ANALYSIS OF THE GOVERNANCE FRAMEWORK FOR VEHICULAR AIR POLLUTION ABATEMENT IN KENYA: A CASE STUDY OF NAIROBI CITY

A thesis submitted to the University of Nairobi in partial fulfillment of the Master of Science degree in Environmental Governance

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September, 2017
DECLARATION

This thesis is my original work and has not been presented for award of a degree in any other University.

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For my loving wife Helidah and our sons Simon, Adrian and Henry
ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to my Supervisors, Prof. David Mungai and Dr. Jones Agwata for their invaluable support throughout my research, for their patience, motivation, and immense knowledge. Their guidance was very helpful to me in undertaking my research and writing of this thesis. I am especially grateful to both Supervisors not only for their insightful comments and encouragement, but also for the hard questions which incented me to widen my research from various perspectives.

Secondly, I thank the entire faculty and staff at Wangari Maathai Institute for Peace and Environmental Studies, and my fellow classmates for their support throughout my study.

I would also like to thank my wife and children for their support and prayers throughout my MSc. Study.

Last but not least, to the Almighty God for the gift of life and for enabling me to accomplish my dreams.
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LIST OF ABBREVIATIONS

AQM – Air Quality Monitoring

CNG – Compressed natural Gas

EMCA – Environmental Management and Co-ordination Act

GHG – Green House Gas

GoK – Government of Kenya

HC – Hydrocarbons

KEBS – Kenya Bureau of Standards

KNBS – Kenya National Bureau of Statistics

LPG – Liquefied Petroleum Gas

MVIU – Motor Vehicle Inspection Unit

NEMA – National Environment Management Authority

NTSA – National Transport and Safety Authority

PM – Particulate Matter

TSP – Total Suspended Particles

UNEP – United Nations Environment Programme

WHO – World Health Organization
ABSTRACT

Air pollution has been singled out as a fast growing health and environmental challenge in most cities especially in the developing world. Numerous studies show that emissions from motor vehicle traffic contribute significantly to the deteriorating air quality in many of these cities. This state of affairs is attributable to various governance challenges pertaining to the abatement of vehicular air pollution. The objective of this study was to analyze the governance framework for the abatement of air pollution from motor vehicle emissions in Kenya using the capital city, Nairobi, as a case study. Specifically, the study sought to critically review relevant policies, laws, regulations and standards in order to evaluate their scope and appropriateness for regulating emissions from vehicles in Kenya, and to analyze the implementation challenges of the existing policies, laws, regulations and standards for the control of air pollution from motor vehicle emissions in Kenya.

This study employed a case study research design. A case study of Nairobi City was chosen so as to allow for an in-depth inquiry into the research problem by narrowing down the broader Kenyan scenario to the more easily researchable example of Nairobi. Data was collected through relevant document review and analysis, key informant interviews and a questionnaire. All three sources of data were triangulated in the final data analysis from which the study results and conclusions were drawn.

The study found that Kenya has several policies, laws, regulations and standards aimed at controlling air pollution emanating from vehicular sources. On the institutional framework, the study established that the existing laws, regulations and standards are implementable by different agencies including National Environment Management Authority (NEMA), Kenya Bureau of
Standards (KEBS), National Transport and Safety Authority (NTSA), Kenya Police Service (KPS) and Energy Regulatory Commission (ERC). However, the study found that there are several implementation challenges to the existing policies, laws, regulations and standards. These challenges include: weaknesses in the laws, regulations and standards in terms of limited scope and coverage of the types of vehicles subject to inspections, low penalties for offenders, overlaps in institutional mandates and outdated provisions that do not match current technologies; inadequate institutional capacities in terms of low funding, limited staff and lack of necessary emissions measurement and monitoring equipment; poor co-ordination between various law enforcement agencies such as some agencies not being aware of what other agencies are doing regarding abatement of vehicular emissions, different organizations developing parallel regulations and lack of cooperation in implementation of the same; low public awareness; absence of reliable emissions monitoring and inventorying systems hence lack of adequate scientific data for decision making; and low priority given to vehicular emissions hence the lack of incentives for adoption of cleaner vehicle technologies.

The overall conclusion of the study is that despite there being several policies, laws, regulations and standards with corresponding implementing institutions to control vehicular air pollution in Kenya, their implementation and enforcement is not effective due to the various challenges outlined above.

To policy makers, the study makes several recommendations which include the need to enhance the capacity of relevant agencies to implement and enforce vehicular emissions laws, regulations and standards, the need to enhance inter-agency co-ordination on vehicular emission control, the
need to create public awareness on vehicular emissions and their impact on health and the environment, the need to build national capacity for emissions monitoring and inventory, and the need to provide adequate incentives to encourage the adoption of cleaner vehicle technologies. For further research, it is recommended that detailed air pollution studies be carried out to determine the actual loads by motor vehicles to the air pollution in Nairobi. In addition, epidemiological studies are recommended to determine the effects of this pollution in Nairobi City.
CHAPTER ONE

1.0 INTRODUCTION
This Chapter provides the background of the study, statement of the research problem, research questions, objectives, justification, scope and limitations of the study.

1.1 Background
Air pollution refers to the introduction into the environment of any chemical, physical or biological matter in a way that interferes with the natural elements of the atmosphere. The pollutants can originate from anthropogenic or natural sources and can occur in such quantities as to cause adverse impacts to human life and the environment. (WHO, 2014; Gurjar et al., 2010; Elsom, 1987; Cooper and Alley, 1986).

The combustion of fossil fuels releases a complex mixture of air pollutants including particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO₂), volatile organic compounds (VOCs) and sulfur oxides (SOx). Out of these pollutants, those that are considered as having greater negative impact on human health are particulate matter (PM), carbon monoxide (CO), ozone (O₃), nitrogen dioxide (NO₂) and sulfur dioxide (SO₂). Several studies have pointed out an array of adverse health impacts from exposure to these pollutants including a rise in cardiovascular diseases, respiratory illnesses and premature death (UNEP, 2014 & WHO, 2014).

It is now recognized that air pollution presents the greatest environmental health risk globally. According to the World Health Organization (WHO), exposure to air pollutants causes one out of eight of total human deaths globally. WHO reports show that in 2012 alone seven million deaths were attributed to exposure to outdoor and indoor air pollution. The reports further show that of
the total global air pollution related deaths in 2012, almost 700,000 occurred in Africa (WHO, 2014).

Some of the air pollutants, besides their adverse health impacts, have serious immediate and long term environmental effects. Air pollution negatively affects plant biodiversity and their attendant ecosystem services, destroys cultural heritage and contributes to global warming (UNEP, 2014).

The United Nations Environment Programme (UNEP) attributes up to 90% of air pollution in rapidly growing cities, especially in Sub-Saharan Africa, to motor vehicle emissions as a result of rising motor vehicle populations, poor infrastructure, poor vehicle servicing and maintenance, and wanting fuel quality (UNEP, 2014).

Kenya’s capital city, Nairobi, is reflective of the country’s growing vehicular air pollution problem and is in many ways similar to other cities in Sub-Saharan Africa. Some recent studies have pointed to motor vehicle emissions as a significant source of air pollution in Nairobi. Some of these studies show that the concentration of fine particulate matter (PM$_{2.5}$) and nitrogen oxides (NO$_x$) in the air of Nairobi is strongly correlated to motor vehicles density, indicating that motor vehicle emissions contribute significantly to the city’s air pollution (Gaita et al., 2014; Kinney et al., 2011; Odhiambo et al., 2010; van Vliet et al., 2009; Schwela, 2007; Awange & Obera, 2007; van Vliet and Kinney, 2007 and 2006; Maina, 2004; Mulaku and Kariuki, 2001; Karue et al., 1992).

On the health impact of motor vehicle emissions in Nairobi, the studies point out that the most vulnerable groups are those that are most exposed to the air pollutants as a result of spending longer time periods on or near the city’s roads. The major groups in this category are pedestrians,
cyclists, motorists, traffic police, roadside traders and hawkers, and those persons residing near major roads (Kinney et al., 2011; Odhiambo et al. 2010; Van Vliet et al. 2007).

On the environmental front, the Government of Kenya has, for example, singled out climate change as an effect to which vehicular air pollution can be attributed. Whereas the government acknowledges that Kenya’s share of global greenhouse gas (GHG) emissions is still low, it points out that the transport sector accounts for a large portion of the country’s GHG emissions. This is mainly attributed to the rapidly increasing private car use in Nairobi and other cities and towns as the public transport sector continues to erode (GoK, 2010).

Whereas several policies, laws, regulations and standards with matching implementing institutions have been put in place to address vehicular air pollution in Kenya, the problem seems to be compounding especially in the fast growing cities such as Nairobi, Mombasa and Kisumu. This trend has been attributed to governance challenges related to vehicular air pollution control in Kenya (ERC, 2014; Odhiambo et al., 2010; Schwela, 2007).

1.2 Statement of Research Problem

Deteriorating air quality is a growing environmental and health problem in Kenya, especially in the cities and major towns including Nairobi, Mombasa, Kisumu, Nakuru and Eldoret. For Nairobi, recent air pollution studies have shown that the mean values for air pollutants such as particulate matter (PM10 and PM2.5) and gaseous pollutants such as ozone (O3) and nitrogen oxides (NOx) are well above WHO guidelines. The findings point to motor vehicle traffic as the most significant source of harmful emissions that pollute the air in Nairobi city. These studies have established a strong positive correlation between fine particles (PM2.5) in Nairobi’s air and
motor vehicles density in the city. In addition, the studies have established a strong positive correlation between PM$_{2.5}$ and NOx, indicating that both may be emanating from same sources. (Gaita et al., 2014; Kinney et al., 2011; Odhiambo et al., 2010; van Vliet et al., 2009; Schwela, 2007; Awange & Obera, 2007; van Vliet and Kinney, 2007 and 2006; Maina, 2004; Mulaku and Kariuki, 2001; Karue et al., 1992).

That pollutants from motor vehicles are becoming an emerging threat in Kenya’s urban areas has been severally highlighted in different studies (Gaita et al., 2014; Kinney et al., 2011; Odhiambo et al., 2010; van Vliet et al., 2009; Schwela, 2007; Awange & Obera, 2007; van Vliet and Kinney, 2007 and 2006; Maina, 2004; Mulaku and Kariuki, 2001; Karue et al., 1992). This state of affairs has been attributed to governance challenges relating to the existing norms (ERC, 2014; Odhiambo et al., 2010; Schwela, 2007). This study, therefore, analyzed the governance framework for vehicular air pollution abatement in Kenya with specific reference to the case of Nairobi City.

1.3 Research Questions

This study was guided by the following research questions:

a) Which policies, laws, regulations and standards are in place for vehicular air pollution abatement in Kenya?

b) What are the implementation challenges of the existing policies, laws, regulations, and standards for vehicular air pollution abatement in Kenya?
1.4 Objectives of the Study

The general objective of this study was to analyze the governance framework for vehicular air pollution abatement in Kenya.

The specific objectives of the study were to:

   a) Critically review and evaluate the scope and appropriateness of existing policies, laws, regulations and standards for regulating emissions from vehicles in Kenya;

   b) Analyze the implementation challenges of the existing policies, laws, regulations and standards for vehicular air pollution abatement in Kenya.

1.5 Justification of the Study

Understanding the governance framework for vehicular air pollution abatement in Kenya is necessary to improve the knowledge base that is essential in determining future actions aimed at addressing the growing problem of air pollution from vehicle emissions in Kenya. The findings of this study are significant to policy makers and implementers at both national and county government levels in informing future policy formulation and implementation options for controlling vehicular air pollution in Kenya.

1.6 Scope and Limitations

This study was carried out in Nairobi, Kenya between July 2014 and December 2015. The study was confined to information related to the abatement of vehicular air pollution in Kenya from key regulators in the environment, energy and motor transport sectors including government ministries, agencies and departments as well as the general public in Nairobi city.
The main factor that presented a challenge during the study was access to complete and reliable information pertaining to vehicular air pollution in Kenya. This is because at the time of the study Kenya did not have a comprehensive continuous Air Quality Monitoring System (AQMS) in place. As a result there was no reliable inventory of air pollutants with source apportionment. In addition, there were numerous government agencies charged with implementation of various policies, laws, regulations and standards on vehicle emissions but with very limited inter-agency coordination. As a result, the little available information on vehicular air pollution in Kenya was scattered among diverse government agencies and was not well coded in most instances.

In dealing with these limitations, the data obtained from the diverse sources was validated through a detailed review and analysis.
CHAPTER TWO

2.0 LITERATURE REVIEW

This Chapter presents a critical review of existing literature on the sources and characteristics of motor vehicle emissions, the health and environmental impacts of motor vehicle emissions and the governance framework for vehicular air pollution abatement. The chapter also outlines the research gaps as well as the conceptual and theoretical framework for the study.

2.1 Nature and Properties of Motor Vehicle Emissions

There are two categories of air pollutants namely: primary pollutants that are directly released into the atmosphere, and secondary pollutants that are formed in the atmosphere due to chemical reactions of primary pollutants. The primary pollutants emanating from motor vehicles are carbon dioxide (CO₂), carbon monoxide (CO), hydrocarbon compounds (HC), sulfur dioxide (SO₂), nitric oxide (NO), particulate matter (PM), and, in some cases, lead (Pb). The Secondary pollutants that occur in the atmosphere as a result of chemical reactions of motor vehicle emissions are nitrogen dioxide (NO₂), ozone (O₃) and sulfuric or nitric acids and their salts. (Onursal and Gautam, 1997; Faiz et. al., 1996).

Fuel combustion and evaporation are the main sources motor vehicle emissions. There are many types of fuels used to power motor vehicles including gasoline, diesel, alcohols like methanol and ethanol, alcohol-gasoline blends, liquefied petroleum gas (LPG) and compressed natural gas (CNG). In Kenya, however, the main fuels used for motor vehicles are gasoline and diesel (Onursal and Gautam, 1997; Faiz et. al., 1996; Kinney et al., 2011).
Gasoline-powered vehicles mainly emit CO, HC, NOx, and lead (in places where leaded gasoline is still in use). Diesel-powered vehicles on the other hand emit mainly particulate matter (PM), SO₂, NOx, CO and HC (Onursal and Gautam, 1997; Faiz et. al., 1996).

2.1.1 Particulate Matter
Particulate matter (PM) is mainly solid particles and liquid droplets and occurs from both natural and anthropogenic activities. Natural PM may occur from sources such as soil and other dusts, ashes and plant pollens. On the other hand, human-induced PM may occur from combustion of fossil fuels and open burning of waste. Based on size, PM can be described as Total Suspended Particulates (TSP), Suspended Inhalable Particulate Matter (PM₁₀) or Fine Particles (PM₂.₅) (Faiz et. al., 1996; Pope III et. al., 1995)

Total Suspended Particulates are the largest form of PM with an aerodynamic diameter greater than 10μm but less than 70μm. TSP does not remain in the atmosphere for long due to its high settling velocity. PM₁₀ on the other hand is inhalable since it has an aerodynamic diameter of 10μm or less and tends to remain suspended in the air for a much longer time. On its part, PM₂.₅ has an aerodynamic diameter of between 2.5 μm and 10 μm or less. Almost all PM associated with motor vehicle emissions is PM₂.₅ emanating from fuel combustion. PM₂.₅ remains in the atmosphere for much longer periods than other forms of PM. (Faiz et. al 1996; Pope III et. al., 1995; Winchester, 1989).

Studies on the state of air quality in Nairobi in recent years have shown that the concentrations of PM₁₀ and PM₂.₅ are higher than WHO recommended levels. Indeed, the high level of PM₂.₅ in Nairobi’s air is strongly correlated to motor vehicles density in the city (Gaita et al., 2014;

2.1.2 Carbon monoxide
Carbon monoxide (CO) is a colourless and odourless gas that occurs from both natural and human activities. Incomplete combustion of carbon containing motor fuels is a major source of anthropogenic CO emissions (Faiz et. al., 1996; Masterson et. al., 1985). At the time of this study there were no published studies on motor vehicle related CO emissions in Nairobi and the obtaining governance framework for the same.

2.1.3 Sulfur dioxide
Sulfur dioxide (SO2) results from the combustion of fossil fuels with sulfur content. In Kenya, both gasoline and diesel contain varying levels of sulfur. Kenya has since January 2015 implemented new standards that regulate the sulfur content in motor fuels (Faiz et. al., 1996; NEMA, 2015).

2.1.4 Nitrogen Oxides
Nitrogen oxides (NOx) collectively refer to nitric oxide (NO), nitrogen dioxide (NO2), nitrous oxide (N2O), dinitrogen trioxide (N2O3), and nitrogen pentoxide (N2O5). Anthropogenic NOx result from combustion of fossil fuels. Motor vehicle emissions mainly contain NO and NO2. (Onursal and Gautam, 1997; Faiz et. al., 1996).
Studies have shown that the concentration of NOx in the air of Nairobi is on the rise, and is strongly correlated to motor vehicles density, implying that motor vehicles are mainly responsible for NOx in the air of Nairobi. The studies have called for the establishment of sound legal and regulatory frameworks to tame the rise in vehicular emissions in Nairobi and other major Kenyan cities (Gaita et al., 2014; Kinney et al., 2011; Odhiambo et al., 2010; van Vliet et al., 2009; Schwela, 2007; Awange & Obera, 2007; van Vliet and Kinney, 2007 and 2006; Maina, 2004; Mulaku and Kariuki, 2001; Karue et al., 1992).

2.1.5 Hydrocarbon Compounds and Volatile Organic Compounds
Hydrocarbon Compounds (HC) and Volatile Organic Compounds (VOCs) such as alcohols and aldehydes (collectively referred to as HC) are emitted from natural and anthropogenic sources. Vehicular HC result from incomplete fuel combustion and are usually emitted as benzene, 1,3-butadiene, aldehydes, and polycyclic aromatic hydrocarbons (PAH) (Faiz et al., 1996).

2.1.6 Lead
In countries where leaded gasoline is still in use, lead in the ambient air is mainly attributed to motor vehicles emissions (GEMS 1988). However, in Kenya the use of leaded gasoline was phased out at the end of 2005 following the implementation of new fuel standards (UNEP, 2014). Thus, lead emission from vehicular sources is no longer a problem in Kenya.

2.1.7 Ozone
Ground level Ozone (O₃) which is a significant component of urban smog results from the chemical reaction of VOCs and NOx with O₂ in the troposphere. Motor vehicles are a major source of the VOCs and NOx that react with natural O₂ under sunlight and elevated temperatures to form O₃ (Horowitz, 1982).
2.1.8 **Carbon dioxide**
Carbon dioxide (CO\textsubscript{2}) is a greenhouse gas (GHG). The increase in CO\textsubscript{2} concentrations is associated with global warming and results mainly from increased combustion of fossil fuels, including motor vehicle fuels, and land use, including deforestation (USEPA, 2014).

2.2 **Health Effects of Vehicular Air Pollutants**
The impacts of pollutants on human health depend on many factors such as the number and age group of exposed persons and their health status, concentration levels and typology of the contaminants, and dose-response functions (Kjellstrom et. al., 2002; Onursal and Gautam, 1997).

Air pollution is currently recognized as the world’s greatest single environmental health risk. According to the WHO, one out of eight of total global deaths can be attributed to exposure to air pollutants. WHO reports that in 2012 alone seven million deaths globally were attributed to exposure to both outdoor and indoor air pollution. Of the total air pollution exposure related deaths, almost 700,000 occurred in Africa (WHO, 2014).

Pollutants contained in motor vehicle emissions pose numerous negative impacts to human health. Exposure to these pollutants may occur not only through inhalation but also through other routes such as water and food contamination, and also through absorption by the skin (WHO, 2014; UNEP, 2014: Bailey, 2011; Kampa, 2007; Kjellstrom et. al., 2002).

The health impacts of the various pollutants in motor vehicle emissions are discussed in more detail below.
2.2.1 **Particulate Matter**
Exposure to PM is mainly through inhalation by nasal and mouth breathing. PM may contain various pollutants such as heavy metals and organic compounds that may adversely affect humans. PM2.5 poses the greatest health risk because it can easily find its way into the lung tissue and may be absorbed into the blood stream (CDC, 2014; Bailey, 2011; Kampa 2007; Kjellstrom *et. al.*, 2002).

Exposure to PM in both children and adults may result in negative health effects including respiratory diseases such as pneumonia, asthma, and bronchitis. Exposure to PM may also cause cancer and exacerbate morbidity and mortality from respiratory dysfunctions. (CDC. 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; Kjellstrom *et. al.*, 2002; MARC, 1991; Faiz, Walsh and Varma, 1990).

2.2.2 **Carbon monoxide**
Carbon monoxide (CO) enters the blood stream through the lungs and drastically hinders the blood’s capacity to transport oxygen to various body tissues. The resultant effects of low oxygen levels in body tissues include impaired perception, slow reflexes and drowsiness. CO exposure may cause unconsciousness and death.

2.2.3 Sulfur dioxide
SO$_2$ is absorbed through the nose and watery membranes of the upper respiratory tract. Exposure to SO$_2$ may impair lung function and result in respiratory diseases such as bronchitis, and increased morbidity and mortality risk. (CDC, 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; MARC, 1991; Faiz et. al., 1990).

2.2.4 Nitrogen dioxide
NO$_2$ is absorbed in the respiratory tract through the mucous membrane. Exposure to NO$_2$ increases one’s chances of contracting respiratory infections, impairs pulmonary function and may exacerbates airway resistance in asthmatics (CDC, 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; Kjellstrom et. al., 2002; MARC, 1991; Faiz et. al., 1990).

2.2.5 Hydrocarbon Compounds
HC emissions from motor vehicles are mainly benzene, 1,3-butadiene, aldehydes, and polycyclic aromatic hydrocarbons (PAH). The health impacts of these compounds are discussed below:

**Benzene:** Benzene causes cancer, especially leukemia. It also affects the central nervous system as well as the body’s hematological and immunological functions. Benzene exposure also damages the respiratory tract and lung tissue and may result in death. (CDC, 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; Kjellstrom et. al., 2002; MARC, 1991; Faiz et. al., 1990).
Polycyclic aromatic hydrocarbons: PAH enter the body through the lungs and intestines and are mutagenic and carcinogenic (CDC. 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; Kjellstrom et. al., 2002; MARC, 1991; Faiz et. al., 1990).

Aldehydes: These also enter the body through the respiratory, gastric and intestinal tracts. Exposure to aldehydes may cause irritations in the eyes, nose and throat, coughing, difficulty in breathing and nausea. Long term exposure to aldehydes may increase the risk of cancer (CDC. 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; Kjellstrom et. al., 2002; MARC, 1991; Faiz et. al., 1990).

2.2.6 Lead
Lead is absorbed into the body through the respiratory tract and the skin. Exposure to lead among children is associated with lower intelligence quotients (IQs), short-term loss of memory, visual motor function impairment, hyperactivity, and slowed reflex. Exposure of pregnant women to lead may cause similar problems as above to newborns. Other effects of lead exposure among adults are increased incidence of high blood pressure. Exposure to lead among male adults is also associated with low sperm count. (CDC. 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; Kjellstrom et. al., 2002; MARC, 1991; Faiz et. al., 1990).

2.2.7 Ozone
O3 is a significant component of urban smog. The precursors of O3 are HC and NOx, exposure to which may cause diverse health problems. People most at risk from breathing air containing O3 include people with asthma, children, older adults, and people who are active outdoors. When
inhaled, O3 can cause the muscles in the airways to constrict, trapping air in the alveoli. This can cause shortness of breath and pain when taking a deep breath. It may also cause irritations leading to coughs and sore or scratchy throat. O3 can also cause inflammation of the airways and aggravate lung diseases such as asthma, emphysema, chronic bronchitis and chronic obstructive pulmonary disease (CDC. 2014; USEPA, 2014; WHO, 2014; Bailey 2011; Kampa, 2007; MARC, 1991; Faiz, et.al., 1990).

2.3 Environmental Effects of Vehicular Air Pollutants
Pollutants in vehicular emissions not only pose grave health risks but also impact the environment in many ways as described below.

2.3.1 Acid Rain
Acid rain contains nitric and sulfuric acids that result from NOx and Sox emitted during in the process of combusting fossil fuels. Acid rain causes damage to vegetation, acidifies soils and water bodies and accelerates the decay of heritage structures such as buildings, statues and sculptures (Gurjar et. al., 2010; USEPA, 2014; MassDEP, 2014).

2.3.2 Eutrophication
Eutrophication occurs when high nutrient concentrations in a water body stimulate algae blooms. This condition depletes oxygen in the water body and results in fish deaths as well as loss of other fauna and flora. Whereas eutrophication occurs naturally as a result of decaying matter in water bodies, it may be accelerated by human activities that add nutrients in aquatic environments. NOx in vehicle emissions increases the amount of nitrogen entering water bodies (Gurjar et. al., 2010; USEPA, 2014; MassDEP, 2014).
Awange and Obera (2007) in their study of the impacts of motor vehicles on the Kenya’s lakeside city of Kisumu concluded that pollutants from motor vehicle emissions were threatening the air quality of Kisumu and by extension the waters of Lake Victoria.

2.3.3 Haze
Haze is the resultant obscuration of visibility when sunlight is blocked by particulate matter resulting in distorted appearance of objects in terms of clarity, colour and form. PM, NOx and Sox associated with motor vehicle emissions are major causes of haze (Gurjar et. al., 2010; USEPA, 2014; MassDEP, 2014).

2.3.4 Effects on wildlife
Animals, just like human beings, may be adversely affected if exposed to air pollutants from vehicular and other sources. Effects may include ill health as well as reproductive and birth defects. Aquatic living organisms are especially sensitive to persistent organic pollutants that may occur in air pollutants (Gurjar et. al., 2010; USEPA, 2014; MassDEP, 2014).

2.3.5 Damage to vegetation
Tropospheric ozone affects vegetation in many ways. For example, it reduces crop and forest yields through inhibited growth as well as increased susceptibility to diseases, pests and extreme weather conditions. Thus, air pollution is a direct threat to food security in many developing countries (Gurjar et. al., 2010; USEPA, 2014; MassDEP, 2014).
2.3.6 Climate Change
Motor vehicles significantly contribute to anthropogenic CO$_2$ emissions. CO$_2$ is a greenhouse gas that contributes to global warming hence climate change. Climate changes modify natural systems in ways that endanger the very existence of many fragile ecosystems and the security of human populations depending on them (Gurjar et. al., 2010; USEPA, 2014; MassDEP, 2014).

2.4 Policy, Institutional, Legal and Regulatory Framework for Abatement of Vehicular Emissions
Whereas most countries have various forms of policies, laws and institutional arrangements for controlling pollutants from motor vehicle emissions, the efficacy of these interventions is wanting in most cases (Plaut, 1998). Previous work nevertheless shows that policies that integrate various approaches such as economic incentives and mandatory requirements efficiently reduce pollution (West, 2004).

Harish (2012) conducted a study on the status of air pollution in Bangalore City, India. His conclusion was that motor vehicles were the major source of air pollution in the city. He proposed stringent traffic regulations, efficient public transportation systems and public awareness as the means to dealing with the problem.

Scorgie, et.al, (2003) in their report on the air quality management policy for Johannesburg City recommended pollution prevention approaches through integrated development planning as opposed to end of pipe air pollution control as the best way for assuring clean air in the city.
Kenya’s capital city, Nairobi, is in many ways similar to other cities of the developing world such as Bangalore and Johannesburg. With a population growth rate of 4.8% per annum, Nairobi’s population grew from 2.1 million in 1999 to 3.1 million in 2009. Its population density is 4,515 persons per sq. km (KNBS, 2012).

In terms of motor vehicle population, Nairobi is estimated to be home to 30% of the total national vehicle population (Omwenga, 2011). According to the Kenya National Bureau of Statistics, Kenya had 1,789,789, registered vehicles in 2012. (Table 1) (KNBS, 2014).

Table 1: Registered vehicles in Kenya 2008-2012

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Cars</td>
<td>450,137</td>
<td>499,679</td>
<td>553,397</td>
<td>591,958</td>
<td>644,805</td>
</tr>
<tr>
<td>Utilities, Panels Vans, Pick-ups, etc</td>
<td>209,628</td>
<td>219,901</td>
<td>226,876</td>
<td>234,427</td>
<td>242,372</td>
</tr>
<tr>
<td>Lorries, Trucks and Heavy Vans</td>
<td>81,285</td>
<td>91,431</td>
<td>96,355</td>
<td>100,190</td>
<td>108,001</td>
</tr>
<tr>
<td>Buses and Mini-buses</td>
<td>61,886</td>
<td>84,844</td>
<td>89,708</td>
<td>91,627</td>
<td>93,343</td>
</tr>
<tr>
<td>Motor and Auto cycles</td>
<td>130,307</td>
<td>252,960</td>
<td>371,747</td>
<td>514,241</td>
<td>610,058</td>
</tr>
<tr>
<td>Trailers</td>
<td>43,485</td>
<td>27,039</td>
<td>29,418</td>
<td>32,002</td>
<td>35,763</td>
</tr>
<tr>
<td>Other motor vehicles*</td>
<td>32,710</td>
<td>45,229</td>
<td>50,038</td>
<td>52,310</td>
<td>55,449</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,009,438</td>
<td>1,221,083</td>
<td>1,417,539</td>
<td>1,616,745</td>
<td>1,789,789</td>
</tr>
</tbody>
</table>


In 2013 a total of 222,178 new vehicle registrations were recorded (Table 2) (KNBS, 2014). Thus, Kenya had a total of 2,011,967 registered vehicles as at the end of 2013, rising from 1,009,438 in 2008. This translates to a national vehicle population growth rate of 20% per annum.
Table 2: New Registration of Road Motor Vehicles in Kenya 2010 – 2013

<table>
<thead>
<tr>
<th>Type of Vehicle</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saloon Cars</td>
<td>16,165</td>
<td>11,026</td>
<td>12,985</td>
<td>16,343</td>
</tr>
<tr>
<td>Station Wagons</td>
<td>37,553</td>
<td>31,199</td>
<td>39,862</td>
<td>48,662</td>
</tr>
<tr>
<td>Panel Vans, Pick-ups, etc</td>
<td>6,975</td>
<td>7,442</td>
<td>7,945</td>
<td>9,819</td>
</tr>
<tr>
<td>Lorries/Trucks</td>
<td>4,924</td>
<td>5,247</td>
<td>7,821</td>
<td>9,570</td>
</tr>
<tr>
<td>Buses and Coaches</td>
<td>1,264</td>
<td>1,662</td>
<td>1,638</td>
<td>2,062</td>
</tr>
<tr>
<td>Mini Buses/Matatu</td>
<td>3,600</td>
<td>451</td>
<td>78</td>
<td>235</td>
</tr>
<tr>
<td>Trailers</td>
<td>2,379</td>
<td>2,556</td>
<td>3,761</td>
<td>3,973</td>
</tr>
<tr>
<td>Wheeled Tractors</td>
<td>1,161</td>
<td>1,179</td>
<td>1,386</td>
<td>1,902</td>
</tr>
<tr>
<td>Motor and Auto Cycles</td>
<td>117,266</td>
<td>140,215</td>
<td>93,970</td>
<td>125,058</td>
</tr>
<tr>
<td>Three Wheelers</td>
<td>1,521</td>
<td>2,140</td>
<td>1,845</td>
<td>3,103</td>
</tr>
<tr>
<td>Other vehicles</td>
<td>3,648</td>
<td>2,724</td>
<td>1,753</td>
<td>1,451</td>
</tr>
<tr>
<td><strong>Total Units Registered</strong></td>
<td><strong>196,456</strong></td>
<td><strong>205,841</strong></td>
<td><strong>173,044</strong></td>
<td><strong>222,178</strong></td>
</tr>
</tbody>
</table>


The sharp increase in Kenya’s middle class is mainly responsible for the rise in private car ownership and use in the wake of deteriorating public transport services (GoK, 2010). Majority of Kenya’s new vehicle registrations are used vehicle imports from Japan (Kinney et. al., 2011).

Air Quality Monitoring (AQM) is not continuously performed in Kenya and there is no national air quality inventory in place. Some ad hoc monitoring is performed sporadically by organizations such as the Kenya Meteorological Department (KMD), Kenya Medical Research Institute (KEMRI), Ministry of Transport and the universities. It is therefore very difficult to find comprehensive air quality monitoring data for Kenya (Schwela, 2007).

However, the little information available on motor vehicle related air pollution in Kenya revolves around the city of Nairobi, and points to high pollutant emission levels. Some of these studies
have pointed to motor vehicles emissions as the significant contributor to the city’s declining air quality. For example, the high PM$_{2.5}$ and NOx concentrations in Nairobi’s air are strongly correlated to motor vehicles density (Gaita et al., 2014; Kinney et al., 2011; Odhiambo et al., 2010; van Vliet et al., 2009; Schwela, 2007; Awange & Obera, 2007; van Vliet and Kinney, 2007 and 2006; Maina, 2004; Mulaku and Kariuki, 2001; Karue et al., 1992).

Awange and Obera (2007) who studied the impacts of motor vehicles on Kenya’s lakeside city of Kisumu also concluded that pollutants from motor vehicles emissions were threatening not only Kisumu’s air but also the waters of Lake Victoria, hence the need for sound policy, legal and institutional interventions.

Kamau (2011) states that whereas air pollution was previously a limited and localized problem in many cases, today it has become a major environmental problem especially in Kenya’s big cities and towns like Nairobi, Mombasa, Kisumu and Nakuru. He attributes the situation mainly to industrial expansion and vehicular traffic that is characteristic of the environments of major towns.

A projection by JICA (2006) estimated that in a business as usual scenario, the average vehicle travel speed in Nairobi would decrease from 35 km/h in 2004 to 11 km/h in 2025 due to increased vehicle populations, a situation that would worsen the city’s air quality.

Schwela (2007) opines that the capacity and capability to assess and manage air pollution in Kenya is generally undeveloped due to policy gaps and resource challenges. In addition to this, Kenya’s Energy Regulatory Commission (ERC, 2014) and UNEP (2014) have acknowledged
that there are fundamental limitations and weaknesses in implementation of existing policies, laws and standards. This situation hampers the achievement of the intended impact of the existing measures for the abatement of vehicular air pollution.

All the above factors put together call for a sound governance framework for vehicular air pollution abatement in Kenya. This would entail not only policy, legal, regulatory and institutional interventions but also effective enforcement strategies (UNEP, 2014; Kinney, et.al, 2011; Odhiambo et.al, 2010; Schwella, 2007; Gatari, 2006; JICA, 2006)

2.5 Vehicle Characteristics, Road Conditions and Emissions
Vehicle characteristics such as weight, age and load have a direct impact on fuel combustion, along with its aerodynamics and the friction between its parts. The heavier the vehicle the less efficient its fuel combustion is, hence more emissions. In addition, an older vehicle tends to consume more fuel as its parts and engine become less efficient. Improvements in vehicle technology such as introducing catalytic converters have significantly reduced CO, CO₂, and HC emissions but have increased NOₓ emissions (USEPA, 2014). At the same time, many urban roads are characterized by traffic congestion. These conditions do not allow optimal travel speeds thereby raising fuel combustion and emission levels (Anderson, 1995).

In Kenya, the standards for importation of used motor vehicles (KS 1515:2000) limits the age of such cars to a maximum of 8 years from the date of manufacture. This limit is not only meant to ensure mechanical soundness and roadworthiness but also environmental compliance with emission standards.
2.6 Research Gaps
The are two main research gaps revealed by this literature review, namely:

i. There is no study that has critically reviewed the existing policies, laws, regulations, standards to determine their appropriateness for controlling vehicular air pollution in Kenya; and,

ii. There is no study that has comprehensively analyzed the implementation challenges of the existing policies, laws, regulations and standards for the abatement of vehicular air pollution in Kenya.

This study, therefore, sought to bridge the above research gaps.

2.7 Theoretical Framework
This study applied the institutional theory as the basis for coming up with appropriate policy measures for the control of air pollution associated with vehicle emissions. According to this theory, public policy emanates from and is granted legitimacy by governmental institutions. Thus, government institutions are the ones responsible for formulation and implementation of policies, including enforcement thereof where necessary (Scott, 2004).

Scott (2004) identified the three pillars of the institutional theory as as regulative, normative, and cultural-cognitive. The regulative pillar revolves around laws and regulations that require some enforcement to achieve compliance. The normative pillar on its part is prescriptive in terms of specifying behaviours that is right and expected. The cultural-cognitive pillar on the other hand revolves around entrenched and shared beliefs and practices by communities.
The institutional theory is relevant to this study to the extent that the policy direction relating to abatement of air pollution from vehicle emissions in Kenya is mainly government driven. The regulatory pillar is applicable in the formulation of the necessary instruments for policy implementation such as laws, regulations, standards and guidelines. The government also establishes the relevant institutions to implement these instruments and mandates them with legal tools and mechanisms to enforce compliance where necessary. The normative pillar goes hand in hand with the regulatory pillar to the extent that the laws, regulations, standards and guidelines developed by the government prescribe required behaviour. Finally, the cultural-cognitive pillar is relevant in determining whether those targeted by the regulations are willing to change their entrenched behaviours and practices in order to comply with the laws, regulations and standards for controlling vehicular emissions.

2.8 Conceptual Framework

This study adopted the Environmental Management Cycle model (INECE, 2009) as the conceptual framework for understanding the context of the existing governance framework for abatement of vehicular air pollution in Kenya. The Environmental Management Cycle is a model that can be applied to address diverse environmental problems in any society. The model is premised on the idea that the choice of effective responses to an environmental problem must be planned and implemented strategically. Behavior change is central to the Environmental Management Cycle. This implies that harmful environmental practices must be replaced by sustainable ones in order to achieve a given set of environmental goals. Figure 1 below is a diagrammatic representation of the cycle.
This model begins with societal agreement that there is an environmental problem that requires a response. Such agreement is followed up with planning on the best way to tackle the problem. Using this approach in the context of Nairobi’s vehicular air pollution problem, the starting point for a sustainable solution should be an overall awareness and acknowledgement by all stakeholders that indeed emissions from motor vehicles are causing air pollution in the city. Once that acknowledgement exists then strategic goals must be set through a planning process.

The next step in the cycle is to select an appropriate management response or combination of responses that will help in achieving the desired change. These responses may require voluntary or mandatory compliance, while others may impose economic sanctions or grant rewards for compliance. Enforcement is a critical component for the success of mandatory approaches.
Program evaluation is a key component of the cycle so as to find out whether the chosen responses are achieving the desired goals. Feedback from the evaluation leads to better planning and implementation. If the intended results are not being achieved, an evaluation of all the steps of the cycle should reveal where the problem is so that appropriate remedial measures may be taken.

This cycle is applicable in the current study to evaluate the existing responses towards abating pollution from vehicular sources in Kenya. By applying this model, it will be possible to establish whether existing responses are effective, and if not, where the problem is.
CHAPTER THREE

3.0 MATERIALS AND METHODS

This Chapter outlines the study area, research design, target population, sampling technique and data collection methods, data analysis and presentation.

3.1 Study Area

The study was conducted in Kenya’s capital city, Nairobi. The choice of Nairobi was because it is not only the largest city in Kenya but also has the highest human and vehicle populations among Kenya’s cities. Figure 2 below shows the land use map of Nairobi.

Figure 2  Nairobi land use Map (Adapted from World Resources Institute, 2013)
3.1.1 Location

Nairobi city is located 140 kilometers below the Equator at coordinates 1°16'South and 36°48' East. The city is at an altitude of 1,680 meters above sea level. The city’s land mass is 691.5 sq. km.

3.1.2 Climate

Nairobi has a moderate climate tempered by its high elevation. The warm seasons are between November and February with temperatures being around 25°C. The cold season is usually between June and August when the temperature can drop to 10°C. Nairobi receives mean annual rainfall of 875mm (KNBS, 2012; Omwenga, 2011; Mitullah, 2003).

3.1.3 Population

Nairobi’s population grew at the rate of 4.8% per annum between 1999 and 2009. As per the last census in 2009, the city’s population stood at 3.1 million, rising from 2.1 million in 1999. The city’s population density is 4,515 persons per sq. km (KNBS, 2012).

3.1.4 Vehicle Population

Nairobi is estimated to accommodate 30% of the total national vehicle population (Omwenga, 2011). Kenya had 2,011,967 registered vehicles in 2013, rising from 1,009,438 in 2008. This translates to a national vehicle population growth rate of 19.9% per annum (KNBS, 2014). Based on the estimates, Nairobi City alone was home to approximately 603,590 motor vehicle units at the end of 2013.
3.2 Research Design
A case study research design was used for the study. Whereas the overall inquiry related to the governance framework for vehicular air pollution abatement in Kenya, a case study of Nairobi was chosen so as to allow for an in-depth inquiry into the research problem by narrowing down the broader Kenyan scenario to Nairobi city. This approach helped to bring out a better understanding of an otherwise complex issue through detailed contextual analysis.

3.3 Target Population
The target population comprised of the residents of the city of Nairobi and key informants in governmental agencies in charge of various regulatory elements regarding vehicular air pollution control and/or the motor transport including policy makers and implementers such as government ministries, agencies and departments, as well as residents of the City of Nairobi. The key informants were from the following governmental agencies: Ministry of Transport and Infrastructure; National Environment Management Authority (NEMA); National Transport and Safety Authority (NTSA); Energy Regulatory Commission (ERC); Kenya Bureau of Standards (KEBS) and the Traffic Police Department of the Kenya Police Service.

3.4 Sampling Technique
For the key informants in government agencies and departments, the study employed the purposive sampling technique. Key informants on whom a semi-structured interview was administered were identified from KEBS, NEMA, NTSA, ERC, Kenya Police Service and Ministry of Transport &Infrastructure. The unique characteristic of this group was that they are officers of governmental agencies that are involved in one way or another in vehicular air pollution control and/or the motor transport sector regulation in Kenya.
For the residents of Nairobi on whom the questionnaire was administered, the respondents were selected through stratified random sampling based on the age of respondents (18 years old and above) and length of residence in Nairobi (1 year and above). This was aimed at ensuring that respondents have interacted with the problem of vehicular emissions in a Kenyan urban setting, in this case Nairobi city. The study made use of the Raosoft® Sample Size Calculator to come up with an ideal sample size. With Nairobi’s population assumed to be about 5 million, and working within a margin of error of 5%, confidence level of 95% and a response level of at least 50%, the selected sample size was 267 respondents. These respondents were picked randomly on a first encounter basis. Out of the 267 respondents, 163, representing 61% of the total sample, responded. The spatial distribution of the respondents covered the entire Nairobi city divided geographically into Eastlands, Westlands, Southlands and the Central Business District.

The Raosoft® Sample Size Calculator used to determine sample size is based on the normal distribution and assumes that there are more than 30 samples. The formula applied for determining the sample size $n$ in this calculator is given below:

$$n = \left( \frac{Z\sigma}{E} \right)^2$$

Where $Z$ is the value from the normal distribution representing the confidence level, $\sigma$ is the standard deviation of the outcome variable and $E$ is the desired margin of error. The formula above generates the minimum sample size needed to ensure that the margin of error in the confidence interval for $\mu$ does not exceed $E$. 

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3.5 Data Collection Methods
This study used a variety of methods and instruments including relevant document review and analysis, semi-structured interviews and questionnaires to collect data. The data collected through the various methods was triangulated to ensure that the validity of conclusions is enhanced. The various data collection methods are discussed below in relation to each of the research questions:-

To answer the question “Which policies, laws, regulations and standards are in place for vehicular air pollution abatement in Kenya?” the following data collection methods were used:

a) Document review and analysis

Several documents were reviewed and analyzed including the Constitution of Kenya, government policy documents, Acts of Parliament, subsidiary legislation, books, reports, academic work, journals, and periodicals.

b) Semi-structured interviews

These consisted of a series of questions designed to elicit specific answers on the part of key informants in governmental agencies in charge of vehicular air pollution abatement or motor transport regulation and included: National Environment Management Authority (NEMA), National Transport and Safety Authority (NTSA), Kenya Police (Traffic Department), Kenya Bureau of Standards (KEBS), Energy Regulatory Commission (ERC) and Ministry of Transport and Infrastructure. The semi structured interview is annexed as Appendix 2.

c) Questionnaire

A questionnaire was administered on 267 residents of Nairobi city sampled on the basis of the technique described in 3.4 above. The questionnaire is annexed hereto as Appendix 3.
To answer the question “What are the implementation challenges of the existing policies, laws, regulations and standards for vehicular air pollution abatement in Kenya?” the following data collection methods were used:

a) Document review and analysis

Several documents were reviewed and analyzed including the Constitution of Kenya, government policy documents, Acts of Parliament, subsidiary legislation, books, reports, academic work, journals, and periodicals.

b) Semi-structured interviews

These consisted of a series of questions designed to elicit specific answers on the part of key informants in government agencies that are responsible for vehicular air quality monitoring, pollution control or motor transport regulation and included: National Environment Management Authority (NEMA), National Transport and Safety Authority (NTSA); Kenya Police (Traffic Department); Kenya Bureau of Standards (KEBS), Energy Regulatory Commission (ERC) and Ministry of Transport and Infrastructure. The semi structured interview is annexed as Appendix 2.

c) Questionnaire

A questionnaire was administered on 267 residents of Nairobi city sampled on the basis of the technique described in 3.4 above. The questionnaire is annexed hereto as Appendix 3.
3.6 Data Analysis and Presentation

For the qualitative data, analysis involved synthesizing the information obtained from the document reviews and key informant interviews using content analysis approach into a coherent description of the findings for each research question. The results of the qualitative analysis are presented textually.

For the quantitative data obtained through the questionnaires, there was a data entry process using MS Excel by focusing on the research questions and variables of interest from the collected data. The data was entered in excel spreadsheets in a format that would facilitate easy analysis bearing in mind the research questions. After data entry, the next process involved data cleaning. This is the process of detecting, diagnosing, and editing faulty data as well as dealing with data gaps and inconsistencies. The steps for data cleaning involved: creating a backup copy of the original data in a separate workbook, ensuring that the data was in a tabular format of rows and columns with similar data in each column, ensuring all columns and rows were visible and that there were no blank rows within the range.

Finally, the data analysis involved sorting excel data on either one column or multiple columns. Conditional formatting in excel made it possible to highlight cells with a certain color, depending on the cell's value. What-If Analysis in Excel allowed for the trying out of different values (scenarios) with the given data. At the end of the analysis it was possible to generate and present the results of the analysis in both charts and tables.
CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This Chapter presents the results of the study and discussion based on the research objectives.

4.1 Policies, Laws, Regulations, Standards and Institutional arrangements for Vehicular Air Pollution Abatement in Kenya

The study established that there are several policies, laws, regulations and standards with matching institutional arrangements for controlling vehicular air pollution in Kenya. These are discussed below:

4.1.1 Policies

a) *Sessional Paper No. 6 of 1999 on Environment and Development*

Sessional Paper No. 6 of 1999 on Environment and Development (GoK, 1999) was passed by the Government of Kenya through the then Ministry of Environmental Conservation as a policy in response to the increasing concerns regarding the effects of development and population growth on the environment. The sessional paper aims at achieving sustainability by integrating environmental concerns into national development programmes.

The study established that the Sessional Paper identifies the major sources of air pollution in Kenya as being domestic cooking and heating, electric power generation, industrial and vehicle fuel consumption and emissions. In order to effectively manage air pollution from the diverse sources, the Sessional Paper commits the government to undertake several actions including formulating a comprehensive policy on the management of air pollution, establishing emission
standards and regulations for gaseous emissions and particulate matter, and, strengthening research and monitoring capacity for managing air quality.

Despite the ambitious provisions in the Sessional Paper as outlined above, the study established that there is so far no comprehensive policy on the management of air pollution as envisaged, and that the research and monitoring capacity for managing air pollution is still very weak. However, there are in place air quality regulations and standards set up under the Environmental Management and Co-ordination Act (EMCA, No. 8 of 1999) but with many implementation and enforcement challenges as discussed later in this Chapter.

b) Integrated National Transport Policy, 2009

The Integrated National Transport Policy was passed by the Government of Kenya in 2009. This study established that the Policy recognizes environmental protection as critical in the development transport infrastructure. The Policy singles out emissions by road motor vehicles as one of the prominent issues that require redress. The study established that the Ministry of Transport and Infrastructure incorporates environmental impact assessment (EIA) in road infrastructure planning and development in order to minimize vehicle emissions.

Another important element of the policy is the recognition and promotion of various forms of Non-Motorized Transport (NMT) infrastructure including pedestrian walk-ways and cycling lanes. However, this study established that although various forms of NMT are already in use in several parts of Nairobi, their incorporation into the formal road transport network has been very slow. As such, most major roads in Nairobi do not have proper pedestrian walk-ways and bicycle lanes.
Regarding traffic demand and flow management, the policy promotes sustainable land use planning and spatial development for road transport. The policy recognizes that one of the reasons for traffic congestion in urban areas is improper land use and physical planning. In this respect, the policy promotes integrated planning of infrastructure and land use. In addition, the policy promotes the introduction of high capacity buses on dedicated lanes for urban public transport. However, this study established that these ambitious policy proposals still remain a pipe dream as there is no implementation on the ground.

4.1.2 Laws, Regulations, Standards and Institutional Arrangements
The study established that there are several legislative interventions in place in the form of laws, regulations and standards that address vehicular air pollution in Kenya with designated implementing institutions as discussed below:

a) Constitution of Kenya, 2010

Article 42 of the Constitution of Kenya guarantees all persons the right to a clean and healthy environment. Article 69 sets out the obligations of the state in respect of the environment which include, inter alia, to ensure sustainable exploitation and utilization of the environment and natural resources, and to control activities that are likely to endanger the environment.

Regarding the responsibility towards vehicular emissions, the Fourth Schedule of the Constitution gives county governments the function of controlling air pollution within their respective jurisdictions.

This study found that the implementation of the above constitutional provisions especially as relates to the control of vehicular air pollution is wanting. Many county governments including
that of Nairobi County are yet to put in place measures to control air pollution from different sources.

\[ b) \] **Environmental Management and Co-ordination Act (EMCA, No. 8 of 1999)**

The Environmental Management and Co-ordination Act (EMCA) 1999 is Kenya’s overarching law for sound management of all matters relating to the environment. EMCA establishes the National Environment Management Authority (NEMA) as the principal agency for implementation of all government policies on the environment. The study established that NEMA, in fulfillment of its mandate, has established the Air Quality Unit within its Compliance & Enforcement Department to coordinate and supervise all matters relating to air quality and vehicular emissions.

Under the provisions of section 147 of EMCA, the minister for environment has power to make regulations to give effect to the provisions of the Act. The study established that the minister has exercised the powers conferred by this section of the law and put in place two regulations towards controlling emissions, namely: Environmental Management and Co-ordination (Fossil Fuel Emission Control) Regulations, Legal Notice No. 131 of 2006, and Environmental Management and Co-ordination (Air Quality) Regulations, Legal Notice No. 34 of 2014. Both regulations are intended to tackle air pollution from diverse sources including motor vehicles.

\[ c) \] **Environmental Management and Co-ordination (Fossil Fuel Emission Control) Regulations, Legal Notice No. 131 of 2006**

These regulations were made in 2006 and came into operation on 1\textsuperscript{st} February 2007. The regulations were intended to control pollutants in emissions arising from combustion of fossil fuels such as petrol, diesel and kerosene.
The regulations require NEMA in collaboration with relevant lead agencies to carry out regular emissions inspections on all mobile and stationery internal combustion engines that use fossil fuels in Kenya so as to ensure no pollutants are emitted in excess of the standards outlined in the Regulations. In addition, the Regulations grant power to NEMA to approve the use of fuel catalytic substances that reduce harmful emissions.

This study found that the regulations have never been implemented by NEMA since their coming into force due to two main reasons. Firstly, the regulations created undesirable overlaps in mandates between NEMA and other lead agencies such as KEBS and MVIU/NTSA. Secondly, the regulations did not comprehensively address all forms and sources of air pollution. These shortcomings are discussed in more detail in the section below on implementation challenges of existing policies, laws, regulations, standards and institutional arrangements.

*d) Environmental Management and Co-ordination (Air Quality) Regulations, Legal Notice No. 34 of 2014*

These regulations were made in 2014 and aim at controlling air pollution from diverse sources. The study found that the regulations have very elaborate provisions on vehicular emissions and provide limits that must not be exceeded.

The regulations require annual emission testing for all commercial and public service vehicles and bi-ennial testing for private vehicles over five years old.

According to NEMA, these regulations effectively supersede the Environmental Management
and Co-ordination (Fossil Fuel Emission Control) Regulations, Legal Notice No. 131 of 2006 (NEMA, interview on 25.06.2015) even though this is not mentioned in the latest regulations and in spite of the fact that the former regulations are still officially in the books.

In addition, the study found that implementation and enforcement of these regulations with respect to vehicular emissions is yet to start as NEMA and NTSA are still working out modalities for implementation and enforcement. Other implementation challenges are discussed in a subsequent section below.

e) Climate Change Act (No. 11 of 2016)

This Act provides for a regulatory framework for enhanced response to climate change in Kenya. It sets the foundation for the setting up of mechanisms and measures to achieve low carbon climate development. Some of the emissions from motor vehicles such as CO2 are also greenhouse gases that contribute significantly to global warming. The Climate Change Act envisages deliberate government actions to manage these emissions through national action planning.

f) National Transport and Safety Authority (NTSA) Act, No. 33 of 2012

The Act establishes the National Transport and Safety Authority (NTSA) to implement government policies in the road transport sector. NTSA registers, inspects and licenses motor vehicles. Among the conditions for licensing include requirements that the motor vehicle is maintained in a fit and serviceable condition.
This study found that NTSA’s inspection and licensing mandate is currently limited to passenger service and commercial vehicles as a result of low capacity and inadequate resources. As such, motor vehicles that are not in the above stated categories are not required to undergo any inspection unless involved in an accident. In addition, even the vehicles that are required by law to undergo inspection are only tested for mechanical roadworthiness without any emission test for compliance to emission standards. These challenges are discussed in more detail in a subsequent section below.

\textit{g) Traffic Act, (Chapter 403 Laws of Kenya)}

The Traffic Rules made under the Act prohibit the emission of visible smoke and sparks by all motor vehicles. This study found that the provisions of the Act relating to emission of visible smoke is not strictly implemented by the police due to greater focus being placed on what the police consider to be more serious traffic violations. Again, this challenge is discussed in more detail in a subsequent section below.

\textit{h) Energy Act (Chapter 314 Laws of Kenya)}

The Act establishes the Energy Regulatory Commission (ERC) as the principal agency that regulates the energy sector in Kenya. Section 95 of the Act stipulates the applicable petroleum fuel standards for Kenya. This study established that ERC is currently enforcing the relevant standards as prescribe by KEBS. These standards are discussed in more detail below.

\textit{i) Standards Act (Chapter 496 Laws of Kenya)}

The Act establishes the Kenya Bureau of Standards (KEBS) and mandates it to set standards for various sectors and activities in Kenya.
The study established that KEBS has put in place four standards that have direct and indirect bearings on vehicular emissions. These standards are outlined and described in more detail below.

**KS 1515:2000 – Code of Practice for Inspection of Road Vehicles**

This standard regulates the quality and condition of motor vehicles. It specifies general, safety and environmental requirements for motor vehicles, including inspection schedules.

The standard stipulates that all motor vehicles must be subjected to inspection by a government authorized body before importation and/or registration.

This standard caps the age limit of imported second hand motor vehicles at eight years from the date of manufacture.

On exhaust emissions, the standard prescribes limits for concentration of carbon monoxide (CO) at no more than 0.5% by volume and hydrocarbons (HC) at a maximum of 0.12% by volume.

The standard requires that all heavy duty trucks, buses, light duty vehicles including passenger cars, taxis and motorized tri-cycles should undergo periodic inspection every 12 months. It also authorizes on-road random inspections for safety and emissions.

**KS EAS 158:2012 – Automotive Gasoline (Premium Motor Spirit) Specification**

This standard applies in the entire East African Community (EAC). It stipulates specifications for gasoline and petrol.
On fuel quality, standard specifies the maximum lead level in gasoline at 13.0 g/L and maximum sulfur level at 0.015% m/m.

The standard allows additives to improve fuel performance provided there are no known harmful side effects, there is no deterioration of drivability and emission control durability is not compromised.

*KS EAS 177:2012 – Automotive Gas Oil (Automotive Diesel) Specification*

This is also an East African Community (EAC) standard. It specifies requirements and methods of sampling and testing for automotive diesel as manufactured, stored, transported and marketed.

On fuel quality, the standard specifies the maximum requirement of diesel fuels sulfur content at 50mg/kg (effective January 1, 2015), polycyclic aromatic hydrocarbons (PAH) at 11% by volume, carbon residue at 0.15% (m/m), and ash content at 0.01% (m/m).

The standard also allows additives to improve fuel performance provided there are no known harmful side effects, there is no deterioration of drivability and emission control durability is not compromised.

*KS 03-1099:1992 – Specification for Engine Oils*

This standard specifies requirements and methods of sampling and testing for lubricating oils suitable for light and heavy duty petroleum and diesel engines used in automotive and other purposes. This standard specifies maximum requirement of engine oils sulfur content as 0.05% by volume.
This study established that KEBS has over the years implemented the above standards. However, as discussed in the subsequent section below, there have been numerous challenges including advances in technology that call for review of the standards to match current trends, low institutional capacity and overlapping mandates between different government agencies.

4.2 Implementation Challenges of existing Policies, Laws, Regulations and Standards for Vehicular Air Pollution Abatement in Kenya

This study established that there are numerous challenges impeding the effective implementation of the existing policies, laws, regulations, and standards for vehicular air pollution abatement in Kenya. These are discussed in detail below:

4.2.1 Inadequacies in vehicular emission regulations and standards

Whereas there are in place various tools in the form of regulations and standards all intended towards abating vehicular emissions in Kenya as already discussed above, the study identified several inadequacies that have been an impediment to their effective implementation and enforcement as discussed in this section.

Regarding the Fossil Fuel Emission Control Regulations of 2006, NEMA indicated that it entirely put on hold implementation of the same (NEMA, interview on 25.06.2015) for several reasons including:

a) The said regulations created unhealthy overlaps and conflicts in mandates between NEMA and other lead agencies such as KEBS, NTSA and local authorities with respect issues such as fuel quality control and approval of fuel catalysts and catalytic
converters, inspection of motor vehicles, and licensing of traders/dealers in fuel products, catalysts and catalytic converters, respectively.

b) The regulations only targeted emissions from combustion of fossil fuels in internal combustion engines whereas the sources of air pollution are varied including both mobile and non-mobile sources. At the time that the regulations were gazetted by the Minister, NEMA had already embarked on a process of developing comprehensive and all inclusive air quality regulations and standards, so it was thought prudent to await the enactment of the latter.

On the Kenya standards touching on vehicular emissions, the Code of Practice for Inspection of Road Vehicles (KS 1515:2000) has been pointed out as needing urgent review for various reasons. The Kenya Bureau of Standards (KEBS, interview on 09.06.2015) states that the emissions limits provided under the standard are obsolete due to the following reasons:

a) There have been tremendous improvements in the quality of fuel being imported into Kenya since January 2015, following the implementation of new fuel quality standards. There is, therefore, an urgent need to review KS 1515:2000 to provide for tighter emission limits to match the improved fuels quality.

b) Over the years vehicle manufacturers have greatly improved vehicle technologies to ensure fuel efficiency and reduce noxious emissions yet KS 1515:2000 was adopted at a time when vehicle technologies were not as advanced as today. It is therefore important to keep the standard in tandem with technological advancements.

c) The standard limits the age of imported used motor vehicles at 8 years. Whereas this provision was meant to cater for environmental integrity as well as road safety, it has
become apparent that the older the vehicle the more polluting it is even if regularly serviced. Hence, there is need to cut back the age limit of imported used cars to a much stricter limit so as to encourage importation of newer vehicles.

The National Transport and Safety Authority (NTSA), adds its voice to the shortcomings of KS 1515:2000 by stating that this standard did not envisage the influx of three wheelers (tuk tuk) and two wheelers (motor cycles) yet this category of motor vehicles run on very basic engines (two stroke in most cases) that cannot support efficient fuel combustion hence a major source of vehicular air pollution (NTSA, interview on 15.06.2015). A review of the standard to bring the three wheelers and two wheelers under regulation so as to provide for engine standards and mandatory emission testing is therefore necessary.

Regarding KS 03-1099:1992 – Specification for Engine Oils, KEBS points out that whereas better quality of engine oils can have greater impact on the character of vehicle emissions, the current standard is too low to have any impact on emission reductions. Hence, this standard also needs a review to provide for higher quality of engine oils (KEBS, interview on 09.06.2015).

With respect to the Traffic Act, the Kenya Police Service through the Traffic Police Department have over the years implemented the provisions of the Traffic Rules that prohibit the emission of smoke and sparks by requiring that every motor vehicle be so constructed, maintained and used that no smoke or visible vapour is emitted therefrom. Many times the police have impounded heavily polluting vehicles and charged the owners and/or drivers in court for violating the rule. However, the police point out long standing frustrations with the rules because of the very lenient penalties it prescribes and which are often imposed by the courts on the violators. The Police
Service laments that these low penalties have failed to create an environment of deterrence (Kenya Police Service, interview on 10.07.2015)

Quantitative results on respondents’ perceptions about the adequacy of current policies, laws, regulations and standards as analyzed from data obtained through the questionnaire administered as part of this study seems to agree with the position that there are indeed shortcomings and inadequacies. On the question as to whether the current policies, laws, regulations and standards are adequate to curb or reduce harmful vehicle emissions in Kenya, 55% of the respondents answered in the negative whereas only 15% were affirmative, with a substantial 30% not sure about the adequacy or otherwise of the policies, laws, regulations and standards. This result is presented in Figure 3 below:
4.2.2 Inadequate institutional capacities to implement and enforce laws, regulations and standards

The study found that there are several institutions with mandates for the abatement of vehicular emissions in Kenya coupled with equally multiple institutional mandates. These institutions include various government ministries (Transport, Environment, Energy) and state agencies such as NEMA, NTSA, ERC, KEBS, National Police Service and the various county governments.

Whereas the various institutions have specific legal mandates with respect to vehicular emissions abatement, the study found that most of them have inadequate technical (equipment and know-how), financial and human resources capacities to effectively and efficiently discharge their respective mandates.

For example, NEMA, the principal government agency in charge of co-ordination of environmental management throughout the Republic of Kenya is still in the process of setting up an Air Quality Management Unit. So far the Unit has only one officer in charge of the entire Republic. In addition, the Unit lacks air quality sampling and measurement equipment due to budgetary constraints (NEMA, interview on 25.06.2015).

On its part, NTSA which has the mandate to implement the vehicle emission standards through inspections also faces similar challenges as NEMA. As at the time of this study, NTSA had only 19 motor vehicle inspection centres across the country against a national vehicle population of 2.1 million. Spread across these centres was 78 motor vehicle inspectors most of whom were not conversant with vehicle emission testing and measurement. NTSA also had only 6 vehicle emission testing equipment all located at the Likoni Road Motor Vehicle Inspection Centre. Out of the 6, only 2 were in working and/or serviceable condition while the remaining 4 were broken
down and not economically serviceable. NTSA also lacked the budget to set up more vehicle inspection centres, purchase new vehicle emission testing equipment and to train its staff on emission testing and measurement. For these reasons, NTSA did not carry out any emissions tests on motor vehicles (NTSA, interview on 15.06.2015).

The study further found that due to the institutional challenges facing the key government agencies charged with controlling vehicular emissions in Kenya, the visibility and effectiveness of these agencies is severely compromised. For example, from the analysis of the data collected for this study through questionnaires, only 36% of the respondents were aware of the existence of an agency or agencies in charge of inventorying and regulation of vehicular emissions in Kenya. This result is presented in the Figure 4 below.

![Figure 4: Level of Awareness of institutions in charge of inventory and regulation of Vehicular emissions](image-url)
4.2.3 Policentricity and poor co-ordination between various law implementing and enforcement agencies

The study found that the existence of multiple institutions with similar and sometimes overlapping mandates with respect to vehicular air pollution abatement presents the challenge of policentricity. There was apparent poor co-ordination between the various government agencies in charge of vehicular emission abatement in Kenya. For example, whereas NEMA is the overall coordinating agency on all environmental matters, there was an apparent disconnect between it and other agencies when it comes to formulation of measures for abatement of vehicle emissions. A case in point was a new plan by the Energy Regulation Commission (ERC) to formulate regulations on vehicle emissions whereas NEMA already had these in place (ERC interview on 13.07.2015; NEMA interview on 25.06.2015).

Another instance which showed lack of coordination was whereby the National Transport and Safety Authority (NTSA) insisted that it was not able to enforce emissions standards during vehicle inspections due to the absence of legally binding laws and regulations on the same (NTSA interview on 15.06.2015) whereas these standards are in place as outlined earlier in this chapter, and are also referenced in the existing regulations on air quality.

On their part, KEBS and NEMA blamed the failure to implement the regulations and standards especially regarding vehicle inspections and emission testing on the lack of technical capacity and equipment by NTSA (KEBS, interview on 09.06.2015 and NEMA, interview on 25.06.2015).
4.2.4 Low public awareness on vehicular emissions and their effects

The study found that that 77% of the total respondents were not aware of the properties and characteristics of vehicle emissions while only 23% were aware of the same. This finding is presented in Figure 5 below;

![Figure 5: Level of Awareness of the properties and characteristics of Vehicle Emissions among the total respondents.](image)

On the other hand, among those respondents who own motor vehicles, the results of the study show that there was a higher level of awareness of the properties and characteristics of vehicle emissions, being 52% with 48% being not aware as presented in Figure 6 below.
Figure 6: Level of Awareness of the Properties and characteristics of Vehicle Emissions among the respondents who own vehicles

Figure 7 below further shows that only 42% of the total respondents were aware of the impacts of vehicular emissions on the environment and human health.

Figure 7: Overall level of awareness of the impact of vehicle emissions on the environment and health

Among respondents who own motor vehicles, however, the level of awareness of impact of vehicular emissions on the environment and health was slightly higher than that of the overall respondents, standing at 53% as presented in the Figure 8 below.
4.2.5 Absence of an inventory of emissions and their sources
The study found that lack of reliable data on air pollutants and their sources was major challenge with respect to vehicular air pollution abatement. There being no comprehensive national inventory on air pollution, it was not possible to apportion the air pollutants by source and authoritatively determine what the actual contribution of motor vehicles was to that pollution. This situation is blamed not only on the multiplicity of institutions responsible for air pollution abatement but also on the lack of resources by the relevant government agencies to carry out comprehensive and continuous air quality monitoring (NEMA, interview on 25.06.2015).

4.2.6 Low priority given to vehicular emissions and inadequate incentives to encourage adoption of efficient vehicular emissions control technologies
The results of the study as presented in Figure 9 below show that 87% of the respondents to the questionnaire believed the government was not giving sufficient priority to vehicular emissions hence inadequate incentives for the adoption of efficient vehicular emission control technologies.
The above result was further given credence by the findings presented in Figure 10 below which shows that just 28% of the overall respondents had some knowledge about vehicle emission reduction technologies.
On the other hand, among the respondents who owned motor vehicles, there was a higher level of awareness of vehicle emission control technologies, standing at 40% as shown in Figure 11 below as opposed to only 28% of the overall respondents.

![Figure 11: Awareness of vehicle emission Reduction Technologies among Vehicle Owners](image)
CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

This Chapter contains the conclusions and recommendations of the study and suggestions for further research.

5.1 Conclusion

Drawing from the research findings in Chapter Four, the overall conclusion of the study is that whereas there is a multiplicity of policies, laws, regulations and standards with corresponding implementing institutions to control vehicular air pollution in Kenya, there are equally numerous implementation challenges to the existing policies, laws, regulations and standards. These challenges include: inadequacies in vehicular emissions abatement laws, regulations and standards including low penalties for violators; inadequate institutional capacities to implement and enforce laws, regulations and standards; poor co-ordination between various law enforcement agencies; inadequate public awareness of the characteristics and impacts of vehicular emissions on human health and the environment; absence of reliable emissions monitoring and inventory; and low priority given to vehicular emissions hence the lack of incentives for adoption of cleaner vehicle technologies. Because of these challenges, the levels of air pollution from vehicular emissions may continue to rise despite there being measures in place to tackle the problem.

5.2 Recommendations to policy makers and implementers

Drawing from the above conclusion, it is imperative that some actions should be taken if greater strides are to be made towards an accelerated abatement of vehicular air pollution in Kenya. Thus, the implementation challenges of the existing laws, regulations and standards need to be
tackled so that the fruits of the various efforts towards abating harmful vehicular emissions in Kenya can be realized.

To policymakers the study makes the following recommendations:

a) *Strengthen existing vehicular emissions laws, regulations and standards*

Some of the laws, regulations and standards touching on vehicular emissions have clear shortcomings as already pointed out in this chapter that have made it difficult for effective implementation and enforcement of the same. The very low penalties provided for under the Traffic Act for example need to be revised upwards to provide for more stringent penalties that can create a climate of deterrence among motor vehicle owners and operators so as to achieve greater compliance with the relevant requirements under the law (Kenya Police Service, interview on 10.07.2015)

On the part of the Fossil Fuel Emission Control Regulations, the noted shortcomings in terms of institutional mandate overlaps have been addressed by a new set of regulations, the Air Quality Regulations of 2014. Plans are now at an advanced stage to fully implement and enforce the new regulations (NEMA, interview on 25.06. 2015).

On the standards under the mandate of KEBS, it is noteworthy that the revision of the Code of Practice for Inspection of Motor Vehicles is currently ongoing. This review is meant to bring the standard up to speed with the improvements in fuel quality following the recent coming into force, in January 2015, of East African fuel standards. In addition, the revision will bring the standard up to speed with advancements in vehicle technologies (KEBS, interview on
09.06.2015). Indeed, KEBS points out that there are plans in place to also review other related standards including the one for engine oils.

b) Enhance the capacity of relevant agencies to implement and enforce vehicular emissions laws, regulations and standards

Whereas there are different governmental agencies charged with implementation and enforcement of different laws, regulations and standards touching on vehicular emissions, most of these agencies have capacity challenges ranging from funds to personnel and equipment. It is therefore important to build and/or enhance the capacity of these agencies to enable them effectively discharge their mandates.

On the part of NEMA, it is necessary to urgently put in place a functional Air Quality Unit with sufficient staff, funds and equipment. This will help in ensuring NEMA discharges its co-ordination and law enforcement mandate effectively.

For NTSA’s Motor Vehicles Inspection Unit, it is worthy to note that they hold the key to the success of any programme for implementation of laws, regulations and standards requiring testing of motor vehicles. Thus, the capacity of NTSA to carry out vehicular emissions inspections and testing needs enhancement. This is more urgent especially with the coming into force of the Environmental Management and Co-ordination (Air Quality) Regulations, 2014 which henceforth require annual inspections and emissions testing of all commercial and passenger service vehicles and bi-ennial inspections and emissions testing for all private cars over five years old.
c) **Enhance inter-agency co-ordination on vehicular emission control**

As already outlined in this chapter, management of air pollution in Kenya is a shared responsibility not only between the county government and the national government but also among various state institutions. Therefore, the success of any vehicular emissions abatement programme will to a large extent depend on co-operation between the two levels of government as well as between the various state agencies. All the players involved must co-ordinate their efforts so as create synergy towards the achievement of set health and environmental goals. Any overlaps in legal mandates must be ironed out for enhanced inter-agency co-ordination with clear demarcations on the roles and mandates of all the players involved.

*d) Create Public Awareness on the vehicular emissions and their impact on health and the environment*

Obtaining public support is key to the success of any efforts to tame the rising harmful vehicle emissions in Kenya. As already pointed out, the levels of public awareness among the Kenyan public on this subject is still very low. It is therefore necessary to put in place a robust public awareness campaign to enlighten the populace on this important issue. This will not only enlighten the public towards holding law enforcement agencies accountable but will also raise the awareness of motor vehicle owners and operators on the need to regularly service their vehicles and use the right quality of fuels so as to protect the environment and protect human health (NEMA, interview 25.06.2015, KEBS, interview 09.06.2015 and NTSA, interview 15.06, 2015).

Of particular concern in this regard is the large number of Kenyans who spend many hours daily on or near busy and traffic congested roads in major cities and towns. These include motorists, commuters, public transport crew, cyclists, pedestrians, traffic police, hawkers and other small
scale traders. This category is most exposed to the adverse health impacts of the harmful vehicular emissions (Kinney, et. al., 2011)

e) Build National Capacity for Emissions Monitoring and Inventory

The absence of a comprehensive inventory of air emissions in Kenya makes it difficult to make informed decisions towards abating pollution. The country lacks dedicated monitoring stations for urban air pollution. However, there is some ad hoc monitoring of various air pollutants being done by the Kenya Meteorological Department (KMD) and institutions of higher learning such as University of Nairobi’s Institute of Nuclear Studies. Thus, it is necessary to build the national capacity for monitoring and inventorying air emissions. This will make it possible to characterize and apportion various emissions from various sources including vehicular emissions. This in turn will be a big step towards controlling the various emissions from different sources.

f) Prioritize vehicular emissions and provide adequate incentives for adoption of cleaner vehicle technologies

Cleaner vehicle technologies to reduce harmful air emissions from combustion of fuels exist. Some of these technologies include fuel catalytic converters, hybrid and electric vehicles, among others. It is therefore necessary for the government to prioritize the control of vehicle emissions and provide incentives such as tax reductions on cleaner vehicle technologies to encourage widespread adoption of the same.
5.3 Recommendation for Further Research
For further research, it is recommended that detailed air pollution studies be carried out to
determine the actual air pollution loads by motor vehicles on Nairobi’s overall air pollution
levels, and epidemiological studies to determine the effects of this pollution in Nairobi
REFERENCES


Center for Disease Control and Prevention (2014), Respiratory Health and Air pollution

http://www.cdc.gov/healthyplaces/healthtopics/airpollution.htm (accessed on 10.06. 2014)


Faiz, A., Walsh, M., and Varma, A., (1990), Automotive Air Pollution Issues and Options for Developing Countries, Infrastructure and Urban Development Department, The World Bank, WPS 492


Gaita, S. M., J.Boman, M. J. Gatari, J. B. C. Pettersson, & S. Janhäll (2014), Source apportionment and seasonal variation of PM$_{2.5}$ in a Sub-Saharan African city: Nairobi, Kenya


GoK (2010), National Climate Change Response Strategy, Ministry of Environment and Mineral Resources


Japan International Development Cooperation (JICA) (2006), Nairobi Urban Transportation Studies (NUTRANS), Nairobi, Kenya.

Kamau, E.C., (2011), Pollution Control in Developing Countries with a Case Study of Kenya: A need for Consistent and Stable Regimes, Revista Internacional de Direito e Cidadania, n. 9, p. 29-42, fevereiro/2011

Kampa, M., & Castanas, E. (2008), Human Health Effects of Air Pollution, Environmental Pollution, Barking, Essex 151(2), 362–7

- 62 -


Massachusetts Department of Environmental Protection (MassDEP) (2014), Health & Environmental Effects of Air Pollutionwww.mass.gov/dep (accessed on 10.06. 2014)


Monitoring and Assessment Research Center (MARC), (1991), Health Implications of Averaging Times Shown, University of London, King’s College

Mulaku, G. C., & Kariuki, L. W. (2001), Mapping and Analysis of Air Pollution in Nairobi


Schwela, D., (2007), Review of Urban Air Quality in Sub-Saharan Africa Region - Air Quality Profile of SSA countries


United Nations Environment Program (UNEP), Urban Air Pollution.

http://www.unep.org/urban_environment/issues/urban_air.asp (accessed on 17.07.2014)


World Health Organization (WHO) (2014), Air Pollution,


World Health Orhanization (WHO) (2014), Burden of Disease from the Joint Effects of Household and Ambient Air Pollution for 2012,

APPENDICES

APPENDIX 1: RESEARCH DATA COLLECTION MATRIX

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Information/data set to be generated</th>
<th>Data sources</th>
<th>Data collection techniques</th>
</tr>
</thead>
</table>
| **Question 1**    | Existing policies, laws, regulations and standards for the control of vehicular air pollution in Kenya | • Acts of Parliament  
• Subsidiary legislation  
• Court decisions  
• Books, reports, academic work, journals, periodicals  
• Government Ministries and departments (key informants) | • Document review  
• Key informant interviews |
| **Question 2**    | Deficiencies and inefficiencies in the text of existing policies, laws, regulations and standards for the control of vehicular air pollution in Kenya | • Books, reports, academic work, journals, periodicals.  
• Government Ministries and departments  
• Public (citizens) | • Document review  
• Key informant interviews  
• Questionnaire |
| **Question 3**    | Recommendations for solving the deficiencies, inefficiencies and of existing policies, laws, regulations and standards for the control of vehicular air pollution in Kenya | • Books, reports, academic work, journals, periodicals.  
• Key informants  
• Public (citizens) | • Document review  
• Key informant interviews |
APPENDIX 2: KEY INFORMANT INTERVIEW GUIDE FOR GOVERNMENTAL REGULATORY AGENCIES

Preliminaries:

Institution................................................................................................................................................

Name of Officer: ............................................................Designation: .................................

Length in service/current position..............................................................................................................

Date and Time of Interview .....................................................................................................................

Venue....................................................................................................................................................

<table>
<thead>
<tr>
<th>Topic 1: Policy, Legal and Institutional arrangements</th>
<th>Topic 2: Implementation of the Policy and Legal Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the policies, laws, regulations and standards within the mandate of your institution for abatement of vehicular emissions in Kenya?</td>
<td>1. What is the implementation status of the various policies, laws, regulations and standards for vehicular air pollution abatement under your institution’s mandate?</td>
</tr>
<tr>
<td>2. Are there any implementation challenges for the policies, laws, regulations and standards within the mandate of your institution for abatement of vehicular emissions in Kenya?</td>
<td>2. Are there any implementation challenges pertaining to the policies, laws, regulations and standards for vehicular air pollution abatement under your institution’s mandate?</td>
</tr>
<tr>
<td>3. Is your institution solely responsible for the implementation/enforcement of the aforesaid policies, legal and regulatory instruments?</td>
<td></td>
</tr>
<tr>
<td>4. Are there any conflicts and/or overlaps in policies/laws/mandates between your institution and other governmental agencies with respect to abatement of vehicular air pollution in Kenya?</td>
<td></td>
</tr>
</tbody>
</table>
### Topic 3: Recommendations

1. How can the implementation challenges pertaining to the policies, laws, regulations and standards within the mandate of your institution for abatement of vehicular emissions in Kenya be addressed?

2. How can the conflicts and/or overlaps (if any) in policies/laws/mandates between your institution and other governmental agencies with respect to abatement of vehicular air pollution in Kenya be overcome?

### Topic 4: Perception of Current and Future Outlook

1. Do you think the government is doing enough to tackle the rising vehicular emissions challenge in Kenya?

2. Are there any new/upcoming initiatives on vehicular air pollution abatement that your institution is involved in?

3. How do you see the future of vehicular emissions abatement in Kenya?

4. Is there anything else you would like to say that may be helpful for my study?
APPENDIX 3: QUESTIONNAIRE FOR RESIDENTS OF NAIROBI

Instructions
This questionnaire is prepared in order to collect data required for conducting a research entitled: Analysis of the Governance Framework for Vehicular Air Pollution Abatement in Kenya: A Case Study of Nairobi City. The findings of the survey are intended to document the implementation challenges pertaining to the existing policy, legal and institutional arrangements regarding vehicular air pollution abatement in Kenya. The data collected will be used for academic purposes only.

Please note that the information you provide will be treated with utmost confidentiality. The researcher takes all necessary precautions to ensure that the information you give is used only for the intended purpose. Findings will not be linked to an individual to ensure anonymity of respondents.

Please, read and answer all the questions. Tick/ Circle/Write the answers as applicable.

Thank you.

For official use only

<table>
<thead>
<tr>
<th>Date</th>
<th>Keyed in by</th>
<th>Date keyed in</th>
</tr>
</thead>
</table>

**QUESTIONS** | **Please tick/circle/write response where applicable.**

1. Name (Optional) | ................................................................. | 1
   Gender | Male........................................................................ | 1
   | Female...................................................................... | 2

2. What is your age group? | 18 -35yrs ............................................................. | 1
   | 36-45yrs ............................................................. | 2
   | 46-55 yrs. ............................................................ | 3
   | 56 and above ....................................................... | 4

3. What is the highest level of education attained? | Primary ..................................................................... | 1
   | Secondary .................................................................. | 2
   | Diploma ..................................................................... | 3
   | Bachelor’s degree .................................................. | 4
   | Post-graduate diploma/degree/doctorate.................... | 5

4. What is your marital status? | Single ...................................................................... | 1
   | Married ..................................................................... | 2
   | Separated/ Divorced/ Widowed .................................. | 3

5. a) Are you employed? | Yes ....................................................................... | 1
   | No ......................................................................... | 2
   | Retired .................................................................... | 3
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<thead>
<tr>
<th></th>
<th>Question</th>
<th>Options</th>
<th>Number</th>
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<tbody>
<tr>
<td>b)</td>
<td>What is the nature of your employment?</td>
<td>Permanent .................................................................................................................. 1</td>
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<td></td>
<td></td>
<td>Temporary ................................................................................................................. 2</td>
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<td>Others ..................................................................................................................... 3</td>
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<td></td>
<td></td>
<td>Don’t know ............................................................................................................. 4</td>
<td></td>
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<tr>
<td>c)</td>
<td>Do you own a motor vehicle?</td>
<td>Yes .......................................................................................................................... 1</td>
<td></td>
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<td></td>
<td>No ......................................................................................................................... 2</td>
<td></td>
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<td>d)</td>
<td>How often do you drive?</td>
<td>Daily ....................................................................................................................... 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-4 times a week ................................................................................................. 2</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Less than 4 times a month .................................................................................. 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I don’t drive ....................................................................................................... 4</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>a) Are you a resident of Nairobi City?</td>
<td>Yes .......................................................................................................................... 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No ......................................................................................................................... 2</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>How long have you been resident in Nairobi City?</td>
<td>Over 5 years ......................................................................................................... 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-5 years ............................................................................................................. 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 1 year ................................................................................................. 3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>a) Are you aware of vehicle emission standards, laws and regulations in</td>
<td>Yes .......................................................................................................................... 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kenya</td>
<td>No ......................................................................................................................... 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Somehow ............................................................................................................... 3</td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Are you aware of agencies in charge of inventory and regulation of</td>
<td>Yes .......................................................................................................................... 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vehicular emissions in Kenya?</td>
<td>No ......................................................................................................................... 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Don’t know ........................................................................................................... 3</td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>How satisfied are you with current institutional capacities (financial,</td>
<td>Fully satisfied ....................................................................................................... 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>technical and human resources) to regulate vehicular emissions in</td>
<td>Satisfied ............................................................................................................... 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kenya</td>
<td>Somewhat satisfied .............................................................................................. 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dissatisfied ......................................................................................................... 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very dissatisfied .............................................................................................. 5</td>
<td></td>
</tr>
</tbody>
</table>
8. a) Are you aware of the characteristics and properties of motor vehicle emissions?
   - Yes ................................................................. 1
   - No ................................................................. 2
   - Not sure ........................................................... 3

   b) Do you know the impact of motor vehicle emissions on environment and human health?
   - Yes ................................................................. 1
   - No ................................................................. 2
   - Not sure ........................................................... 3

9. a) Are you aware of any vehicle emission reduction technologies?
   - Yes ................................................................. 1
   - No ................................................................. 2

   b) If Yes, list some the technologies you are aware of.
   - ........................................................................
   - ........................................................................
   - ........................................................................
   - ........................................................................
   - ........................................................................

   c) Do you believe in the efficiency of the above technologies in reducing vehicle emissions?
   - Yes ................................................................. 1
   - No ................................................................. 2
   - Not sure ........................................................... 3

10. Are the current policies, laws, regulations and standards adequate to curb or reduce harmful vehicle emissions in Kenya?
    - Yes ................................................................. 1
    - No ................................................................. 2
    - Not sure ........................................................... 3

11. Do you think the Government is giving enough incentives to reduce vehicular emissions?
    - Yes ................................................................. 1
    - No ................................................................. 2

Thank you for taking your time to answer this questionnaire!