n_2 is the number of cartpushers' patron sampled

The test is a two-tailed test and we take α to be 0.02. The decision rule is: if Z–calculated is greater than Z-critical as $\alpha = 0.02$, reject the null hypothesis and accept the alternative hypothesis that the average charges by PSP is significantly different from those of the cartpushers. If our result indicates the contrary, then we accept the null hypothesis.

Secondary data:

Lagos projected population, % of population between 15-49, Lagos area from which Lagos population density was obtained were derived from the National Population Commission. The consumer price index (CPI) was obtained from the Statistical News of the Federal Office of Statistics – FOS (July 2004), 1996/97 to 2000 figures for average household income in Lagos State was obtained from the Annual Abstract of Statistics various issues and we made our extrapolation to 2003 using the growth rate of Nigeria's GDP.

The following data were obtained from LAWMA's landfill records – Daily quantity of residential wastes disposed, daily quantity of commercial waste disposed (these quantities were used as proxies for actual waste generated), and the quantity of waste dumped in Lagos. Also, meteorological department provided the meteorological variables while ARMA with monthly dummies were used to capture more recent data. Lastly, some of the data were generated or transformed linearly to weekly data for analyzing. The method of linearizing is as follows.

We utilized simple extrapolation models which is the linear trend model when we believe that a series y_t will increase in constant absolute quantities in each time period, we can predict term y_t by fitting the trend line given as;

$$Y_t = c_1 + c_2$$

Where t is time and y_t is the value of y at time t. Usually, t is chosen to equal zero in the base period. c_1 is the quantity of y_t in time zero or in the base period while c_2 is the constant increase in c_1 from one period to the other (Pindyck and Rubinfeld 1998).

CHAPTER FIVE

PRESENTATION AND DISCUSSION OF RESULTS

5.1: Covariance results

Table 5.1 shows the covariance matrix of the variables of our household models. Covariance is a measure of the linear association between variables A and B. if both variables are always above and below their means at the same time, the covariance will be positive. If on the other hand, A is above its mean when B is below its mean and vice versa, the covariance will be negative. Cov (A,B) = 1/(N-1) Σ (Ai –Ā)(Bi – B)

Table 5.1: Covariance half-matrix table of variables of the model

	Qres	Wpc	Rusa	Rprecy	Popden	Rinc	Workpop	Househsiz	Temp	Rain
Qres	1305844									
Wpc	164.917	0.021								
Rusa	-3816.739	-0.476	193.524							
Reprecy	-86.680	-0.084	44.112	31.498						
Popden	5680.337	-0.590	-62.922	203.687	3751.850					
Rinc	-84032.65	5.526	3888.251	-1659.970	-46926.37	692988.7				
Workpop	-3.875	0.000	0.039	-0.115	-1.975	24.572	0.002			
Househsiz	7.928	-0.001	-0.088	0.281	5.113	-64.629	-0.003	0.007		
Temp	87.017	0.014	11.102	1.850	-14.393	434.463	0.009	-0.019	2.134	
Rain	-19841.35	-2.655	-283.979	-60.076	469.810	-18973.89	-0.211	0.470	-96.696	12504.2
Observations	156	156	156	156	156	156	156	156	156	156

(Pindyck and Rubinfeld, 1988). From table 5.1, waste per capita has a positive covariance with total waste generation, this shows that growth in waste capita significantly contributes to growth in residential waste generation. In the same manner, high positive covariance between population density and total residential waste indicates that urbanization causes waste generation to rise tremendously while waste per capita declines with level of urbanization showing the economies of scale of urbanization.

User fee has a negative covariance with total residential waste as well as waste generation per capita indicating that as user fee is increased above its mean, waste generated per capita as well as total residential waste would fall below their means confirming the beneficial role of user fee in curtailing waste generation. Income has a high negative covariance with total residential waste indicating that as household's mean income rises above its mean, total residential waste was below its mean value. On the other hand however, waste per capita has a positive covariance with household income. The above result showed that household income relates directly with waste per capita than with total waste (that may not be related to income level)

Positive covariance between temperature level and both waste per capita and total residential waste is expected. High temperature is related to high level of economic activity and converse is also true for low temperature level. Level of precipitation is inversely related to waste per capita and total residential waste. The explanation for this is also related to that of temperature level. Other results also confirmed the direct covariance between household size and population density showing that household size could be a major determinant of population density. Price of recyclables has a negative covariance with waste per capita as well as total residential waste as expected. This indicates that if we are targeting waste minimization, setting up of well functional recyclables markets can help in bringing about this.

The major shortcoming of the above presentation is that the value of covariance depends on the units of measurements of A and B. Due to this reason, we will have to present the correlation-coefficient. Unlike the covariance, the correlation coefficient has been normalized and is scale-free. It ranges between -1 and +1. Corr. (A, B) = ρ (A, B) = Cov. (A, B)/ $\sigma_A\sigma_B$. Where, σA and σB represent the standard deviations of A and B respectively (Pindyck and Rubinfeld, 1988). The result of the correlation can be found in the appendix O. The correlation results are not different in signs with those of the covariance table except that their normalized values are very low. Also featured in the analysis is the relationship between residential waste per capita and the real user fee at one hand, and the total residential waste and user fee depicted in appendices P and Q. The scatter plot confirmed the inverse relationship between user fee and waste per capita at one hand and user fee and total residential waste at the other hand. The significant contribution of the plot is that, it has shown that user fee is potentially beneficial in providing the disincentive effect of wasteful behaviour and the consequent excessive waste generation.

5.2 Stationarity Results for Monthly Data

The first step in the analysis of economic instruments for waste management in Lagos state is the determination of the series' stationery (since the study employed time series in the analysis). To do this, we utilize the Philip-Perron unit root test which is the same as Augmented Dickey fuller test (ADF – test) based on asymptotic distribution (Gujarati, 2003). The results for monthly data are as follows:

Table: 5.2: The Augmented Dickey Fuller Result For Monthly Data

	Philip-Perron test statistic/ADF			Mackinnon critical at 1% significance level			
Variable	Level	1st difference	2nd difference	Level	1st difference	2nd difference	Remark
HOUSEHSIZ	0.188	-4.739	-	-3.635	-3.642	-	I(1)
POPDEN	0.222	-5.389	-	-3.635	-3.642	-	I(1)
RPRECY	-1.607	-3.660	-	-3.635	-3.642	-	I(1)
QCOM	-3.886	-	-	-3.635	-3.642	-	I(0)
WPC	-4.339	-	-	-3.635	-	-	I(0)
RAIN	-3.830	-	-	-3.635	-	-	I(0)
RINC	-1.498	-4.617	-	-3.635	-3.642	-	I(1)
WORKPOP	0.240	-5.853	-	-3.635	-3.642	-	I(1)
RUSA	-2.111	-3.326	-6.5173	-3.635	-3.642	-3.647	I(2)
RUSFCOM	-1.512	-3.653	-	-3.635	-3.642	-	I(1)
TEMP	-5.628	-	-	-3.635	-3.642	-	I(0)
DUMPIN	-0.691	-5.116	-	-3.635	-3.642	-	I(1)
CARPRICE	-0.050	-3.710	-	-3.635	-3.642	-	I(1)

Where:

Househsiz = Mean household size in Lagos

Popden = Population per square kilometer (population density)

Rprecy = Average monthly price of recyclables (deflated by the consumer price index) corresponding to time t.

Qcom = Weekly/Monthly tonnes of commercial/industrial solid waste

Wpc = Weekly/Monthly waste per capita

Rain = Average monthly level of precipitation in Lagos corresponding to time t.

Rinc = Monthly household income (deflated by the CPI) corresponding to time t.

Workpop = Percentage of population between 15 and 49 of age

Rusa=Average monthly residential user charge (deflated by CPI) corresponding to time t.

Rusfcom = Average monthly user charge for commercial/industrial waste (deflated by the CPI) corresponding to time t.

Temp = Average mean temperature in Lagos

Dumpin = Monthly quantity (in tonnes) of waste dumped in Lagos Streets

Carprice = Cart pusher's average monthly charge

Dump = Quantity of waste dumped in Lagos in time t.

Rcarpr = Monthly real cart pusher's charge corresponding to time t.

Based on Philip Perron (PP) test statistic implemented above, four variables are integrated of order zero (quantity of commercial waste, waste per capita, temperature and precipitation level) while all other variables are integrated of order 1 (except the household user fee that is integrated of order 2) and as such needs a second differencing so as to achieve stationarity. The study incorporated these in the subsequent model.

We proceeded by analyzing the impact of economic instruments on household waste generation. This same model also captures the impact of some socioeconomic variables (such as household's real income, and population density). A linear model to capture the above relationship was fitted, the result of which is presented under section 5.3.

5.3 Household monthly regression results for differenced-stationary data

OLS regression for household model (monthly data)

$$Wpc = \beta_0 + \beta_1 D(Rprecy) + \beta_2 Rain + \beta_2 temp + \beta_4 d(Rinc) + \beta_5 D(Popden) + \beta_6 D^2(Rusa) + \varepsilon_{it} \quad (1)$$

Where D(variable) is the first difference of the variable, D^2 (variable) is the second difference of variable.

Table 5.3: OLS Regression result for residential model (differenced monthly data).

Dependent variable is WPC (waste per capita)

Variable	Coefficient	t-statistic
D(Rprecy)	-0.043	0.766
Rain	-0.001	-0.915
Temp	0.077	0.826
D(Rinc)	-0.000	-0.733
D(Popden)	0.265	0.502
D^2 (Rusa)	0.019	0.943
R^2	0.120	
Adjusted R^2	-0.038	
DW	1.361	
F-statistics	0.761	
Akaike info criterion	2.466	
Schwarz criterion	2.735	

The above result indicates that none of the independent variables on their own significantly explained waste generation per capita even at 10 percent significance level. Temperature increases, population density, and user fee positively increase waste generation per capita. Real price of recyclables, level of precipitation, and real household income insignificantly depressed waste generation.

A look at the result indicates that contrary to expectation, waste generation responded positively to user fee and negatively to income. Another look at the other statistics indicated that R-squared of about twelve percent indicates that this is rather a poor fit.

F-statistics result also indicates that the joint contributions of the independent variables in explaining waste generation per capita in Lagos state was unfounded. Lastly, Durbin Watson result indicates that first-order auto correction was present.

The negative adjusted coefficient of determination, insignificant F-statistic, and contraintuitive results made us to simulate with various functional forms.

Pindyck and Rubinfeld (1998) suggest that time-series analysis and regression analysis can be combined to produce a better forecast than would be possible with the use of either of these techniques alone. A regression model would have the dependent variable explained by all the independent variable(s) and an additive error term. The additive error term accounts for unexplained variance in the dependent variable. However, one source of forecast error of this regression model come from the additive error (noise) term whose future values cannot be predicted.

We therefore went further by re-specifying the model in such a way that the residuals would resemble a white noise process. In particular, the residuals must be nearly uncorrelated with each other so that a sample autocorrelation function of the residuals would be close to zero for displacement $K \geq 1$ (Pindyck and Rubinfeld, 1998).
In order to correct the misspecification problem, we simulated various ARMA terms as suggested by the Eviews User's Guide (2003: 311) which gave an insight into the AR and MA terms to fit the properties of the residuals. It suggests that the Akaike information criterion and Schwarz criterion provided with each set of estimates may be used as a guide for appropriate lag order selection and we simply took a clue from this, and, based on their robustness, adopted ARMA (2,1) the result is hereunder presented:

Table 5.4: OLS regression for household model (differenced monthly data) with ARMA terms.

Dependent variable is WPC (Waste per capita)

Variables	Coefficient	t-statistic
D(Rprecy)	-0.010	-0.198
Rain	-0.002	-1.256
Temp	0.125	1.101
D(Rinc)	-0.001	-2.356
D(Popden)	0.012	0.018
D^2(Rusa)	0.025	1.399
AR(1)	1.215	7.285
AR(2)	-0.541	-3.210
MA(1)	-0.967	-28.030
R^2	0.448	
Adjusted R^2	0.256	
DW	1.966	
F-statistic	2.335	
Akaike info criterion	2.245	
Schwarz criterion	2.658	
Convergence achieve after 16 iterations		

There was a positive relationship between monthly waste generated per capita and temperature, population density and user fee. Real household income, level of precipitation, and price of recyclables were negatively related to waste per capita even though only income significantly explained waste generation per capita.

The coefficient of determination and the adjusted coefficient of determination are high enough for difference-stationary model, but the insignificant F-statistic however is a major flaw of this functional form. The Durbin Watson result here may not be of guidance in the test of a first-order autocorrelation but the counter-intuitive results and nonconformity with theory and practice of results has made us to conclude that fitting the monthly data to our residential demand for solid waste services may produce misleading results.

5.4 Commercial monthly regression results for differenced-stationary data

OLS regression for differenced commercial model (monthly data)

The model to be analysis here is hereunder stated:

$$Qcom = \alpha_1 Qcom_{t-1} + \alpha_2 D(Rprecy) + \alpha_3 Rain + \alpha_4 Temp + \alpha_5 D(Rusfcom) + \varepsilon_{t-1} \quad (2)$$

Where D(variable) is the first difference of the variable, D^2 (variable) is the second differenced of variable.

Table 5.5: OLS Result for differenced variables (commercial model)

Dependent variable is Qcom (monthly quantity of commercial waste)

Variables	Coefficient	t-statistic
$Qcom_{t-1}$	0.617	5.289
d(Rprecy)	390.577	0.781
Rain	2.016	0.158
Temp	557.177	3.322
d(Rusfcom)	-0.378	-0.149
R^2	0.473	
Adjusted R^2	0.403	
F-statisic	6.734	
Akaike info criterion	20.994	
Schwarz criterion	21.217	

The above result indicates that commercial waste generated in the previous time period has a significantly high positive impact on those generated in the present or current period. At the other hand, temperature level is a significant explanatory factor of commercial waste. This is also in conformity with Jenkin's finding that commercial waste is positively related to the level of economic activities which is positively influenced by temperature level. In addition, commercial user charge exhibited an inverse relationship with the quantity of commercial waste generation in conformity with theories. A further look at the result indicates that commercial waste is positively related to price of recyclables as opposed to the theoretical postulates. Level of precipitation is also positively related to total commercial waste although, neither of these variables significantly accounted for commercial waste generation. The other statistics produced R-squared of about fourty-seven percent and this is rather a good fit for a difference-stationary model. Collectively, the variables contributed significantly to waste generation, but individually insignificant. The adjusted coefficient of determination of fourty percent and Lagrange-Multiplier result which ruled out the presence of serial correlation points to the fact that this model is reliable. Since autocorrelated errors can be ruled out (see table 5.5), we do not see any reason for estimating the ARMA version of the model.

The Breusch-Godfrey LM test is a general autocorrelation test which can accommodate lagged explanatory variables and can test for higher-order autoregressive schemes like AR(2), AR(3), *etc.* In addition, it can allow for simple or higher-order moving averages of white noise error terms (Gujarati, 2003: 473). For the above-mentioned reasons, we consider it more appropriate in testing for serial correlation of our models and the procedure is as follows:

In a model $Y_t = \beta_0 + \beta_1 X_{it} + \ldots + \beta_{nt} X_{nt} + \mu_t$ (3)

If the error term follows pth-order autoregressive scheme (AR(p)), then;

$$\mu_t = \rho_1\mu_{t-1} + \rho_2\mu_{t-2} + \ldots + \rho_p\mu_{t-p} + \varepsilon_t \quad (4)$$

ε_t is a white noise error term. The null hypothesis of the test is, $\rho_1 = \rho_2 = \ldots = \rho_p = 0$.
In other words, there is no serial autocorrelation of any order (in the above case, of order p). the decision rule is to use the F-test and Obs*R-squared to test the joint significance of the coefficients of the error terms. If we obtain a probability value greater than 0.05, it means that, at 5% significance level, the LM test does not reject a null hypothesis of no autocorrelation (Hill, Griffiths and Judge, 2001: 275).

The implementation procedure is to run OLS on model Y_t and obtain the μ_t. We then regress μ_t on the original explanatory variables as well as the lagged values of μ to the desired order. For example, in an AR(2) for the original model above, we have;

$$\mu_t = \beta_0^* + \beta_1 X_{it} + \ldots + \beta_n X_{nt} + \mu_{t-1} + \mu_{t-2} + \varepsilon_t \qquad (5)$$

Table 5.6: Breusch-Godfrey Serial Correlation LM test for differenced weekly model

F-statistic	2.575	Probability	0.094
Obs*R-squared	5.436	Probability	0.066

The search for the most befitting estimate of commercial model still continues. Since the intent of this research is to obtain a most reliable estimate of data, we therefore performed analysis on weekly data of all variables earlier mentioned. Before we proceeded, we still tested for the presence of a unit root and the results are as follows:

Weekly results

Table 5.7: The augmented Dickey-Fuller result for weekly data

	Philips-Perron test statistic /ADF		Mackinnon critical at 1% significance level				
Variable	Level	1st Difference	2nd difference	Level	1st difference	2nd difference	Remark
Househsiz	0.062	-5.595	-	-3.474	-3.474	-	I(1)
Popden	-0.335	-9.295	-	-3.474	-3.474	-	I(1)
Rprecy	-1.610	-4.935	-	-3.474	-3.474	-	I(1)
Qcom	-3.543	-	-	-3.474	-	-	I(0)
Wpc	-3.488	-	-	-3.474	-	-	I(0)
Rain	-3.237	-4.663	-	-3.474	-3.474	-	I(1)
Rinc	-1.473	-5.622	-	-3.474	-3.474	-	I(1)
Workpop	-1.674	-9.295	-	-3.474	-3.474	-	I(1)
Rusa	-1.775	-4.999	-	-3.474	-3.474	-	I(1)
Rusfcon	-1.550	-5.375	-	-3.474	-3.474	-	I(1)
Temp	-3.907	-	-	-3.474	-	-	I(0)
Dumpin	-1.012	-7.061	-	-3.474	-3.474	-	I(1)
Carprice	-2.321	-4.267	-	-3.474	-3.474	-	I(1)

Where:

Househsiz = Mean household size in Lagos

Popden = Population per square kilometer (population density)

Rprecy = Average monthly price of recyclables (deflated by the consumer price index) corresponding to time t.

Qcom = Weekly/Monthly tonnes of commercial/industrial solid waste

Wpc = Weekly/Monthly waste per capita

Rain = Average monthly level of precipitation in Lagos corresponding to time t.

Rinc = Monthly household income (deflated by the CPI) corresponding to time t.

Workpop = Percentage of population between 15 and 49

Rusa=Average monthly residential user charge (deflated by CPI) corresponding to time t.

Rusfcom = Average monthly user charge for commercial/industrial waste (deflated by the CPI) corresponding to time t.

Temp = Average mean temperature in Lagos

Dumpin = Monthly quantity (in tonnes) of waste dumped in Lagos Streets

Carprice = Cart pusher's average monthly charge

Dump = Quantity of waste dumped in Lagos in time t.

Rcarpr = Monthly real cart pusher's charge corresponding to time t.

The result of a-unit root test on all weekly series are shown above and based on the order of integration, we ran regression on the differenced variable. In order words, for variable X with a unit root, we replaced X with $\Delta X = D(X) = X_t - X_{t-1}$. For variable X integrated of order 2, $D^2(X) = D(X_t) - D(X_{t-1})$. By so doing, the model is transformed as follows:

5.6 Household weekly regression results for differenced-stationary data

<u>OLS Regression for Differenced Residential Model (Weekly Data)</u>

$$Wpc_i = \beta_1 D(Rprecy) + \beta_2 D(Rain) + \beta_3 Temp + \beta_4 D(Rusa) + \beta_5 D(Rinc) + \beta_6 D(Popden) + \varepsilon_{it}$$

Where D(variable) is the first difference of the variables, D^2(variable) is the second difference o variable. Note that first differencing eliminates the need for a constant term in the transforme equation. If a constant term were included, it would pick up the effect of any time trend present i the initial model (Pindyck and Rubinfeld, 1998).

Table 5.8: OLS regression result for differenced weekly residential model

Dependent variable is WPC (waste per capita).

Variables	Coefficient	T-statistics
D(Rprecy)	0.055	3.401
D(Rain)	2.62E.05	0.090
Temp	0.027	69.620
D(Rinc)	5.23E.05	0.604
D(Popden)	0.000	0.180
D(Rusa)	-0.007	-1.192
R^2	0.074	
Adjusted R^2	0.043	
DW	1.151	
F-statistic	2.373	
Akaike info criterion	-1.032	
Schwarz criterion	-0.914	

The result in table 5.8 indicates that price of recyclables as represented by its first difference metrological variables (temperature and precipitation levels), real income, and population densit were positively related to waste generation per capita. Real user fee however was inversely relatec to waste per capita in conformity with theory and practice. Price of recyclables and temperatur level are significantly accounted for in our model.

This model is not acceptable however on the ground of very low coefficient of determination an adjusted-coefficient of determination even though the F-statistic is barely significant at the 5% level. To overcome this, we simulated with various ARMA models and based on level o robustness settled for ARMA(2. 1) which result is presented as follows:

Table 5.9: OLS regression result for differenced weekly variable with ARMA term.

Dependent variable is Wpc (waste per capita).

Variables	Coefficient	T-statistic
D(Rprecy)	0.072	5.132
D(Rain)	0.000	1.156
Temp	0.027	24.185
D(Rinc)	2.39E.05	0.350
D(Popden)	0.000	0.313
D(Rusa)	-0.010	-2.070
Ar(1)	0.893	4.420
Ar(2)	-0.016	-0.117
Ma(1)	-0.587	-3.117
R-squared	0.315	
Adjusted R-squared	0.277	
DW	1.979	
F-statistic	7.211	
Akaike info criterion	-1.306	
Schwarz criterion	-1.127	
Convergence achieved after 8 iterations		

A close examination of the result indicates that the coefficient of determination has greatly improved. A coefficient of determination of approximately 32 percent and adjusted-coefficient of determination of almost 28% is not a bad one for differenced variables, although there is still room, for improvement. The MA and AR roots also confirm that spurious regression has been avoided. The highly significant F-statistic indicates that all the independent variables jointly explained waste per capita in Lagos.

Table 5.10: Breusch-Godfrey serial correlation LM test for differenced weekly model with ARMA term

F-statistic	0.062	Probability	0.939
Obs *R-square	0.131	Pobability	0.936

The Lagrange-multiplier result above also rejects the possibility of first and second-order autocorrelation, meaning that this model is more reliable.

The above result indicated that price of recyclables, meteorological variables (temperature and precipitation levels), real income, population density are positively related to waste generation per capita. Real user fee is negatively related to waste capita in conformity with theory and practice.

User fee, temperature level and the price of recyclables were significantly accounted for in th above model. Despite the level of confidence exhibited by the model here, we still feel that othe techniques can still be explored so as get the best linear unbiased estimate of the household model.

5.7 Commercial weekly regression results for differenced-stationery data

OLS regression for differenced commercial model (weekly data)

The model to be analyzed here is hereunder stated:

$$Qcom = \alpha_1 Qcom_{t-1} + \alpha_2 (Rprecy) + \alpha_3 D(Rain) + \alpha_4 Temp + \alpha_5 D(Rusfcom) + \varepsilon_{it} \quad (7)$$

Where D(variable) is the first difference of the variable, D^2(variable) is the second difference o variable.

Table 5.11: regression result for differenced weekly commercial model

Dependent variable is Qcom (Monthly quantity of commercial waste)

Variables	Coefficient	T-statistics
$Qcom_{t-1}$	0.803	18.061
D(Rprecy)	157.312	1.257
D(Rain)	-5.082	-1.496
Temp	65.585	4.322
D(Ruscom)	0.089	0.152
R^2	0.669	
Adjusted R^2	0.660	
DW	2.370	
F-statistic	75.654	
F-statistics	75.654	
Akaike info criterion	17.720	
Schwarz criterion	17.818	

The unreported result of the commercial model shows a disappointed result as the coefficient o determination and adjusted coefficient of determination are negative making the model totall unacceptable. When we factor in the fact that waste generation in time t-1 could significantl explain waste generation in time t, there is a remarkable improvement in our estimate which i presented in Table 5.10. First, the coefficient of determination of about sixty-seven percent and the adjusted coefficient of determination of sixty-six percent, and highly significant F-statistic made this estimate looks unbiased and acceptable.

The result indicates that precipitation level is the only variable that has an inverse relationship with commercial waste. Contrary to theory and practice, price of recyclables as well as the commercial user fee relates positively to commercial waste generation.

Table 5.12: Breusch-Godfrey serial correlation LM test for differenced weekly commercial model.

F-statistic	6.528	Probability	0.002
Obs*R-squared	12.563	Probability	0.002

Breusch-Godfrey serial correlation result for the model however failed to reject the presence of serial correlation. Therefore, a more appropriate model has to be estimated by introducing the ARMA terms to correct the misspecification in the above model. Based on the robust nature, we settled for ARMA (1, 2). The result based on this is hereunder presented.

Table 5.13: OLS results for weekly commercial model with ARMA term

Dependent variable is Qcom (Monthly quantity of commercial waste)

Variables	Coefficient	T-statistics
$Qcom_{t-1}$	0.894	17.551
D(Rprecy)	158.831	1.525
D(Rain)	-4.147	-1.464
Temp	36.672	2.144
D(Ruscom)	-0.157	-0.340
AR(1)	0.815	7.032
MA(1)	-1.250	-11.299
MA(2)	2.370	1.731
F-statistic	75.654	
Akaike info criterion	17.720	
Schwarz criterion	17.818	
Convergence achieved after 99 iterations		

Table 5.14 serial correlation LM test for weekly commercial model with ARMA term.

F-statistics	11.161	Probability	0.000
Obs*R-squared	20.661	Probability	0.000

Table 5.13 shows the result which indicates that the coefficient of determination and the adjusted coefficient of determination have increased due to the addition of the ARMA (1, 2) term. The coefficient of determination is very high for a differenced variable, this is quite remarkable. The joint contributions of the independent variables in explaining the quantity of commercial waste generation was confirmed by the highly significant F-statistic.

Last period commercial waste quantity is directly and significant related to the current commercial waste quantity. In addition, commercial waste quantity is significantly explained by the temperature level in agreement with Jenkin's findings. The relationship between commercial waste and temperature level is direct. This is an agreement with the findings of Jenkins that commercial activities increase with high temperature. On the overall, most independent variables behaved in conformity with theories and practice. Price of recyclables responded positively to commercial waste turnout, level of precipitation responded negatively to commercial waste. In addition, commercial user charge exhibited an inverse relationship with the quantity of commercial waste generation in conformity with theory and practice. None of these variables significantly affect commercial waste generation.

However, the Lagrange-Multiplier result also presented is a confirmation of the presence of serial correlation. The search for the most robust estimate of commercial model still continues.

5.8 Monthly regression results for unfiltered commercial data at levels

Commercial model (data estimation at levels)

The models to be analyzed here is hereunder stated:

$Qcom = \alpha o + \alpha_1 Rrprecy + \alpha_2 Rain + \alpha_3 Temp + \alpha_4 Rusfcom + \varepsilon_{it}$

Where, all variables are as previously defined.

Table 5.15 regression for commercial model (unfiltered monthly data at levels)

Dependent variable is Qcom (Monthly quantity of commercial waste)

Variables	Coefficient	T-statistics
Constant	83622.080	1.613
D(Rprecy)	269.115	0.746
(rain)	-6.300	-0.298
Temp	-2543.065	-1.494
Rusfcom	3.281	1.803
R^2	0.156	
Adjusted R^2	0.047	
DW	0.0706	
F-statistic	1.430	
Akaike info criterion	21.698	
Schwarz criterion	21.918	

The above results on table 5.15 indicate that none of the independent variables on their own significantly explained waste generation even at 10 percent significance level.

A further look at the result indicates that most of the included explanatory variables exhibited contrary signs to theory and practice. The coefficient of determination produced a result of about sixteen percent which indicates that this is a poor fit. The adjusted coefficient of five percent and Durbin Watson of 0.71 points to the fact that serial correlation is present. The main conclusion that can be drawn from this is that fitting OLS to unfiltered and undifferenced monthly data of the commercial model will produce a misleading result.

The justification for applying the Cochrance-Orcutt's estimated generalized least squares (EGLS) when OLS shows autocorrelated disturbances was provided by Greene (1997), Judge *et. al.* (1985), Hill, Griffith and Judge (2001). Taking a clue from this, we present our EGLS result as follows:

Table 5.16 EGLS regression for commercial model (unfiltered monthly data at levels)

Dependent variable is Qcom (Monthly quantity of commercial waste)

Variables	Coefficient	T-statistic
Constant	76441.400	1.506
Rprecy	240.938	0.555
Rain	-16.706	-1.056
Temp	-1470.394	-0.887
Rusfcom	0.548	0.240
AR(1)	0.579	4.543
R^2	0.506	
Adjusted R^2	0.420	
DW	75.654	
F-statistic	5.933	
Akaike info criterion	20.988	
Schwarz criterion	21.254	
Convergence achieved after 6 iterations		

A look at the result on table 5.16 indicates that the coefficient of determination and the adjusted coefficient of determination have improved. The coefficient of determination indicates that independent variables have explained about 51 percent variability in the quantity of commercial waste.

The joint contributions of the independent variables in explaining the quantity of commercial waste generated was confirmed by the highly significant F-statistic. In addition, the Durbin-Watson statistic of 2.50 is an indication of the absence of at least a first-order autocorrelation. This is also confirmed by the LM result hereunder presented.

Table 5.17: Breusch-Godfrey serial correlation LM test for commercial model (unfiltered monthly data at levels)

F-statistics	2.830	Probability	0.077
Obs*R-squared	6.066	Probability	0.048

While the price of recyclables responded positively to commercial waste turnover, meteorological variables (level of precipitation and temperature level) responded negatively to total commercial waste. In addition, commercial user charge exhibites a direct relationship with the quantity of commercial waste generation. On the overall, most independent variables exhibited counter-intuitive results which are at variance with theories and practice and none significantly explained commercial waste generation but collectively, they contributed to the explanation of commercial waste. The search for the most robust estimate of commercial model still continues.

5.8 Monthly regression results for filtered commercial data at levels

Commercial model (filtered data and levels' estimation

The model to be analysed here is hereunder stated:

$$\text{Qcomsm} = \alpha o + \alpha_1 \text{ Rprecysm} + \alpha_2 \text{ Rainsm} + \alpha_3 \text{ Tempsm} + \alpha_4 \text{ Rusfcomsm} + \varepsilon_{it} \qquad (9)$$

Where, all variables are as previously defined and SM after a variable means the variable has bee filtered using Holt-Winters method. The choice of Holt-Winters' filtering technique over that o others has already been explained in the analytical technique, so we are not going to bring that u here in this discussion.

Table 5.18 regression for commercial model (monthly filtered data at levels)

Dependent variable is Qcomsm (Monthly quantity of commercial waste)

Variables	Coefficient	T-statistics
Constant	31141.610	0.602
Rprecysm	133.176	0.336
Rainsm	14.507	0.557
Tempsm	-782.836	-0.500
Rufcosm	3.717	1.875
R^2	0.142	
Adjusted R^2	0.031	
DW	0.299	
F-statistics	1.281	
Akaike info criterion	21.909	
Schwarz criterion	22.129	

The result on Table 5.18 indicates that the coefficient of determination as well as the adjusted coefficient of determination are too low. The F-statistic result also failed to support the joint contributions of the independent variables in explaining commercial waste generation. In addition, the Durbin-Watson result failed to reject the presence of serial autocorrelation and most variable results showed counter-intuitive signs and are insignificant thus necessitating the estimating of an EGLS version of the model.

Table 5.19 GLS regression for commercial model (monthly filtered data at levels)

Dependent variable is Qcom (Monthly quantity of commercial waste)

Variables	Coefficient	T-statistics
Constant	74351.140	2.544
Rprecysm	97.776	0.285
Rainsm	-9.719	-0.931
Tempsm	-889.867	-1.157
Rufcosm	-0.253	-0.143
AR(1)	0.797	10.562
R^2	0.812	
Adjusted R^2	0.779	
DW	2.018	
F-statistics	24.978	
Akaike info criterion	20.254	
Schwarz criterion	20.521	
Convergence achieved after 8 iterations		

A look at the result on Table 5.19 indicates that the autoregressive process is 0.80 which is within a unit bracket indicating the stationarity of the process. In addition, we present the estimate of autocorrelation using the Breusch-Godfrey serial correlation LM-test. The result of this is presented below on table 5.20.

Table 5.20: Breusch-Godfrey serial correlation LM test for commercial model (monthly filtered data at levels):

F-statistics	0.573	Probability	0.571
Obs*R-squared	1.424	Probability	0.491

The serial correlation result presented above confirmed that serial correlation has been corrected by the use of GLS or EGLS or FGLS to estimate the monthly commercial model. Other results indicated that the independent variables have been able to account for about 81 percent variability in commercial waste, this is a good fit. The joint contributions of the independent variables in explaining commercial waste has been confirmed by our significant F-statistic.

Meteorological variables affected commercial waste generation negatively and, commercial user charge has an inverse relationship with quantity of waste generated by the commercial sector. Contrary to expectation, price of recyclables reacted directly to the commercial waste quantity. In all, none of the independent variables on its own significantly explained the commercial waste quantity. This on a first inspection looks like the problem of multicollinerarity. Gujarati (2003) referred to Goldberger's parody which emphasized that small sample size and lack of variability in the explanatory variables may cause problems that resemble multicollinearity (Gujarati 2003). The remedial measures are in two categories. One is to follow some rule of thumb (pooling the data, dropping variable(s) and specification bias, transformation of variables, addition of new data *etc.*). The other way around it is the "do nothing" approach championed by Blanchard (1967). According to this approach, multicollineratiy is not a problem with OLS or statistical technique in general, it is a data deficiency problem (micronumerosity) and most time, we have no choice over the data we have available for analysis (Gujarati 2003). It is true that there is non-variability in most of our explanatory variables. This could be the reason why our coefficient of determination and adjusted coefficient of determination are so high whereas all the explanatory variables are insignificant but nearly exhibited expected signs. Following Blanchard's suggestions, we do not see any reason why we should do anything to correct this, moreso that other approach to the issue is based on rule of thumb and their potentials in solving the problem without creating a more difficult problem into our analysis is doubtful.

5.9 Weekly regression results for filtered commercial data at levels

<u>Regression results after applying Holt-Winters filter on weekly series commercial model</u>

The model to be analysed here is hereunder stated:

$$Qcomsm = \alpha_0 + \alpha_1 \text{ Rprecysm} + \alpha_2 \text{ Rainsm} + \alpha_3 \text{ Tempsm} + \alpha_4 \text{ Rusfcosm} + \varepsilon_{it}$$

(In the above model, the SM after a variable indicated that the variable has been filtered).

Table 5.21: OLS estimate of weekly filtered data for commercial model

Dependent variable is Qcomsm (weekly quantity of commercial waste)

Variables	Coefficient	T-statistic
Constant	12408.200	2.224
Rprecysm	74.709	1.891
Rainsm	0.817	0.337
Tempsm	-390.277	-2.160
Rufcosm	0.778	3.918
R^2	0.147	
Adjusted R^2	0.124	
DW	0.142	
F-statistic	6.577	
Akaike info criterion	18.640	
Schwarz criterion	18.737	

The OLS result on smoothed series was not too different from that of the unsmoothed weekly commercial model except that two variables significantly explained commercial waste generation. R-squared and adjusted R-squared improved slightly, but the autocorrelated disturbances still appeared. This therefore, made our OLS estimate inefficient. Applying GLS due to its efficiency property (Green, 1997), a better estimate was achieved.

GLS estimate of weekly commercial model.

The model to be analyzed here is hereunder stated:

$$\text{Qcomsm} = \alpha_0 + \alpha_1\text{Rprecysm} + \alpha_2\text{Rainsm} + \alpha_3\text{ Tempsm} + \alpha_4\text{ Rusfcom} + \varepsilon\text{it} \qquad (11)$$

Table 5.22 GLS estimate of weekly filtered data for commercial model

Dependent variable is Qcomsm (Weekly quantity of commercial waste)

Variables	Coefficient	T-statistics
Constant (α_0)	3230.565	0.519
Rprecysm	59.461	0.895
Rainsm	-1.906	-0.990
Tempsm	188.827	1.000
Rufcosm	-0.019	-0.342
AR (1)	0.924	36.514
R^2	0.894	
Adjusted R^2	0.891	
DW	1.891	
F-statistic	254.904	
Akaike info criterion	16.521	
Schwarz criterion	16.638	
Convergence achieved after 7 iterations		

A close look at the result on Table 5.22 indicates that autoregressive process is 0.92 which is within a unit bracket indicating the stationarity of process. In addition, we analyzed the autocorrelation process using the Breusch-Godfrey serial correlation LM test. The result of this is presented on Table 5.23.

Table 5.23: Breusch–Godfrey serial correlation LM test of weekly filtered data for commercial model

F-squared	0.621	Probability	0.539
Obs*R-squared	1.297	Probability	0.523

The Lagrange multiplier result indicates that autocorrelation was not present. The EGLS result for commercial model showed that the coefficient of determination improved tremendously to 89 percent, the F-statistic of 254.9 validated the joint significance of the independent variables in explaining total commercial waste generated. The LM confirmed the absence of autocorrelation meaning that estimates based on the weekly commercial model is good for policy formulation. A fairly comprehensive interpretation of result is hereunder given.

Based on the FGLS estimates reported, the coefficient of determination of 89 percent points to the fact that all independent variables explained up to 89 percentage variability in total commercial waste generation.

Even though each of the independent variable did not explain total commercial waste generation significantly, a combination of these variables explained the commercial waste generation significantly.

Contrary to expectation, commercial waste generated responded positively to the average price of recyclables. This result is also related to what was obtained by Jenkins in his commercial model.

Precipitation level and commercial waste generated are inversely related indicating that rain reduces the level of commercial activity and hence the quantity of commercial waste generation. The quantity of commercial waste generation responded positively to temperature in conformity with intuition. The above result is true since commercial activity and temperature are positively related, it is expected that total commercial waste should have a positive relationship with temperature level.

Lastly, the commercial user fee was negatively related to commercial waste generation. This is also a confirmation of theories, especially Jenkin's (1993) theory of firms' behaviour adopted in this work.

The above result also exhibited traits that resemble multicollinearity. Gujarati (2003) referred to Goldberger's parody which emphasized that small sample size and lack of variability in the explanatory variables may cause problems that resemble multicollinearity (Gujarati, 2003). We also adopted the "do nothing" approach championed by Blanchard (1967). Since we have no choice over the data we have available for empirical analysis (Gujarati, 2003).

5.10 Monthly regression results for unfiltered household data at levels

OLS estimates for unfiltered monthly household model (variables at levels)

OLS regression for residential unfiltered model at levels (monthly data) is produced below:

$$Wpc = \beta_0 + \beta_1 Rinc + \beta_2 Popden + \beta_3 Rain + \beta_4 Temp + \beta_5 Rprecy + \beta_6 Rusa + \varepsilon_{it} \quad (12)$$

Table 5.24: OLS estimate of monthly unfiltered data for household model.

Dependent variable is Wpc (Monthly waste per capita)

Variable	Coefficient	T-statistic
Constant (β_0)	4.693	0.177
Rinc	0.000	0.196
Popden	-0.001	-0.122
Rain	-0.000	-0.240
Temp	0.131	0.926
Rprecy	0.073	1.272
Rusa	-0.037	-1.194
R^2	0.101	
Adjusted R^2	-0.085	
DW	1.603	
F-statistic	0.543	
Akaike info criterion	2.482	
Schwarz criterion	2.790	

OLS result of monthly series shows some unimpressive result as it has, very low R-squared and negative adjusted R-squared, Durbin-Watson of 1.60 indicating the presence of serial correlation. We further applied an FGLS on series and the result is not in anyway better than the OLS estimate. The FGLS estimate is presented below.

GLS estimates for unfiltered, household model (monthly variables at levels)

GLS regression for residual unfiltered model at levels (monthly data) is produced below:

$$Wpc = \beta_0 + \beta_1 \, Rprecy + \beta_2 \, Rain + \beta_3 \, Temp + \beta_4 \, Rusa + \beta_5 \, Rinc + \beta_6 \, Popden + \varepsilon_{it} \quad (13)$$

Table 5.25: FGLS estimate of monthly unfiltered data for household model.
Dependent variable is Wpc (Monthly waste per capita).

Variables	Coefficient	T-statistic
Constant (β_0)	13.816	0.479
Rinc	-0.000	-0.163
Popden	-0.004	-0.406
Rain	-0.001	-0.587
Temp	0.095	0.585
Rprecy	0.066	0.935
Rusa	-0.026	-0.690
AR(1)	0.235	1.195
R^2	0.143	
Adjusted R^2	-0.079	
DW	1.849	
F-statistic	0.646	
Akaike info criterion	2.530	
Schwarz criterion	2.886	
convergence achieved after 7 iterations		

The result on Table 5.25 shows that household user fee, level of precipitation, household income and population density are inversely related to waste per capita. On the other hand temperature level, and price of recyclables are positively related to waste per capita contrary to expectation.

A further look at the result indicates that the coefficient of determination is very low and the adjusted coefficient is negative and all the independent variables have not significantly explained waste per capita. In addition, the Durbin-Watson result shows the presence of serial correlation making us to suspect the inadequacy of this model. We therefore proceeded by smoothing our monthly data and then re-made our estimates.

5.11 Monthly regression results for filtered household data at levels

OLS estimate for filtered, monthly household model (variables at levels)

OLS regression for filtered household model at levels (monthly data) is produced below:

$$Wpcsm = \beta_0 + \beta_1 Rprecysm + \beta_2 Rainsm + \beta_3 Tempsm + \beta_4 Rusasm + \beta_5 Rincsm + \beta_6 Popdensm + \varepsilon_{it} \quad (14)$$

Table 5.26: OLS Estimate of monthly filtered data for household model.

Dependent variable is Wpc (Monthly waste per capita)

Variables	Coefficient	T-statistic
Constant (β_0)	-4.999	-1.100
Rincsm	0.000	1.354
Popdensm	0.003	1.913
Rainsm	8.65E-05	0.332
Tempsm	0.003	0.179
Rprecysm	0.011	1.235
Rusasm	-0.005	-1.108
R^2	0.521	
Adjusted R^2	0.422	
DW	0.488	
F-statistic	5.261	
Akaike info criterion	-1.147	
Schwarz criterion	-0.839	

The result on Table 5.26 shows that income is positively related to waste generated per capita in conformity with theory and practice. Population density significantly explained waste generated per capita and the relationship is a direct one. Other results indicate that temperature level and price of recyclables directly explained waste per capita. Precipitation level was positively related to waste per capita. In agreement with theory, user fee is inversely related to waste generated per capita.

In the above case however, the F-statistic justified the joint contributions of the independent variables in explaining waste per capita. The coefficient of determination of 52 percent is not too low. With Durbin-Watson of 0.49 however, there is surely the presence of at least a first-order autocorrelation. This further necessitated analyzing with an FGLS because of its efficiency property.

Table 5.27: GLS estimate of monthly filtered data for household model

Dependent variable is Wpc (Monthly waste per capita)

Variables	Coefficient	T-statistic
Constant (β_0)	-2.808	-0.745
Rincsm	-4.34E-05	-0.571
Popdensm	0.003	1.910
Rainsm	-1.15E-05	-0.083
Tempsm	0.002	0.146
Rprecysm	-0.003	-0.377
Rusasm	0.002	0.518
AR (1)	0.782	7.941
Adjusted R^2	0.810	
DW	1.232	
F-statistic	21.707	
Akaike info criterion	-2.214	
Schwarz criterion	-1.859	
Convergence achieved after 12 iterations		

Table 5.28: Breusch-Godfrey serial correlation LM test of monthly filtered data for household model.

F-statistic	3.652	Probability	0.041
Obs*R-squared	7.914	Probability	0.019

The result on Table 5.27 shows the FGLS for the filtered monthly data. The result also is not too different from the OLS counterpart just estimated. This lends credence to the postulates that whenever we use FGLS, or EGLS method, the estimates may not be best linear unbiased estimate (BLUE) in small samples. The estimated OLS coefficients may have their usual optimum properties asymptotically. Griliches and Rao (1969) in a Monte Carlo study found that if the sample is relatively small and the 'rho' value is less than 0.3, OLS is as good or better than FGLS when there is autocorrelation. The determination of large or small samples is however not easily determinable. Practical judgment however suggests that if you have observations of 15 to 20, the sample may be small, but if you have, say, 50 or more observations, the sample may be relatively large (Gujarati, 2003).

Lastly, the Lagrange multiplier result of the model indicates that at least a first-order autocorrelation was still present and as such this model is not reliable as it is not efficient and cannot be relief upon for policy formulation.

5.12 Weekly regression results for unfiltered household data at levels

OLS estimate for unfiltered, weekly household model (variables at levels)

OLS regression for residential unfiltered model at levels (weekly data) is produced below:

$$Wpc = \beta_0 + \beta_1 Rprccy + \beta_2 Rain + \beta_3 Temp + \beta_4 Rusa + \beta_5 Rinc + \beta_6 Popden + \varepsilon_{it} \qquad (15)$$

Table 5.29: OLS estimate of weekly unfiltered data for household model

Dependent variable is Wpc (waste per capita)

Variables	Coefficient	T-statistic
Constant (β_0)	0.469	0.227
Rprecy	0.007	1.848
Rain	-0.000	-0.789
Temp	0.019	1.669
Rinc	4.85E-05	0.962
Popden	4.80E-05	0.068
Rusa	-0.006	-4.297
R^2	0.149	
Adjusted R^2	0.115	
DW	1.655	
F-statistic	4.347	
Akaike info criterion	-1.083	
Schwarz criterion	-0.946	

OLS result of weekly series for unfiltered data series at levels shows some unimpressive results as it has, low R-squared, and autocorrelation cannot be ruled out. We further applied an FGLS on series and the result is presented below.

<u>FGLS estimates for unfiltered, weekly household model (variables at levels)</u>

FGLS regression for residential filtered model at levels (weekly data) is produced below:

$$Wpc = \beta_0 + \beta_1 Rprecy + \beta_2 Rain + \beta_3 Temp + \beta_4 Rusa + \beta_5 Rinc + \beta_6 Popden + \varepsilon_{it} \quad (16)$$

Table 5.30: FGLS estimate of weekly unfiltered data for household model

Dependent variable s Wpc (waste per capita)

Variables	Coefficient	T-statistic
Constant (β_0)	0.279	0.126
Rprecy	0.008	1.893
Rain	-0.000	-0.771
Temp	0.017	1.264
Rinc	6.24E-05	1.134
Popden	7.47E-05	0.098
Rusa	-0.006	-3.786
AR (1)	0.516	1.945
R^2	0.179	
Adjusted R^2	0.140	
DW	1.925	
F-statistic	4.589	
Akaike info criterion	-1.127	
Schwarz criterion	-0.970	
Convergence achieved after 6 iterations		

Before an in-depth breakdown of the above result, it is good to test for the presence of autocorrelation using the Lagrange multiplier test and the result is depicted as follows:

Table 5.31: Breusch-Godfrey serial correlation LM test on weekly unfiltered data for household model

F-statistics	3.422	Probability	0.035
Obs*R-squared	6.986	Probability	0.030

LM test above failed to reject the presence of serial correlation up to order 2. In addition, there was a low coefficient of determination of about 18%, although F-statistic was significant and autoregressive root within a unit bracket is a clear sign of stationarity.

Looking at the coefficient of determination and the adjusted coefficient of determination, the independent variables have explained only about 18 and 14 percent respectively of the variability in waste per capita. This is a bad fit. In addition, the coefficient of determination and the adjusted coefficient of determination of 18 and 14 respectively indicates that the included explanatory variables contributed insignificantly to the explanation of waste per capita and were not properly accounted for.

A further look at the result showed that household income, population density, price of recyclables, and temperature level have positive impact on waste generated per capita although the coefficients are very low and insignificant.

Other result shows that the level of precipitation was indirectly related to waste generated per capita. However, what the precipitation adds to waste per capita was very slight and insignificant. The logic behind this result is simple, since not all households do keep their refuse bins indoor, it is expected that precipitation may cause waste to increase in weight. Again, the user fee was negatively related to waste per capita in conformity with intuition, theory, and empirical findings of earlier works (Jenkins, 1993; Richardson and Havlicek, 1978; Wertz, 1976; Fullerton and Kinnaman,1996). Based on the result of Table 5.29 however, this estimate is not good for policy formulation and forecast. A new approach has to be devised.

5.12 Weekly regression results for filtered household data at levels

<u>OLS estimate for filtered, weekly household model (variables at levels)</u>

OLS regression for residential filtered model at levels (weekly data) is produced below:

$$\text{Wpcsm} = \beta_0 + \beta_1\text{Rprecysm} + \beta_2\,\text{Rainsm} + \beta_3\,\text{Tempsm} + \beta_4\,\text{Rusasm} + \beta_3\,\text{Rincsm} + \beta_6\,\text{Popden} + \varepsilon_{it} \qquad (17)$$

Table 5:32: OLS estimate of weekly filtered data for household model

Dependent variable is Wpcsm (waste per capita)

Variables	Coefficient	T-statistics
Constant (β_0)	1.657	1.329
Rprecysm	0.005	2.121
Rainsm	6.93E-05	0.955
Tempsm	0.032	5.543
Rusasm	-0.005	-6.447
Rincsm	-1.29E-05	-0.426
Popdensm	-0.000	-0.426
R^2	0.339	
Adjusted R^2	0.312	
DW	0.290	
F-statistics	12.884	
Akaike info criterion	-2.295	
Schwarz criterion	-2.159	

OLS result of weekly series after applying Holt-Winter's filter on series at levels also shows some unimpressive results as it has, low R-squared, almost zero Durbin-Watson (0.29). This indicates the presence of serial correlation. We further applied an FGLS on series and the result is quite interesting.

FGLS estimates for filtered, weekly household model (variables at levels)

FGLS regression for residential filtered model at levels (weekly data) is produced below:

$$Wpcsm = \beta_0 + \beta_1 Rprecysm + \beta_2 Rainsm + \beta_3 Tempsm + \beta_4 Rusasm + \beta_5 Rincsm + \beta_5 Popdensm + \varepsilon_{it} \quad (18)$$

Table 5.33: FGLS estimate of weekly filtered data for household model

Dependent variable is Wpcsm (waste per capita)

Variables	Coefficient	T-statistic
Constant (β_0)	3.080	2.120
Rprecysm	0.016	4.305
Rainsm	3.50E-05	0.494
Tempsm	0.017	2.320
Rusasm	-0.003	-2.610
Rincsm	1.00E-05	0.439
Popdensm	-0.001	-2.188
AR(1)	0.902	33.375
R^2	0.859	
Adjusted R^2	0.852	
DW	1.764	
F-statistic	129.222	
Akaike info criterion	-3.890	
Schwarz criterion	-3.734	
Convergence achieved after 9 iterations		

Before an in-depth breakdown of the above result, it is good to test for the presence of autocorrelation using the Lagrange multiplier test and the result is depicted as follows:

Table 5.34: Breusch-Godfrey serial correlation LM test on weekly filtered data for household model

F-statistics	2.230	Probability	0.111
Obs*R-squared	4.623	Probability	0.099

LM test of Table 5.34 rejects the presence of serial correlation up to order 2. In addition, the 'rho' value of 0.9 points to the absence of a unit root and the stationarity of the process.

There was a high coefficient of determination of about 86%, significant F-statistic and autoregressive root within a unit bracket is a clear sign of stationarity. LM test confirmed the absence of serial correlation. Full and meaningful presentation of result based on this estimate can therefore be given.

Looking at the coefficient of determination and the adjusted coefficient of determination, the independent variables have explained about 86 percent respectively of the variability in waste per capita. This is a good fit. In addition, the coefficient of determination and the adjusted coefficient of determination of 86 and 85 respectively indicates that the included explanatory variables contributed highly to the explanation of waste per capita and were well accounted for. The F-statistic also validates the joint contributions of independent variables in explaining waste per capita.

A further look at the result shows that household income has a positive impact on waste generated per capita although the coefficient is very low and insignificant (0.00001). The elasticity of waste generation per capita with respect to a small change in income at their sample means is about 0.2, meaning that a 100 percent rise in income will lead to a 20 percent rise in waste generation. This shows that waste generation was less elastic of household's real income. This elasticity was similar to those obtained by Wertz (1976) -0.272 Richardson and Havlicek – non uniformity of income effects on different waste components (1976) and Jenkins (1993). This elasticity is very important for policy making since any government's deliberate plan to boost income level in the state must go with adequate waste management services.

Interestingly, the average price of recyclables did not conform to theory and intuition as it was directly related to waste per capita. The reason for this may not be unconnected with the nature of recyclables. The average price of recyclables in waste streams was too low to provide the needed incentive for households to recycle because of the high transport costs for large volume, low value recyclables generated in Lagos.

This result is very similar to what Jenkins obtained in his empirical validation of his theory. Other results showed that the level of precipitation was directly related to waste generated per capita. However, what the precipitation adds to waste per capita was very slight and insignificant. The logic behind this result is simple, since not all households do keep their refuse indoor, it is expected that precipitation causes waste to increase in weight.

There was a high, significant positive relationship between waste generated per capita and the level of temperature. A unit rise in temperature level can bring about as much as 0.016562 kilogrammes increase in waste per capita. The reason for this relationship may not be unconnected with the fact that the level of activities (including domestic) increases the more in warm season than in cold season.

The user fee was negatively related to waste per capita in conformity with intuition, theory, and empirical findings of earlier works (Jenkins, 1993; Richardson and Havlicek, 1978; Wertz, 1976; Fullerton and Kinnaman,1996). A unit increase in monthly user fee other things remaining constant would lead to a 0.003318 decline in weekly waste per capita.

Elasticity of waste generated per capita with respect to a small change in the average monthly user fee at their sample means was about -0.9. The meaning of this is that a 100 percent rise in the user fee will lead to a 90 percent decline in waste per capita. This is almost a unitary elasticity value which is similar to the ones obtained by Wertz (1976); Richardson and Havlicek (1976) and Jenkins (1993). The clear import of this finding is that user fee is a very potent instrument in curtailing excessive waste generated per capita in Lagos.

There was an inverse relationship between waste per capita and population density. This result also indicates that the more compacted the population is, the more people tends to take advantage of the resulting economics of scale of sharing items.

In all, waste per capita was significantly explained by user fee, level of temperature, the price of recyclables and population density.

Improvement of filtered data analysis version over the ARMA model estimation

Charemza and Deadman (1997) highlighted the traditional econometric criteria for selecting the 'best model' such as the maximum R^2 (co-efficient of determination) criterion, which are far from being the ideal especially if the model has been derived through data mining (procedures which used a fixed data sample in some sequential manner to arrive at the final model specification). Perhaps, a brief consideration of coefficient of determination is important, so that we can know the potentials and relevance of this tool in this research effort. The co-efficient of determination measures the proportions of the total variation in the dependent variable that is accounted for by variations in the regressors.

Regression analysis is often used for forecasting and in this case, we are interested in how well the regression model predicts movements in the dependent variable. The coefficient of determination (R^2) is a measure of the fit of the model. R^2 is the squared correlation between the observed values of the dependent variable and the predictors produced by the estimated regression (Green 1997). Even though a high R^2 may be achieved, the direction of causation in the behavioural relation being tested may be incorrect. This suggests that seeking high R^2 value is no substitute for careful theoretical analysis (Doti and Adibi, 1998). A high R^2 value can also mask other statistical problems (for instance, misspecification) such as the omission of relevant variables which are trended with the included explanatory variables leading to a very high R^2.

Again, some series are inherently more erratic and unstable and, consequently, are more difficult to explain in terms of a regression relationship. In such a case, a low R^2 may be quite an achievement in spite of the fact that it looks paltry when compared with those equations that have R^2 values typically close to one.

Another problem with the coefficient of determination is that it never decreases when another variable is added to a regression equation no matter how irrelevant the variable is to the model. A way of avoiding this is by computing the adjusted – R^2 which will fall (rise) when the variable X is deleted from the regression if the t-ratio associated with this variable is greater (less) than 1 (Greene, 1997).

All the above suggests is that R^2 measure must be used carefully in a discriminating manner. It can prove to be a useful econometric tool of analysis but only when it is used with discretion. Meaningful empirical results are more likely to emerge from an equation that is based on careful theoretical analysis rather than one with a high R^2 and a weak theoretical framework (Doti and Adibi, 1998).

Greene (1997: 256) also corroborated the above point when he stated that, "Little can be said about the relative quality of fits of regression lines in different contexts. One must be careful however, even in a single context, to be sure to use the same basis for comparison for competing models. Usually, this concerns how the dependent variable is computed. For example, a perennial question concerns whether a linear or log-linear model fits the data better. Unfortunately, the question cannot be answered from a direct comparison. An R^2 for the linear regression model is different from an R^2 for the log-linear model. Variation in y is different from variation in log y".

Several other measures were proposed with the aim of improving understanding of the overall characteristics of a model. The most widely used criteria for judging the goodness of a particular model whilst taking into account the number of estimated parameters are:

i The coefficient of determination, adjusted for the number of explanatory variable

ii The Akaike information criterion (AIC) computed as: AIC = $(-2\ l/n + 2.k)/n$ or $\log(\Sigma e^2/n) + 2k/n$. where l is the value of the log likelihood function of the estimated model, k is the number of independent variables and n is the number of observations. The idea behind the use of AIC is the selection of model with minimal loss of information (smallest AIC). For models with the same number of parameters and estimated using the same sample, this leads to selecting the model with the smallest residual sum of squares (RSS).

For model with different number of explanatory variables the AIC and adjusted –

R^2 criteria may differ.

(3) The Schwarz Criterion (SC) is derived as: -2 l/n + 2k (log n)/n or log ($\sum e^2/n$ + k log n/n). The AIC differs from the adjusted – R^2 in that it penalizes the addition of right-hand-side variables (which reduces the number of degrees of freedom) more heavily. The SC also penalizes the addition of right-hand-side variables more heavily than does the corrected R^2.

(4) The final prediction error (FPE) is computed using the formular below: FPE = $((n+k) / (n-k))\sigma^2$ is an unbiased estimate of the residual variance) FPE is based on forecasts made using actual rather than estimated values of explanatory variables for forecast periods and using parameter estimates for the entire sample, inclusive of the forecast period. The model with the smallest ex-post prediction error is selected.

All the above criteria, as well as numerous modifications are based on the principle of minimizing the residual sum of squares as a guide for selecting the best model (Maddala, 1988; Charemza and Deadman, 1997).

The results of coefficient of determination, adjusted coefficient of determination, Akaike information and Schwarz criteria indicates that the FGLS or EGLS estimates on Holt-winters' filtered data are the most robust. In addition, they are the most reliable for forecast and policy decisions.

5.14: results presentation of stepwise regression for dumping model

(1) Dumpsm = $\alpha_0 + \alpha_1$ Rcarprsm + ε (19)

(2) Dumpsm = $\alpha_0 + \alpha_1$ Rusasm + ε (20)

(3) Dumpsm = $\alpha_0 + \alpha_1$ Rusfcosm + ε (21)

(4) Dumpsm = $\alpha_0 + \alpha_1$ Rcarprsm + α_2 Rusasm + ε (22)

(5) $Dumpsm = \alpha_0 + \alpha_1 Rcarprsm + \alpha_2 Rusfcosm + \varepsilon$ (23)

(6) $Dumpsm = \alpha_0 + \alpha_1 Rcarprsm + \alpha_2 Rusasm + \alpha_3 Rusfcosm + \varepsilon$ (24)

Results

1. Dumpsm = 173244.2 – 933.949 Rcarprsm + ε (25)

t-stats (2.823) (-1.920)

R-squared = 0.098, adjusted R-squared = 0.071, F=3.69

2. Dumpsm = 83208.64 – 142.187 Rusasm + ε (26)

t-stats (1.852) (-0.617) (27)

R-squared = 0.0026, adjusted R-squared = -0.018, F = 3.88

3. Dumpsm = 62044.19 – 0.861 Rusfcom + ε (28)

t-stats (2.84) (-0.299)

R-squared = 0.003, adjusted R-squared = -0.027, F = 0.090 (29)

4. Dumpsm = 205954.8 – 2395.605 Rcarprsm + 779.110 Rusasm + ε

t-stats (3.357) (-0.703) (1.941) (30)

R-squared = 0.190, adjusted R-squared = 0.141, F = 3.88

F-ratio due to the addition of Rusasm = 3.67 (signf.)

5. Dumpsm = 179527.1 – 1107.748 Rcarprsm + 2.076 Rusfcosm + ε

t-stats (2.869) (-1.993) (0.664) (31)

R-squared = 0.1097, adjusted R-squared = 0.0558, F = 2.03

F-ratio due to the addition of Rusfcosm = 3.71 (signif).

6. Dumpsm = 211040.8 – 2528.7 Rcarprsm + 768.5 Rusasm + 1.8 Rusfcosm + ε

t-stats (3.376) (-2.745) (1.895) (0.606) (32)

R-squared = 0.200, adjusted R-squared = 0.125, F =2.66

F-ratio due to the addition of Rusfcosm to (4) = 3.55 (sigif.)

The general conclusion one can draw from the above results is that all the three independent variables are justified for inclusion into the dumping model.

Table 5.35: GLS estimate for dumping model

	FGLS monthly data		FGLS weekly data	
Variable	Coefficient	t-statistic	coefficient	t-statistic
Constant	-26116.80	-0.222	5805.271	0.762
Rcarprsm	49.062	0.096	34.019	0.464
Rusasm	71.062	0.286	-5.860	-0.187
Rusfcosm	2.770	1.053	0.221	0.556
AR(I)	0.976		0.982	
R-squared	0.892		0.955	
Adjusted – R^2	0.850		0.953	
DW	1.850		1.874	
F	62.011		800.260	
N	35		155	

The above result shows the GLS estimates of the dumping model. The import of this model is to account for the dumping that accompanies each user charge. The stepwise regression has enabled us to ascertain the regressors to include in the model. Of course, the three user charges collectively exerted significant influence on dumping.

The GLS result suggests that a first-order autocorrelation has been cured and the dependent variables has explained between 89 % (for the monthly data) and 95% (for the weekly data) variability in the dependent variable indicating that a good fit has been achieved. Autocorrelation has been cured and the inverted roots within a unit bracket is an indication of stationarity. From all these, one can rightly conclude that a good model for dumping has been achieved.

Further look at the result shows that each of the user charge (including the cartpusher's charge) influenced waste dumping though insignificantly. An increase in the user charge gave rise to more dumping. Even though no individual charge increased waste generation significantly, a combination of these charges when increased simultaneously can cause significant waste dumping. This fact is confirmed by the significant F-statistic result.

5.15 Behavioural analysis of household

Although, this section is not a major objective of our analysis, we feel compelled to add it to our analysis because of the value added. It analyzed why a particular household would opt for a particular type of waste service provider. In addition, it indicates the ranking of each waste service provider as perceived by the households and firms. The major tool of analysis here was the difference of two means.

The difference of two means result for the incomes of PSP and the cartpushers' patrons produced a $Z_{calculated}$ of 1.46 which is lower than the $Z_{critical}$ at $\alpha = 0.02$ (that is, 2.33) which indicates that the mean income of the PSP patrons was not significantly different from the mean income of the cartpusher's patron. In order words, income was not a major determinant of which waste service provider to patronize.

Table 5.36: Difference of two means result for household charges

	X_1	X_2	S_1	S_2	Difference of 2 means Z calcul.	Critical Z at α = 0.02	N_1	N_2
1	157.29	97.96	104.65	82.62	4.29	2.33	162	177
2	158.52	99.65	104.73	84.69	4.23	2.33	162	177
3	160.37	98.52	106.49	84.67	4.48	2.33	162	177
4	161.62	99.09	106.52	83.33	4.58	2.33	162	177
5	162.23	97.96	106.85	83.30	4.56		162	177
6	163.46	99.09	104.84	81.96	4.85		162	177
7	157.91	99.65	101.75	82.65	4.95		162	177
8	159.14	100.78	101.72	84.69	4.93		162	177
9	156.06	101.91	100.00	85.35	4.54		162	177
10	158.52	101.91	102.08	84.68	4.75		162	177
11	159.76	105.3	106.13	89.77	4.36		162	177
12	161.61	109.82	105.71	92.54	4.11		162	177
1	177.66	113.21	96.16	92.13	6.42		162	177
2	180.13	113.78	106.45	92.05	6.24		162	177
3	180.13	113.78	107.77	92.67	6.18		162	177
4	181.99	115.47	110.67	94.23	6.07		162	177
5	181.99	115.47	108.73	94.23	6.14		162	177
6	182.60	115.47	108.16	94.83	6.21		162	177
7	181.13	117.73	104.52	95.64	5.95		160	177
8	181.13	117.73	105.21	95.64	5.93		160	177
9	181.13	118.11	105.21	96.97	5.85		160	176
10	180.50	120.39	103.72	100.01	5.57		160	176
11	181.75	120.95	105.99	101.03	5.55		160	176
12	182.23	123.23	106.76	100.54	5.41		160	176
1	209.76	132.32	115.19	103.15	6.91		162	176
2	209.76	132.99	115.19	104.33	6.84		162	177
3	210.99	134.12	117.41	102.32	6.83		162	177
4	210.99	136.38	119.21	102.65	6.58		162	177
5	212.85	135.81	120.04	102.85	6.76		162	177
6	214.08	136.94	120.96	103.01	6.74		162	177
7	213.46	135.81	119.91	102.85	6.82		162	177
8	212.23	136.38	118.97	103.21	6.69		162	177
9	212.23	136.94	118.97	104.65	6.61		162	177
10	212.61	139.2	118.65	106.53	6.42		161	177
11	214.48	139.77	120.05	107.37	6.47		161	177
12	215.10	140.9	119.31	107.49	6.47		161	177

Source: Author's fieldwork, 2004.

Where:

X_1, S_1 and N_1 are respectively the mean charges, the standard deviation and the number of respondents partronizing the PSP. X_2, S_2 and N_2 are respectively the mean charges, the standard deviation and the number of respondents partronizing the cartpushers.

The difference of means' results indicates that the mean charge of the cartpushers was significantly different from the mean charge of the private sector participants. On further inspection of the two means, the cartpushers' charge was significantly lower than those of the PSP which may of course explain why many people are partronizing the cartpushers and indirectly contribute to illegal dumping in Lagos state.

Table 5.37: Residential clients' opinion of effective and efficient waste management

1.	Commensurate service charges with level of solid waste disposal. In other words, waste service delivery must not be too costly.	Observation	Mean scores	STD. DEV.	Observations	Mean scores	STD DEV	Diff. of two mean Z calcul
2.	Waste service delivery must be adequate. That is, waste must be disposed regularly	174	4.67	0.59	220	4.64	0.57	0.51
3.	There must be fair and safe working conditions and job training for waste service providers	174	4.31	0.78	220	4.20	0.85	1.35
4.	Waste collectors must have technical resources (such as equipment, expertise and skills) to cope with waste management	174	4.47	0.68	220	4.35	0.80	1.58
5.	There must be management flexibility. That is, ease in firing waste personnel for non-performance and in providing upward mobility for workers with good performance	174	3.84	0.90	220	3.73	1.04	1.12
6.	There must be a 'task' system of work in which workers may leave whenever they finish their assigned route.	174	3.68	0.85	220	3.61	0.98	0.76
7.	There must be a structure to monitor the performance of waste service providers	174	4.40	0.81	220	4.27	0.85	1.54
8.	The will to enforce or maintain contractual agreements with their clients must be present.	174	3.90	1.07	220	3.65	1.09	2.28

Source: Author's fieldwork, 2004

All items not significant at $\alpha = 0.02$ in a two tailed test. In order words, the opinions of cart pushers' patrons and those of the PSP patrons tally on what efficient and effective waste management should be. This story was however different with the commercial waste service clients who believed that efficiency in waste management entails all but the practicing of a task system. See details of result and ranking below.

Table 5.38: Commercial clients' opinion of effective and efficient waste management

		Observation	Mean scores	STD. DEV.
1.	Commensurate service charges with level of solid waste disposal. In other words, waste service delivery must not be too costly	32	4.69	0.54
2.	Waste service delivery must be adequate. That is, waste must be disposed regularly	32	4.94	0.25
3.	There must be fair and safe working conditions and job training for waste service providers	32	4.69	0.47
4.	Waste collectors must have technical resources (such as equipment, expertise and skills) to cope with waste management	32	4.63	0.61
5.	There must be management flexibility. That is, ease in firing waste personnel for non-performance and in providing upward mobility for workers with good performance	32	4.03	0.69
6.	There must be a 'task' system of work in which workers may leave whenever they finish their assigned route.	32	3.75	1.02
7.	There must be a structure to monitor the performance of waste service providers	32	4.56	0.5
8.	The will to enforce or maintain contractual agreements with their clients must be present	32	4.75	0.56

Source: Author's fieldwork, 2004

Table 5.39: Efficient and effective waste services' provision ranking

		Mean scores (COMMERCIAL)	Mean scores (PSP	Mean scores (CARTPUSHER)
1.	Commensurate service charges with level of solid waste disposal. In other words, waste service delivery must not be too costly	3.22	3.76	3.71
2.	Waste service delivery must be adequate. That is, waste must be disposed regularly	2.78	3.76	3.75
3.	There must be fair and safe working conditions and job training for waste service providers	2.59	3.38	2.97
4.	Waste collectors must have technical resources (such as equipment, expertise and skills) to cope with waste management	2.78	3.4	3.14
5.	There must be management flexibility. That is, ease in firing waste personnel for non-performance and in providing upward mobility for workers with good performance	2.74	NA	NA
6.	There must be a 'task' system of work in which workers may leave whenever they finish their assigned route.	NA	NA	NA
7.	There must be a structure to monitor the performance of waste service providers	2.74	3.46	3.27
8.	The will to enforce or maintain contractual agreements with their clients must be present	2.78	NA	NA
	AVERAGE OF TOTAL	2.8	3.55	3.37

Source: Author's fieldwork, 2004.

Since our bench mark for efficiency was a total average of 3.5, only the PSP service providers slightly passed the efficiency and effectiveness test. It must be mentioned that their services need fine-tuning for better performances.

There is an urgent need to reorganize the waste management institutions for effective and efficient performance. Effective and efficient waste management by the private sector participants (PSP) starts from the type of the PSP. For effective and efficient waste management in Lagos State, the Franchise System in which government or LAWMA award a finite-term monopoly (a franchise) to a private firm (or a group of them merging together to become a firm) for the provision of solid waste collection services looks more attractive. The granting of this franchise should be done after a competitive qualification process. The PSP firm would deposit a performance bond with the government Agency and pay a license fee to cover the government's monitoring costs. The private firm recovers his cost and profit through direct charges to the households, establishments, and companies within his domain. The agency's roles here include its control over the tariff charged to the customer via price regulation.

Be that as it may, there are some factors that can limit the success of PSP in waste management and these include the risks related to environmental regulatory changes. National inflation, currency value and convertibility, fuel prices, pricing policies, import bans or quotas, and taxes among others. Government can therefore come in and cushion the effects of the above shortcomings in addition to providing further incentives in the form of guarantees for meaningful borrowings, assumption of foreign exchange risk, tax incentives, custom duty exemption, and special lines of credit, technical assistance, equipment hiring among others.

Although the collection and disposal of refuse can be done with little knowledge and limited equipment, effective and efficient waste management requires substantial planning ability, appropriate equipment and continuous managerial optimization of vehicle and workers' productivity. The above stated ingredients are the technology for efficient waste management. Waste management Agencies must ensure that PSPs to be licenced must have the appropriate technology capable of ensuring its success in this field.

Smaller, younger crews, lower absenteeism, wages, and benefit cost, more flexible scheduling, efficient vehicle routing, better designed vehicles, managerial incentives, faster vehicle repairs, vehicle standardization, and competition are parts of the important requirements for qualification for appointment as a Franchisee.

CHAPTER SIX
SUMMARY, CONCLUSIONS AND, POLICY RECOMMENDATIONS

6.1 Summary

The health status of Lagos environment is being threatened first by the expansion in the scale of consumption and production and by the population pressure which exerts substantial impact on the carrying capacity of the limited space of Lagos. With the rapid rate of urbanization, more migrants are expected in Lagos in the future with a potential of exerting further impact on Lagos environment. A major impact of increases in economic activities in Lagos is escalation of solid waste quantity and its management problem except something drastic is done. Refuse is a major disutility of urbanization and urban environmental improvement can be an effective means of reducing poverty. It is against this premise that this study investigates the impact of economic instruments in waste management in Lagos state.

Various studies have been conducted in the past on the efficacy of user fee in waste management. Examples of such studies include Wertz (1976), Fullerton and Kinnaman (1996), Richardson and Havlicek (1974) and Jenkins (1993) among others. All these earlier studies were on developed economies with organized but sophisticated Institutions.

However, with the rudimentary system in Lagos and the low level of income, high level of waste generation and the scarcity of landfill spaces in Lagos, this research embarked on a study of economics of waste management focusing on the assessment of the impact of user charges on waste generation both in the residential and commercial sectors. The study also seeks to determine the impact of weather and socioeconomic variables on waste generation. In addition, the study analyzed the impact of cost of recyclables (a recycling incentive) on both residential and commercial waste generation.

Since the impact of user charges on waste generation can also be linked with the quantity of waste dumped in Lagos state, this study also analyzed the impact of the user charges on quantity of waste dumped in Lagos State. The study derived the welfare impacts (conservation and transportation of waste to landfill *etc.*) of increasing the average user charges above the 2003 baseline in Lagos, as well as the average price of recyclables and the average user fee in Lagos (see appendix L and M).

To accomplish the above, weekly and monthly data were used in the analysis with a view to selecting the more robust estimates in the formulation of policy recommendations based on our findings.

Furthermore, we tried to determine the factors that contribute to effective and efficient waste management in Lagos, assess the level of efficiency and effectiveness of waste service providers in Lagos and at the same time identify factors that contribute to dumping in Lagos by utilizing two sets of primary instruments. The summary statistics of our variables is shown in table 6.1 below.

Table 6.1: Descriptive statistical table of variables of the model

	Qres	Wpc	Rusa	Rprecy	Popden	Rinc	Workpop	Househsiz	Temp	Ra
Mean	6310.423	0.813	194.622	45.899	2320.613	11697.26	46.564	3.277	30.192	14
Median	6270.000	0.816	196.205	43.227	2321.406	11669.76	46.562	3.277	30.750	12
Maximum	11528.00	1.463	222.560	58.565	2425.895	13684.42	46.872	3.421	32.000	38
Minimum	2776.000	0.347	171.900	40.034	2214.186	10176.12	46.506	3.132	27.700	13
Std. Dev	1146.416	0.146	13.956	5.630	61.450	835.141	0.041	0.084	1.466	11
Skewness	0.617	0.477	0.039	0.911	-0.018	0.260	2.601	-4.40E-15	-0.399	0.4
Kurtosis	6.541	6.230	2.089	2.463	1.818	2.921	20.833	1.810	1.739	2.2
Jarque-Bera	91.39563	73.735	5.428	23.454	9.085	1.799	2243.162	9.350	14.474	10
Probability	0.000	0.000	0.066	0.000	0.0106	0.407	0.000	0.009	0.001	0.0
Observations	156	156	156	156	156	156	156	156	156	15

The above table shows the descriptive table of variables used in the analysis. A look at table 6.1 shows that the mean weekly waste disposal is about 6,310 metric tonnes. The weekly range of disposal is 2776 to 11,528. Jarque-Bera statistic result and its probability failed to accept the hypothesis of normal distributions of quantity of residential waste. Average real user fee has a mean and median of about 195 and 196 Naira respectively. Jarque-Bera supports the normality in the distributions of residential user fee and household income. Other univariate statistical results of variables can be found in the appendix R and S. Tables 6.3 and 6.4 shows the econometric analysis summary of both household as well as the commercial models.

Table 6.2: Summary of Household weekly results

Variables	Unfiltered	Differenced	Filtered			
	OLS	FGLS	OLS	ARMA	OLS	FGLS
Constant	0.469 (0.227)	0.279 (0.126)	-	-	1.657 (1.329)	3.080 (2.120)
Reprecy	0.007 (1.848)	0.008 (1.893)	0.055 (3.401)	0.073 (5.132)	0.005 (2.121)	0.016 (4.305)
Rain	-0.0001 (-0.7893)	-0.0001 (-0.771)	0.000 (0.090)	0.0003 (1.156)	6.93E-05(0.955)	0.000 (0.494)
Temp	0.019 (1.669)	0.017 (1.264)	0.027 (69.620)	0.027 (24.185)	0.032 (5.543)	0.017 (2.320)
Rinc	4.85E-05 (0.962)	6.24E-05 (1.134)	0.000 (0.604)	0.000 (0.350)	-1.29E-05 (-0.426)	1.000E-05 (0.439)
Popden	4.80E-05 (0.068)	7.47E-05 (0.098)	0.0002 (0.181)	0.0003 (0.313)	-0.0004 (-0.912)	-0.001 (-2.188)
Rusa	-0.006 (-4.297)	-0.006 (-3.786)	-0.007 (-1.192)	-0.010 (-2.070)	-0.005 (-6.447)	-0.003 (-2.610)
Ar(1)	-	0.156 (1.945)	-	0.893 (4.420)	-	0.902 (33.375)
Ar(2)	-	-	-	-0.016 (-0.117)	-	-
Ma(1)	-	-	-	-0.587 (-3.131)	-	-
R-squared	0.149	0.179	0.074	0.315	0.339	0.859
Adjusted R-squared	0.115	0.140	0.043	0. 277	0.312	0.852
DW	1.655	1.925	1.151	-	-0.290	1.765
F-statistics	4.347	4.589	2.373	7.211	12.884	129.222
Akaike info criterion	-1.083	-1.127	-1.032	-1.306	-2.295	-3.890
Schwarz criterion	-0.946	-0.970	0.914	-1.127	-2.159	-3.734
Convergence level	Not applicable	After 6 iterations	Not applicable	After 8 iterations	Not Applicable	After 9 iterations

(Figures in parenthesis under estimates are the corresponding t-statistics)

In models of time series, it is necessary to know whether the underlying stochastic process that generated the series can be categorized as time invariant. If the characteristic of the stochastic process change over time, such a process is non-stationary. It will often be difficult to represent the time series over past and future intervals of time by a simple algebraic model. If on the other hand, the stochastic process is fixed in time, then one can model the process with an equation with fixed coefficients that can be estimated using past data (Pindyck and Rubinfeld, 1988). The consequence of running a regression model on nonstationarity series is the possibility of producing spurious regression result in which a relationship would be established between some unrelated variables whereas they may not be related in real world situation.

However, most time series are time variant, and the data for this study is no exception. Since data for our study are time series, we conducted a unit root test so as to eliminate the possibility of a spurious regression by applying an Augmented Dickey-Fuller (ADF) test on all variables (see Gujarati, 2003). According to Gujarati (2003), to avoid the spurious regression problem that is likely to emerge from regressing a nonstationary time series on one or more nonstationary time series, the affected nonstationary variables have to be transformed so as to make them stationary. A way of transforming such variables is the differencing method. If a variable has a unit root, the first difference of such a variable is stationary. If on the other hand, a time series is integrated of order two {I(2)}, it will contain 2 unit roots, and we will have to difference it twice to make it stationary. Most data used in this study showed some trendy patterns based on the Augumented Dickey-Fuller results. The import of this is that levels of each series tend to increase as the level of data increases or decreases. To avoid the dependence of variance on the level of data of such a variable, we applied the needed differencing based on their order of integration to ensure stationarity.

However, Greene (1989) observed that by differencing or detrending series of the model, we may obtain a white noise series, but it may equally trade trend for autocorrelation in the form of MA(1) process thus, justifying the inclusion of ARIMA model. The ARIMA model uses three tools for modeling serial correlation in the disturbance term. Therefore, it is more useful in generating a white noise process than differencing alone could achieve. Pindyck and Rubinfeld (1998) suggests that time-series analysis and regression analysis can be combined to produce a better forecast than would be possible with the use of either of these techniques alone. A regression model would have the dependent variable explained by all the independent variable(s) and an additive error term. The additive error term accounts for unexplained variance in the dependent variable. However, one source of forecast error of this regression model would come from the additive error (noise) term whose future values cannot be predicted.

One effective application of time series analysis in this case is the construction of ARIMA model for the residual series μ of this regression. We would then substitute the ARIMA model for the implicit error term in the original equation. The ARIMA model provides valuable information about what future values of ε are likely to be. In other words, it helps to explain the unexplained variance in the regression equation. The resultant model is likely to provide better forecast than would the regression equation as it combines both the structural (economics) explanation of part of variance of dependent variable and the explanation of the structurally unexplained variance of the independent variable. This model is referred to as transfer functions model or multivariate autoregressive – moving average model (MARMA).

Our inability to obtain a white noise process through differencing alone further compelled us to use the multivariate autoregressive-moving average (ARMA terms) to the differenced model following the Eviews User's Guide's (2003) insight into the AR and MA terms to fit the properties of the residuals. It suggests that the Akaike information criterion and Schwarz criterion provided with each set of estimates may be used as a guide for appropriate lag order selection and we simply took a clue from this. However, one of ARIMA's greatest shortcomings is its inability to predict accurately sharp downturns and upturns in models thus limiting its value for forecasting (Pindyck and Rubinfeld, 1998).

Such downturns and upturns are called outlier's values. Whenever data levels are thought to be too high or too low for "business as usual" we call such points the outliers. A mathematical reason to adjust for such occurrences is that majority of forecast techniques are based on averaging and arithmetic averaging as we have it in our series are sensitive to outlier values; therefore, some alteration should be made to the data before modeling. One approach to the outlier problem is filtering techniques. This provides a mean of removing, or at least reduce, volatile short-term fluctuations in a time series. Filtering is a series procedure, which may be used to generate new series that are based upon the data in the original series. Filtering enhances the generation of series with white noise, smoothing may be done to make the time series easier to analyze and interpret. In addition, filtering techniques do produce optimal forecast in certain conditions, which turn out to be intimately related to the presence of unit roots in the series being forecast. Then, which smoothing method do we adopt? The answer is; our visual comparison of forecasting power of smoothing techniques (as recommended by Ahamuda and Geragnani, 1999), indicates that Holt-Winters' filter is the most appropriate of them all as it did not alter persistence variability and comovement of (simulated and actual) series.

Ordinary least squares' estimates on the Holt-Winter's filtered weekly data indicates the presence of serial correlation. The justification for applying the Cochrane-Orcutt's estimated generalized least squares (EGLS) when OLS shows autocorrelated disturbances was provided by Greene (1997) who stressed the problem posed by autocorrelated disturbances and a way of dealing with them. He stated that the model with autocorrelated disturbances is a generalized regression model, and we should expect least squares to be inefficient. This problem can be seen when we know the disturbance process and the process generating the independent variables. The efficiency of least squares falls to less than 10% if the autoregressive root (ρ) is close to 1. Judge *et. al.* (1985) also agreed to the loss of efficiency but differed on the severity of the problem (see also, Hill, Griffith and Judges, 2001). Our most reliable household and commercial estimates are the FGLS estimates of weekly models.

Table 6.3: Summary of Commercial Weekly Results

Variables	Unfiltered		Differenced		Filtered	
	OLS	FGLS	OLS	ARMA	OLS	FGLS
Constant	83622.08 (1.613)	76441.40 (1.506)	-	-	12408.20 (2.224)	3230.565 (0.519)
Qcom $_{t-1}$	-	-	0.803 (18.061)	0.894 (17.551)	-	-
Kprecy	269.115 (0.746)	240.938 (0.555)	157.312 (1.257)	158.831 (1. 525)	74.709 (1.891)	59.461 (0.895)
Rain	-6.300 (-0.298)	-16.706 (-1.056)	-5.082 (--1.496)	-4.147 (1.464)	0.817 (0.337)	-1.906 (-0.990)
Temp	-2543.065 (-1.494)	-1470.394 (-0.887)	65.586 (4.322)	37.672 (2.144)	-390.277 (-2.160)	188.827 (1.000)
Ar(1)	-	0.580 (4.543)	-	0.815 (7.032)	-	0.924 (36.514)
Ma(2)	-	-	-	-1.250 (-11.299)	-	-
R^2	0.156	0.506	0.669	0.728	0.147	0.894
Adjusted R^2	0.047	0.420	0.660	0.715	0.124	0.891
DW	0.706	2.497	2.370	2.142	0.142	1.863
F-statistics	1.430	5.933	75.654	55.845	6.577	254.904
Akaike info criterion	21.698	20.988	17.720	17.515	18.640	16.521
Schwarz criterion	21.918	21.254	17.818	17.673	18.737	16.638
Convergence level	Not applicable	After 6 iterations	Not applicable	After 99 iterations	Not applicable	After 7 iterations

(Figures in parenthesis under estimates are the corresponding t-statistics)

The EGLS result on which our commercial model result came from is however not without its problem. None of the explanatory variables on its own significantly explained commercial waste generation, but collectively, they significantly explained commercial waste. The coefficient of determination as high as 89 percent and insignificant explanatory variables would have suggested that there is a multicollinearity problem.

On a first inspection, it looks like we have problem of multicollinearity. Gujarati (2003) referred to Goldberger's parody which emphasized that small sample size and lack of variability in the explanatory variables may cause problems that resemble multicollinearity (Gujarati, 2003). The remedial measures are in two categories. One is to follow some rule of thumb (pooling the data, dropping variable(s) and specification bias, transformation of variables, addition of new data *etc.*). The other way around it is the "do nothing" approach championed by Blanchard (1967). According to this approach, multicollinearity is not a problem with OLS or statistical technique in general, it is a data deficiency problem (micronumerosity) and most time, we have no choice over the data we have available for empirical empirical analysis (Gujarati, 2003). It is true that there is non variability in most of our explanatory variables. This could be the reason why our coefficient of determination and adjusted coefficient of determination are so high whereas all the explanatory variables are insignificant but nearly exhibited expected signs.

6.2 Conclusions

The following conclusions were arrived at, at the end of the study. There is a low positive association between household's mean income and waste generation per capita. This is in conformity with earlier results obtained by Wertz (1976), Richardson and Havlicek (1974) and, Jenkins (1993), meaning that consumption increases as household income goes up. However, this result should be taken with caution as our analysis did not investigate the impact of income growth on various components of waste but on the overall waste turnout. For instance, as the real household income declines, as it has over the years in Nigeria, purchases of starchy, sugary foods and beverages with high associated wastes became the next viable option. In fact, the low-income families have been associated with the consumption of high caloric content foods which are typically with a lot of waste.

The impact of income on waste components are mixed and perhaps it is more appropriate to make reference to Richardson and Havlicecks' result in which wastes were separated into 11 different materials and income were linearly related to each of them using the OLS method. Their results suggest that there is a significant and positive relationship between income and the quantities of green glass, newspapers, grass and aggregate waste discarded while they find a significant and negative relationship between income and quantities of aluminum, textiles, plastics, garbage/others discarded. Future efforts are therefore needed in Nigeria to analyze the impact of income growth on disaggregated waste components.

There are two weather variables employed in our analysis and they are: the level of precipitation and the mean temperature. The results on them are mixed for some obvious reasons. For the commercial equation, waste generation is affected by the level of precipitation and the relationship is negative in conformity with intuition and Jenkin's (although is not a significant variable). In other words, the level of commercial activities decline during the raining season and so is the quantity of commercial waste generated while the temperature rise is supposed to boost economic activity and hence, waste; generation by the commercial sector.

Result for weather variables in the residential equation indicates that temperature significantly affects waste generated per capita. While precipitation level insignificantly affects residential waste generation. While precipitation reduces waste for the commercial sector, it increases waste for the residential sector. The reason for this is that rain increases the volume and weight of residential waste due to lack of good storage for residential waste before they are collected. Increases in temperature also, significantly increase the residential activities hence, the waste per capita.

Findings on the analysis of, the presence of economies of scale due to urbanization indicate that there is significant substantial economics of scale due to urbanization. Generally, the import of our finding here is that as more people are added to an area, the average refuse per family member declines meaning that there is economies of scale due to urban agglomeration. Economies of scale exists when financial savings result from sharing items among the households within an area. For instance, household can share yards or newspaper. One household can recycle for other (that is, one household's waste can be beneficial to another family in the neighbourhood). In addition, members of households are more likely to hand down clothing, toys, books and other items from one household to the other.

The impact of the average cost of recyclables on waste per capita is interestingly fascinating and we will interprete it in an indirect manner. First, cost of recyclables is a significant factor explaining waste generated per capita. The relationship is however positive contrary to intuition and theory. This suggests that as the real costs of recyclables are rising, people devote less time to recycling. This is understandable, possibilities are that the average prices of recyclables were just too low to be an incentive for cutting waste that is why it was not a potent factor for reducing waste per capita in Lagos. Secondly, the cost of sorting and recovery may be too prohibitive that it has lost its incentive effect. For commercial equation, the relationship is positive and, it is not a significant factor explaining the quantity of commercial waste generated.

The result of our user charges for both residential and commercial sectors however produced the expected sign and it shows that the demand for solid waste is sensitive to user fees. There is a negative relationship between waste generation and user charges. The differences in these results are: that user charge is a significant factor explaining residential waste generation whereas it is not a significant factor explaining commercial waste generation in Lagos state. In addition, the elasticity of demand for residential waste services of -0.9 at their sample means is almost unitary and this is quite important in waste management policy formulation. In addition, these results are comparable to those of earlier studies by Wertz (1976), and, Jenkins (1993). Except that the price elasticity of demand for solid waste services in Lagos is higher than those often found in the literature and this is understandable. Cointreau (1994) observed that waste services consume more of the income of individuals in a developing country than it does the middle and higher income countries. In other words, waste service charge as a proportion of income is higher for low income economics than it is for the high income nations, so by increasing this cost further will cause a drastic reaction by the household members to further reduce their waste generation.

The result of model relating dumping to all user charges indicate that all the user charges except the PSP charge are positively related to dumping and their coefficients are much (except for PSP charge). However, none of these charges is a significant factor explaining dumping even though the joint contributions of these variables in significantly explaining waste dumping in Lagos State is confirmed. The insignificance of our user charges made us to conclude that dumping in the state is probably explained by so many other factors other than those captured by our model and these factors may range from low income level, poor services by the service providers, poor institutional arrangements, lack of monitoring and indiscriminate dumping by the cart-pushers to lack of provision/extension of waste collection service to various parts of Lagos state.

6.3 Policy Recommendations

Domestic wastes are inevitable products of daily activities. It is therefore practically impossible to eliminate waste generation out rightly. The major policy implication of this research is that tipping fee or user fee is the most potent instrument in securing waste minimization and secure large welfare gains in Lagos State. This instrument works by discouraging wasteful consumption (while encouraging re-use, recycling and composting) and patronage of over-packaged goods. This sends signal upstream to the producer to design for environment. In addition, if Lagos residents are paying a reasonably low user fee, savings in disposal alone can be substantial. When other costs such as transportation and collection costs are added into the figure, savings would be substantially large especially in view of Lagos population.

It is important to estimate the welfare effects of raising the average user fee or cost of solid waste services by a Naira (in May 2003 prices) other things being constant. This will lead to lead to 0.003 kilogramme decline in weekly waste per capita in Lagos state or approximately 1306.9 tonnes decline in total waste generation in Lagos State (based on 2004 projected population of 8,34,808- National Population Commission's (NPC) estimate). The gross saving (in private cost) resulting from a Naira increase (in real term) in residential user charge (based on Cointreau's estimates above) is between US$24,831.68 and US$49,663.37 yearly (or ₦3,209,742.96 to ₦6,419,486.66 based on the average exchange rate of ₦129.26 to 1US$ of 2003).

Government should stop financing residential Solid Waste Services (SWS) by flat fee or through property tax and instead charge user fee. In addition, this residential user fee should be highly proportional to the volume/weight of waste discarded and should be raised. The commercial user fee too must be substantially raised to as to produce the needed incentive. In other words, this study recommends solid waste pricing systems that provide continuous incentives for households and firms to cut down on their waste generation. The price system should be in the form of variable garbage can rate or pay-per-bag systems. Experience has shown in developed countries that complementing marginal pricing with recycling programmes can reduce waste volume substantially (Anderson *et. al.* 1989).

A second issue that affects our policy suggestions is the increase in the illegal disposal that accompany user fee. This problem would have been dampened through the enforcement of anti-dumping laws. However, in Lagos, as elsewhere in Nigeria, there are institutional weaknesses which encourage dumping. A way out of this problem is waste auditing. Strict enforcement of environmental laws can provide the needed incentives for individuals and organizations to act in an environmentally acceptable manner, and penalties should not be seen only as a means of raising funds for the government. Auditors must be able to monitor individual factories' wastes to ascertain actual quantity generated commercially and if there is a shortfall in quantity, a company must be able to account for it through production process modification, more recycling or reuse among others.

Recycling is almost not cost effective in Lagos for obvious reasons. First, the quantity of recyclables in the waste stream in Lagos State is very low because residents consume less of packaged goods. Optimized recovery of recyclables may also not be feasible because people are not practicing source separation of recyclable materials. Recycling in Lagos is usually done by the scavengers and the recovered items are always contaminated. Other problem facing recycling in the state include high cost of collecting recyclables from door to door. This cost is so high and in fact higher than the cost of collecting solid wastes because it requires almost the same number of stops and the quantity collected for each stop is usually less. For recycling to be profitable therefore, government needs to support the PSP service providers in recycling. This is justifiable when the savings in landfill space due to recycling can justify the cost of government support for recycling. Otherwise, the private sector would bear the recycling cost only if the benefit of recycling is adequate to enable profit.

However, with the low and undeveloped market for recyclables, waste service providers may not find recycling as a feasible option except government or its agencies can provide incentives to waste service providers so as to make recycling more attractive. These options are suggested for consideration: provision of financial incentives in the form of low cost loan, loan guarantees, tax exemption all tied to some recycling targets. Another option is the facilitation of the establishment of a concessional arrangement between the private sector participant and the informal waste pickers. Another option is through government's encouragement of private owned buy-back centre for purchasing recyclables from individuals, process them to meet industrial requirements, and selling them to industries. Government's role in this case is the provision of financial support to privately owned centres. A demonstration of this been made in the New York City of the US where buy-back-centres are given a payment for every of waste recycled back to industry thereby saving on disposal (diversion from landfill disposal and saving of space in the landfill).

Apart from the above, there should be serious encouragement of deposit-refund systems in which special taxes, charges or fees are imposed on consumers in such a way that recycling are encouraged. This approach is currently in use for beverage bottles and beer bottles in Nigeria, but plastic bottles and cans are rarely recycled as they are not subjected to any deposit-refund systems. In fact recently, deposit-refund system has been extended to automobiles and automobile batteries in developed countries. Nigeria should borrow a leaf from this.

In addition, composting can be viable option in the reduction strategy in Lagos State because biodegradable wastes formed between 60% and 68% of total waste generation in Lagos as opposed to the 10.4% found in the worldwide average composition. Paper and paperboard formed about 38% in the worldwide average composition of municipal solid waste and as such recyclables of various components constitute about 76% of total waste generation thus confirming the viability of recycling, reuse and waste-to-energy as means of reducing waste ending up permanently in the landfill. However in Nigeria, we found out that recycling and reuse alone cannot be viable in minimizing waste ending up permanently in the landfill but the complementary role of composting must be seriously recognized in Lagos due to the peculiarity of waste composition in Lagos which is mostly biodegradable.

The advantage of composting here includes the production of organic material (manure) which is capable of the enhancing agricultural productivity. The use of organic material can complement the grossly inadequate inorganic fertilizer. Compost can also be economically beneficial in land reclamation, land cover or as embankment stabilization.

Composting is capable of reducing volume of waste ending up permanently at the dumping/disposal sites by more than 50% and as such, the associated environmental hazards of landfill/dumpsite disposal are only temporary.

Lastly, lack of waste reduction targets for households and firms in the state and the disincentive effect of under-charged disposal facilities encourage recyclables to compete for waste streams, setting waste targets and raising the disposal fee will go a long way in increasing recycling.

6.4 Contributions to Knowledge

Policy contributions

This research has been able to determine the impacts of user's fee as against the conventional property tax (tenement rate used in partly financing waste management) applied on waste generation. Positive user fee has been demonstrated to exert substantial impact on solid waste generation. This is made possible by compelling people and organizations to consume and produce goods with lower waste contents leading to a drastic reduction in the quantity of waste going to the final disposal sites. In addition to this, it reduces the public expenditure on waste management and the savings from this can possibly be channeled to other welfare yielding amenities such as public health, water, *etc.* This finding however should be interpreted with caution as increases in user fee may lead to a great reduction in waste set out for disposal but may also lead to dumping of refuse if appropriate monitoring of dumping as well as the enforcement of anti-dumping laws are not in place. Further research is needed to ascertain the accurate impact of a positive user fee on illegal dumping of refuse.

This study also showed the impact of some socioeconomic variables on waste generation and composition in Lagos state. For instance, waste generation and income is expected to move in the same direction. The implication of this is that any government policy that is expected to increase income must be matched with commensurate waste management facilities. In addition, waste generation has not responded inversely to the price of recyclables in Lagos state, the policy import of this is that the more the government encourage recycling, re-use and composting through the initiation of some relevant economic packages, the greater will the people's welfare be.

Another finding of this research is that higher population density impacts positively on waste generation calling for adequate planning of waste disposal services. Generally, it will be possible to make a future projection and planning on waste management in anticipation of a change in certain demographic/socioeconomic characteristics. This research will be an eye opener to some economic incentives which are potent in solving some pollution and waste management problems in the Lagos metropolis

Lastly, it will serve as a reference to further studies on environmental matters in Lagos metropolis.

Theoretical contributions

The efficacy of economic instruments (as against the conventional regulatory instruments) in pollution control and waste management has been at the centre of theoretical controversy worldwide (Bernstein, 1993).

The recent adoption of the instruments in pollution control and waste management has been theorized to introduce flexibility, efficiency, and cost effectiveness into pollution control and waste management. This study has given further theoretical credibility to the beneficial property of economic instruments in waste management.

The above statement is not to suggest that the beneficial property of regulatory instruments is not recognized, there is a great need for complementarities. The effective utilization of economic instruments requires pre-existing appropriate standards and laws with effective capacities for enforcement and monitoring.

6.5 Suggestions for Future Studies

It has been shown both theoretically and empirically that user fee and other economic instruments employed in the control of pollution do cause some dumping problem, and the optimal economic instrument in waste management and pollution control is indeterminable in any part of the World. Further work is therefore needed on the determination of optimal level of economic instrument.

Further studies are needed on the possibility of extending the studies to cover water pollution, aquifer contamination and under ground water pollution. It is only when these pollution effects are aggregated that an optimal Pigovian tax can be used to correct pollution.

It has been argued that there is always a distortion in the economy in which case the optimal Pigovian tax is indeterminable. For instance, if the tax system in the economy is not optimal, the Pigovian tax may not be optimal in which case there is a need to first of all determine the optimal tax level before the optimal Pigovian tax is derived, so there is need for further research on this aspect.

In addition, there is the need for analyzing the external costs and benefits of different waste management options through the combined process of life-cycle assessment (LCA) and economic valuation in Lagos State so as to minimize costs associated with waste management strategies.

Lastly, there is need for further research on practical aspects of implementing and operating combinations of regulatory and economic instruments that are most appropriate for developing economies like Nigeria.

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APPENDIX A

HOUSEHOLDS

Dear sir or Madam,

RE: ECONOMICS OF WASTE MANAGEMENT IN LAGOS STATE

Mr Sunday Ayadi is doing an academic study into the "Economics of Waste Management in Lagos State" as part of his doctoral dissertation. As one of the selected respondents, we seek your support and co-operation. Your response to this questionnaire and comments would be very much appreciated.

Your responses will be treated with the highest level of confidentiality. Your response along with that of others will be collated, analyzed and interpreted for the benefit of the state and the country.

Thank you for your anticipated cooperation.

Prof. 'Tayo Fakiyesi

Supervisor

SECTION A

ZONE:--------------------------

(1) Name of Respondent ---
(optional).

(2) Address/location of Respondent---

____

(3) Occupation of Respondent---

(4) Educational qualification of the head of household:

Primary School Leaving Certificate ( )

Ordinary Level Certificate ( )

NCE, OND, HSC, A-level ( )

Bachelors', HND, etc. ( )

Other degrees/Cert. (please indicate) ( )

----

(5) How many people are in your household?

1-2 members ( ); 3-4 members ( ); 5-6 members( ) members; 7-8 members ( );

Above 8(please specify( )--

(6) What is your household income monthly?

N1- N20000( ); N20001 – N40000( ); N40001 – N6000( ); N60001– N80000( );

Above N80000 (please specify) N ---------------------------------

SECTION B

INSTRUCTIONS: please tick the answer that corresponds to your choice. Please note that there is no "right" or "wrong" answer – answer each of the questions as honestly as possible. If you wish to make additional comments on any of the specific questions or the issues in general, use the space provided at the end of the questionnaire.

(1) How often is refuse collected in your household daily/weekly? If weekly, state whether: once ( ); twice ( ); thrice ( ); uncertain ( )others (specific)--------------

(2) What quantity of waste pick-up per period?
Any quantity ( ); ¼ of a drum ( ); ½ of a drum( ); ¾ of a drum( ); one drum( );

(3) Do you turn out more waste than required? YES ( ); No ( ).

(4) If your answer to question 3 above is YES, how do you dispose the excess waste? By leaving it within premises( ); By burning it ( ) By disposing it through other means( ); by disposing it through my waste service provider at no extra cost ( ); by paying extra amount to get it disposed (please state the cost implication for example N 10 per extra drum) ( )--

(5) Can you estimate what you pay for waste disposal per periods of collection?
YES or NO.

(6) If yes, for 5, please give the estimate per period for the last 3 years, into the attached schedule.

2001

	(N0 - N100)	(N 101- N200)	(N 201- N300)	(N 301- N400)	(N 401- N500)
JANUARY	( )	( )	( )	( )	( )
FEBRUARY	( )	( )	( )	( )	( )
MARCH	( )	( )	( )	( )	( )
APRIL	( )	( )	( )	( )	( )
MAY	( )	( )	( )	( )	( )
JUNE	( )	( )	( )	( )	( )
JULY	( )	( )	( )	( )	( )
AUGUST	( )	( )	( )	( )	( )
SEPTEMBER	( )	( )	( )	( )	( )
OCTOBER	( )	( )	( )	( )	( )
NOVEMBER	( )	( )	( )	( )	( )
DECEMBER	( )	( )	( )	( )	( )

2002

	(N0 - N100)	(N 101- N200)	(N 201- N300)	(N 301- N400)	(N 401- N500)
JANUARY	( )	( )	( )	( )	( )
FEBRUARY	( )	( )	( )	( )	( )
MARCH	( )	( )	( )	( )	( )
APRIL	( )	( )	( )	( )	( )
MAY	( )	( )	( )	( )	( )
JUNE	( )	( )	( )	( )	( )
JULY	( )	( )	( )	( )	( )
AUGUST	( )	( )	( )	( )	( )
SEPTEMBER	( )	( )	( )	( )	( )
OCTOBER	( )	( )	( )	( )	( )
NOVEMBER	( )	( )	( )	( )	( )
DECEMBER	( )	( )	( )	( )	( )

2003

	(N0 - N100)	(N 101- N200)	(N 201- N300)	(N 301- N400)	(N 401- N500)
JANUARY	( )	( )	( )	( )	( )
FEBRUARY	( )	( )	( )	( )	( )
MARCH	( )	( )	( )	( )	( )
APRIL	( )	( )	( )	( )	( )
MAY	( )	( )	( )	( )	( )
JUNE	( )	( )	( )	( )	( )
JULY	( )	( )	( )	( )	( )
AUGUST	( )	( )	( )	( )	( )
SEPTEMBER	( )	( )	( )	( )	( )
OCTOBER	( )	( )	( )	( )	( )
NOVEMBER	( )	( )	( )	( )	( )
DECEMBER	( )	( )	( )	( )	( )

SECTION C

(1) Who collects your waste? LAWMA ( ); PSP operator ( ); Cart Pushers( ); self disposal( ); Other (please specific)---------------------------------------

(2) Efficient and effective waste management entails:

	I strongly agree	I agree	It depends	I disagree	I strongly disagree
(i) Commensurate service charges with level of solid waste service delivery must not be too costly.	( )	( )	( )	( )	( )
(ii) Waste service delivery must be adequate. That is, waste must be disposed regularly.	( )	( )	( )	( )	( )
(iii) There must be fair and safe working conditions and job training for waste service providers.	( )	( )	( )	( )	( )
(iv) Waste collectors must have technical resource (such as equipment, expertise and skills) to cope with waste management.	( )	( )	( )	( )	( )
(v) There must be management flexibility. That us, ease in firing waste personnel for non-performance and in providing upward mobility for workers	( )	( )	( )	( )	( )

with good performance.					
(vi) There must be a 'task' system of work in which workers may leave whenever they finish their assigned route.	( )	( )	( )	( )	( )
(vii) There must be a structure to monitor the performance of waste service providers.	( )	( )	( )	( )	( )
(viii) The will to enforce or maintain contractual agreements with their clients must be present	( )	( )	( )	( )	( )

(3) How would you rank your waste service provider (for example, LAMWA, PSP operator, cart pusher etc) in relation to the following?

	Excellent	Good	Fair	Poor	Very poor
(i) Commensurate service charges with level of solid waste disposal. In other words, waste service delivery is not too costly.	( )	( )	( )	( )	( )
(ii) Waste service delivery's adequacy. That is, waste is disposal regularly	( )	( )	( )	( )	( )
(iii) Fair and safe working conditions and job training for waste service provider.	( )	( )	( )	( )	( )
(iv) Waste collectors must have technical resource (such as equipment, expertise and skills) to cope with waste management.	( )	( )	( )	( )	( )
(v) Management flexibility. That is, ease in firing waste personnel for non-performance and in providing upward mobility for workers with good performance.	( )	( )	( )	( )	( )
(vi) Practicing of a 'task' system of work in which workers may leave whenever they finish their assigned route.	( )	( )	( )	( )	( )
(vii) The availability of an effective structure to monitor the performance of waste service providers.	( )	( )	( )	( )	( )
(viii) The will to enforce or maintain contractual agreements with their clients	( )	( )	( )	( )	( )

COMMENT:--

THANK YOU FOR YOUR KIND ASSISTANCE

APPENDIX B

COMPANIES

Dear sir or Madam,

RE: ECONOMICS OF WASTE MANAGEMENT IN LAGOS STATE

Mr Sunday Ayadi is doing an academic study into the "Economics of Waste Management in Lagos State" as part of his doctoral dissertation. As one of the selected companies, we seek your support and co-operation. Your response to this questionnaires and comments would be very much appreciated.

Your responses will be treated with the highest level of confidentiality. Your responses along with that of other will be collated, analyzed and interpreted for the benefit of the state and the country.

Thank you for your anticipated cooperation.

Prof. 'Tayo Fakiyesi.

Supervisor

SECTION A

ZONE:------------------

(1) Name of Respondent---------------------------(optional).

(2) Address/company of Respondent ---

(3) Location--

SECTION B

(1) Did you sort out your waste for recycling (that is, the process of recovering waste materials for remarking of another product)? YES ( ), NO ( ).

(2) Did you buy recyclables (that is, recovered waste materials) as your inputs (materials needed for production)? YES ( ), NO ( ).

(3) is using recyclable (that is, recovered waste materials) inputs more economical than using virgin (materials in its original or natural condition) inputs? YES ( ); NO ( ); I don't know ( ).

(4) what percentage is waste sorting in the cost of recyclable inputs? 0%-5%( ); 6%-10%( ); 11%-15% ( ); 16%-20% ( ); 21% - 25%( ).

(5) If your answer to either '1' or '2' above is 'YES', how much did you buy/sell these components from January 2001 to December 2003 per tons/kg etc? (PLEASE SPECIFY)---------------------------

2001	PAPER	PLASTICS	METAL	GLASS/BOOTLES	OTHERS
JANUARY					
FEBRUARY					
MARCH					
APRIL					
MAY					
JUNE					
JULY					
AUGUST					
SEPTEMBER					
OCTOBER					
NOVEMBER					
DECEMBER					

2002

JANUARY					
FEBRUARY					
MARCH					
APRIL					
MAY					
JUNE					
JULY					
AUGUST					
SEPTEMBER					
OCTOBER					
NOVEMBER					
DECEMBER					

2003

JANUARY					
FEBRUARY					
MARCH					
APRIL					
MAY					
JUNE					
JULY					
AUGUST					
SEPTEMBER					
OCTOBER					
NOVEMBER					
DECEMBER					

SECTION C

(1) Who collects your waste? LAWMA ( ); PSP operator ( ); Cart pushers ( ); self disposal ( ); others (please specific)---

(2) Efficient and effective waste management entails:

	I strongly agree	I agree	It depends	I disagree	I strongly disagree
(i) commensurate service charges with level of solid waste disposal. In other words waste service delivery must not be too costly	( )	( )	( )	( )	( )
(ii) waste service delivery must be adequate. That is, waste must be disposal regularly.	( )	( )	( )	( )	( )
(iii) There must be management flexibility. That is, ease in firing waste personnel for non-performance and in providing upward mobility for workers with goes performance.	( )	( )	( )	( )	( )
(v) There must be a 'task' system of work in which workers may leave whenever they finish their assigned route.	( )	( )	( )	( )	( )
(vi) There must be a 'task' system of work in which workers may leave whenever they finish their assigned route.	( )	( )	( )	( )	( )
(vii) There must be a structure to monitor the performance of waste service providers.	( )	( )	( )	( )	( )
(viii) The will to enforce or maintain contractual agreements with their clients must be present cost.	( )	( )	( )	( )	( )

(3) How would you rank your waste service provider (for example, LAMWA, PSP operator, cart pusher etc) in relation to the following?

	Excellent	Good	Fair	Poor	Very poor
(i) Commensurate service charges with level of solid waste disposal. In other words, waste service delivery Is not too costly	( )	( )	( )	( )	( )
(ii) Waste service delivery's adequacy. That is, waste is disposal regularly	( )	( )	( )	( )	( )
(iii) Fair and safe working conditions and job training for waste service providers	( )	( )	( )	( )	( )
(iv) Waste collectors' technical resources (such as equipment, expertise and skills) to cope with waste management	( )	( )	( )	( )	( )
(v) Management flexibility. That is, ease					

in firing waste personal for non-performance and in providing upward mobility for workers with good performance.	( )	( )	( )	( )	( )
(vi) Practising of a 'task' system of work in which workers may leave whenever they finish their assigned route.	( )	( )	( )	( )	( )
(vii) The availability of an effective structure to monitor the performance of waste service providers.	( )	( )	( )	( )	( )
(viii) The will to enforce or maintain contractual agreements with their clients	( )	( )	( )	( )	( )

(5) What percentage is waste in the running cost of your company?

0%-5% ( ); 6%-10% ( ); 11%-15% ( ); 16%-20% ( ); 21%-25% ( ).

(6) COMMENTS:--

THANK YOU FOR YOUR KIND ASSISTANCE.

APPENDIX C

World population data 1992 to 2025

Population (Millions)				population doubling time (years)
	1992	2010	2025	
World	5,420.0	7,115.0	8,547.0	41
Developing	4,197.0	5,782.0	7,155.0	34•
Developed	1,224.0	1,333.0	1,392.0	148
Nigeria	90.1	152.2	216.2	23•
Canada	27.4	32.1	35.0	89
US	255.6	295.5	327.5	89
UK	57.8	59.9	61.0	257
France	56.9	58.8	58.6	169
Former USSR	292.3	336.6	390.6	104
Italy	58.0	56.4	51.9	1,386
Cote d'Ivoire	13.0	25.5	39.3	19
Tanzania	27.4	50.2	77.9	20*
Uganda	17.5	32.5	49.6	19*
Zzambia	8.4	15.5	24.2	18*

Key:* = Critical, = • Serious

Sources: Haub, C., and Yanagishita, M. (1992) World population Data sheet, Washington, D.C.; Population Reference Bureau, 1992.

APPENDIX D

Waste generation rates and income

	Low income Country	Middle income Country	Industrialized Country
Solid waste quantity (tonne/capita/yr.)	0.2/T/c/yr.	0.3/T/c/yr.	0.6/T/c/yr.
Average income $US/capita/yr (in 1988 $US)	$350/c/yr	$1,950/c/yr	$17,500/c/yr

Source: Urban Management Programme.

APPENDIX E

Annual domestic waste per capital for some countries of the world

Country	Annual domestic waste (million metric tons)	Kilograms	Pounds
Australia	12.6	690	1,520
Belgium	4.8	470	1,040
Canada	18.9	630	1,390
Denmark	2.8	530	1,170
Finland	2.1	410	900
France	32.8	560	1,230
Germany	32.8	400	880
Italy	27.0	470	1,040
Japan	50.4	400	880
Mexico	31.9	330	730
Netherlands	9.0	580	1,280
Norway	2.7	620	1,370
South Korea	17.7	390	860
Spain	14.5	370	820
Sweden	3.9	440	970
United Kingdom	28.8	490	1,080
United States	192.9	720	1,590

Source: Organization for Economic Cooperation and Development, Environmental Data 1997.

APPENDIX F

(4A)

WASTE COMPOSITION IN LAGOS STATE

i.	Vegetable	68%
ii.	Paper	9%
iii.	Textiles	4%
iv.	Metals	3%
v.	Plastics	7%
v.	Glass	5%
vi.	Grit	4%

Source: LAWMA (Undated)

APPENDIX G

The Worldwide average composition of MSW in Municipalities

Food wastes	10.40%
Yard wastes	13.45%
Paper and paperboard	38.10%
Plastics	9.40%
Metals	7.70%
Glass	5.90%
Wood	5.20%
Textiles	3.70%
Rubber and leather	3.00%
Other wastes	3.20%

Source: US EPA Survey of 1996.

APPENDIX H

Estimated and projected volume of solid waste generation in some Nigerian cities from 1992 to 2000

Urban Areas	1992	1985	1990	2000
Lagos	625399	681394	786079	998081
Ibadan	350823	382224	440956	559882
Kano	319935	348580	402133	535186
Kaduna	257837	280925	324084	431314
Onitsha	242240	263929	304477	386593
Port Harcourt	210934	229821	265129	352853
Oshogbo	131903	143712	173720	253841
Aba	131903	143712	169719	236703
Jos	99871	111905	135272	197660
Warri	67871	75607	91396	133531
Gusau	44488	48471	57243	79835
Potiskum	15434	16816	19399	28347
Uyo	12508	13628	15721	20923
Suleja	9383	10514	13311	21336
New Bussa	5690	6200	7152	9518

Source: Federal Ministry of Housing and Environment. The state of the Environment in Nigeria, Monograph series, No.2. Lagos (Undated). Adopted from Umoh (1997; 268).

APPENDIX I

Solid waste generation and tonnage in Lagos State from 1978 to 2001

Year	WASTE TONNAGE	WASTE GENERATED BASED ON 73% LANDFILL DISPOSAL COMPLIANCE*
1978	170,000	232,877
1979	367,000	502,740
1980	369,000	505,479
1981	256,013	350,703
1982	456,903	625,895
1983	378,034	517,855
1984	388,000	531,507
1985	573,215	785,226
1986	1,169,215	1,601,664
1987	1,473,144	2,018,005
1988	2,630,613	3,603,379
1989	3,194,148	4,375,545
1990	3,527,109	4,831,656
1991	2,368,770	3,244,890
1992	1,797,682	2,462,578
1993	2,024,197	2,772,873
1994	1,396,847	1,913,489
1995	1,895,504	2,596,581
1996	944,153	1,293,360
1997	1,010,719	1,384,547
1998	1,856,205	2,542,747
1999	2,078,431	2,847,166
2000	1,200,000	1,643,836
2001	1,884,708	2,581,792

Source: LAWMA Landfill Gate Records(Undated) * Computer by the Author

APPENDIX J

Present landfill / dumpsites in Lagos State 2007

a.	Olushosun, Oregun, - Ojota, Somolu LG	(42 Hectares)
b.	Abule-Egba, Alimosho LG	(10.5 Hectares)
c.	Solous, Alimosho LG	(9.3 Hectares)
	Depth of landfill	(18 Metres)

APPENDIX K

Private sector activities in waste management in Lagos State 2002

S/N	LOCAL GOVERNMENT	NO OF REGISTERED PROS	NO OF HOUSES SERVICED	NO OF TONNAGE PER DAY	% COMPLIANCE
1	AGEGE AJEROMI/	40	25,198	223	62
2	IFELODUN	45	40,825	316	88
3	ALIMOSHO	87	43,531	176	49
4	AMUWO/ODOFIN	22	20,946	288	80
5	APAPA	40	22,656	198	55
6	BADADRY	10	5,918	180	50
7	ETI-OSA	35	29,789	288	80
8	IFAKO-IJAYIE	38	27.517	255	71
9	IKEJA	25	21,456	302	84
10	IKORODU	32	13,426	144	40
11	KOSOFE	33	16,000	172	48
12	LAGOS ISLAND	30	21,591	252	70
13	LAGOS	30	25,000	298	83
14	MAINLAND	31	24,727	277	77
15	OJO	47	36,814	273	76
16	OSHODI-ISOLO	49	32,218	234	65
17	MUSHIN	18	10,849	198	55
18	SOMOLU	34	24,347	252	70
	SURULERE				

Source: Ministry of Environment and Physical planning Ministerial Press Briefing in Commemoration of 3rd year in Office (Activity Report).

APPENDIX L

Average residential user fee in Lagos State from January 2000 to December 2003

YEAR	MONTH	AVERAGE USER FEE (₦)	AVERAGE USER FEE IN MAY 2003 PRICES (₦)
		157.29	211.98
		158.52	209.40
		160.37	210.18
		161.62	198.80
		162.23	194.9
2001		163.46	194.9
		157.91	188.21
		159.14	185.91
		156.06	179.17
		158.52	18.55
		159.76	187.51
		161.61	190.35
		177.66	201.89
		180.13	201.49
		180.13	201.04
		181.99	198.90
		181.99	197.82
2002		182.60	197.83
		181.13	186.73
		181.13	188.28
		181.13	189.07
		180.50	195.14
		181.75	190.12
		182.23	191.58
		209.76	215.58
		209.76	218.73
		210.99	222.56
		210.99	212.91
		212.85	212.91
2003		214.08	203.50
		213.46	194.94
		212.23	196.33
		212.23	187.15
		212.61	185.85
		214.48	185.06
		215.10	182.44

SOURCE: Author, Primary survey results 2004

APPENDIX M

Average price of recyclables in Lagos State from January 2000 to December 2003

YEAR	MONTH	AVERAGE USER FEE IN MAY 2003 PRICES (₦)
2001	1	34.83
	2	34.76
	3	34.88
	4	34.80
	5	34.89
	6	34.87
	7	34.87
	8	34.91
	9	35.05
	10	35.15
	11	35.11
	12	35.00
2002	1	38.57
	2	38.75
	3	38.86
	4	38.77
	5	38.83
	6	39.79
	7	40.41
	8	40.02
	9	38.9
	10	38.93
	11	38.95
	12	38.77
2003	1	55.09
	2	55.18
	3	55.52
	4	55.09
	5	55.90
	6	56.16
	7	56.51
	8	56.44
	9	56.38
	10	56.38
	11	56.10
	12	56.46

SOURCE: Author, Primary survey results 2004

APPENDIX N

Global priorities in spending in 1998

Global priority	$U.S. Billions
Basic education for everyone in the world	6
Cosmetics In the United States	8
Water and sanitation for everyone in the world	9
Ice cream in Europe	11
Reproductive health for all women in the world	12
Perfumes in Europe and the united states	12
Basic health and nutrition for everyone in the world	13
Pet foods in Europe and the united states	17
Business entertainment in Japan	35
Cigarettes in Europe	50
Alcoholic drinks in Europe	105
Narcotics drinks in the world	400
Military spending in the world	780

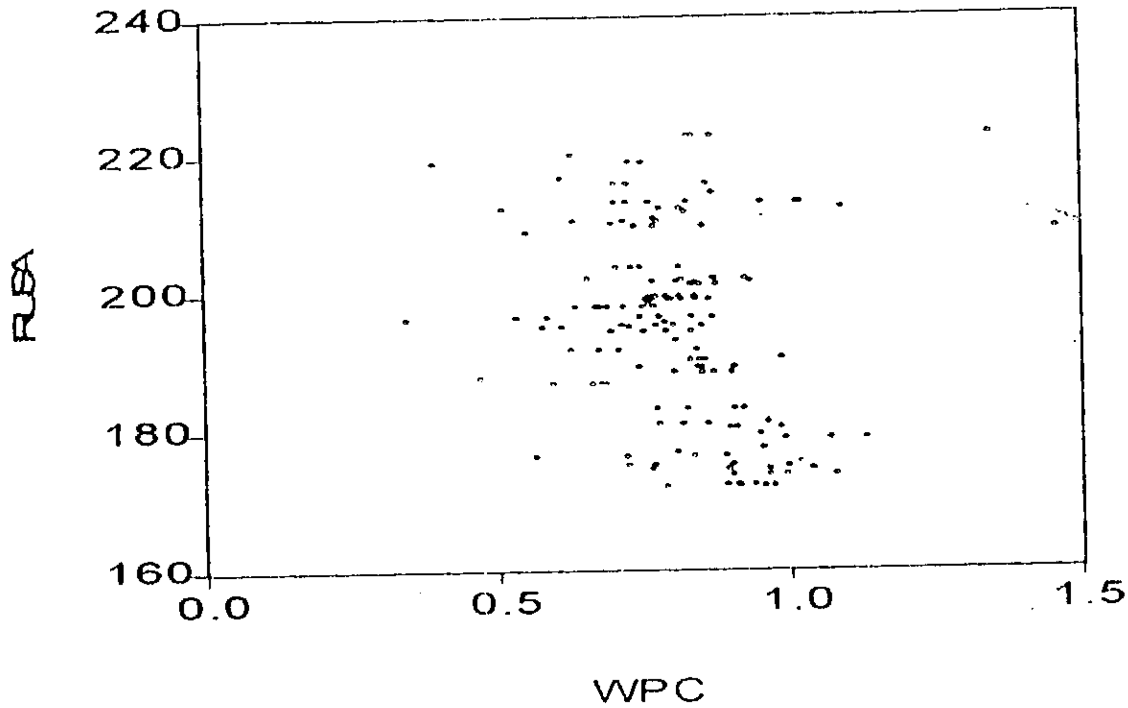
Source: Author, Primary survey results

APPENDIX O

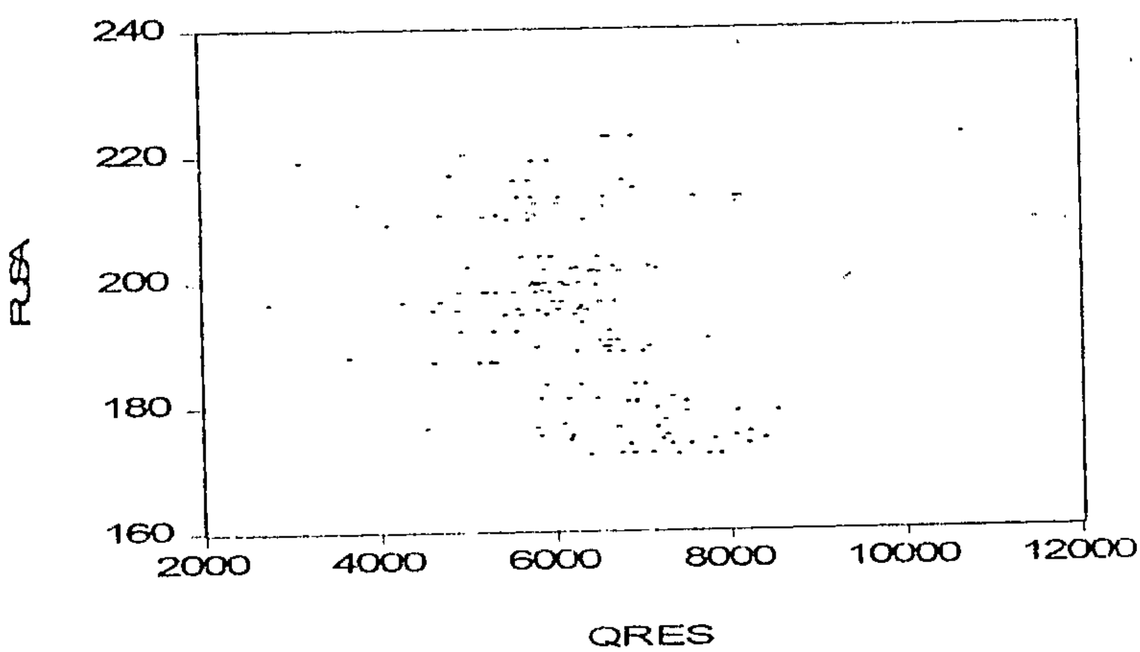
Half correlation matrix table of variables of the model

	Wpc	Rusa	Rprecy	Popden	Rinc	Workpop	Housesiz	Temp	Rain
Wpc	1.000000								
Rusa	-0.234280	1.000000							
Rprecy	-0.102504	0.564994	1.000000						
Popden	-0.065992	-0.073844	0.592514	1.000000					
Rinc	0.045484	0.335756	-0.355300	-0.920304	1.000000				
Workpop	0.032921	0.068562	-0.496551	-0.783719	0.177480	1.000000			
Housesiz	-0.063580	-0.075015	0.595819	0.993211	-0.923739	-0.788897	1.000000		
Temp	0.067561	0.546328	0.225663	-0.160856	0.357269	0.154802	-0.154028	1.000000	
Rain	-0.162715	-0.182554	-0.095727	0.068592	-0.203829	-0.045798	0.049956	-0.591953	1.000000

APPENDIX P
Scatter plot of WPC and real user fee



APPENDIX Q
Scatter plot of total residential waste and real user fee



APPENDIX S

Commercial user charge of Lagos State from 2001 to 2003

2001	
One dino bin once weekly collection	₦ 45,000 Monthly
Additional frequency	₦ 7,500
One mammoth once weekly collection	₦16,000 Monthly
Additional frequency	₦3,000
One drum once weekly collection	₦5,000 Monthly
Additional frequency	₦1,000
2002	
One dino bin once weekly collection	₦ 55,000 Monthly
Additional frequency	₦ 10,000
One mammoth once weekly collection	₦20,000 Monthly
Additional frequency	₦ 4,000
One drum once weekly collection	₦8,000 Monthly
Additional frequency	₦2,000
2003	
One dino bin once weekly collection	₦ 55,000 Monthly
Additional frequency	₦ 10,000
One mammoth once weekly collection	₦20,000 Monthly
Additional frequency	₦ 4,000
One drum once weekly collection	₦8,000 Monthly
Additional frequency	₦2,000

Source: LAWMA Commercial Department (Undated)