UNIVERSITY OF NAIROBI

DEPARTMENT OF ENVIRONMENTAL AND BIOSYTEMS ENGINEERING

EFFECTIVENESS OF CLIMATE CHANGE ADAPTATION MEASURES IN MANUFACTURING INDUSTRIES: A CASE STUDY OF NAIROBI BOTTLERS LIMITED

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F56/82211/2012

A thesis submitted in partial fulfilment for the degree of Master of Science. Environmental and Biosystems Engineering in the department of Environmental and Biosystems Engineering in the University of Nairobi**.**

June, 2019

Declaration

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university. All sources of the information have been acknowledged.

Isaac Odhiambo Nyonje

…… …… …….

Name of Student Date Signature

This thesis has been submitted for examination with my approval as university Supervisor.

Dr Christian Thine

…… …… …….

Supervisor Date Signature

Acknowledgements

First, I would like to thank the almighty God who gave me the divine grace and seen me through this course and research project.

In the same note, I would like to express my deep gratitude to my supervisor Dr Christian Thine for his support in this thesis, his contribution, advice, guidance throughout this research.

I am greatly indebted to Nairobi Bottlers Limited (NBL) and Nairobi Meteorological Station (NMS) for support, resources and approval to do this study using their institution resources and data. In particular, I would like to mention Caroline Keror (Environment Manager) and Alex Sereti (Warehouse Manager) from NBL and of NMS for having put up with my consistent visits, calls and mails – both assisted with the data in their records.

I would also like to thank all my work colleagues at Newport Africa for their endless support and encouragement.

My sincere gratitude to the late Senior Lecturer at Maseno University Pamela Atieno Kouko for her mentoring and continuous follow up on the research progress.

Finally, I am forever grateful to my family members for their boundless effort and consistent support.

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Abstract

Manufacturing industries contribute to greenhouse gas emissions and are vulnerable to its effects. The industries are responsible for some 35% of global electricity use, 20% of CO2 emissions, and 25% of primary resource extraction. Consequently, they have a major impact on the environment and must be factored into the climate change model. While this is under consideration, the industries are also implementing some adaptation measures to cushion them against climate change. The overall objective of this study was to evaluate how the manufacturing industries have adapted to the effects of climate change using Nairobi Bottlers Limited (NBL) as a case study.

An evaluation research/study was used to achieve the objectives of the study. Secondary data from Nairobi Bottlers and Meteorological Department were utilized.

It was established that NBL employed the following adaptation measures; it increased the packaging of beverage in plastic bottles and reduced glass-bottles-packaging. It also changed the design of the plastic bottles from 22g to 18g. The company purchased efficient cooler distribution trucks and soft-starter motors and participating in annual tree-planting. A robust maintenance program for both Forklift and Trucks was also employed. A daily monitoring program was initiated to track LPG, Diesel and water consumption. A program to harvest rain water was started and the company built one million litre capacity storage tank.

The company produced on average 18706 litres of beverage daily translating to 152million litres annually. It used 150 trucks to distribute its products. A total of 15 Forklifts were used.

The values for WUR and EUR dropped within the period of study that is in the year 2009, the values were (WUR 3.8 and EUR 0.58) and they dropped to the year 2014 (WUR 2.3 and EUR - 0.41 respectively). The results of this study showed that adaptation measures can reduce on effects of climate change and improve on process efficiency of manufacturing companies.

From the positive effect seen in NBL, other companies within the city should also make use of the adaptation measure undertaken by NBL.

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List of Abbreviations

CCP	Climate Change and Pollution
CDP	Carbon Discussion Project
CO	Carbon Monoxide
EMCA	Environmental Management and Coordination Act 1999
EMS	Environment Management System an ISO 14001:2004 system
FTSE	Financial Time Stock Exchange
GAW	Global Atmospheric Watch
GHG	Greenhouse Gases
ISO	International Organization for Standardization
KADETFU	Kagera Development and Credit Revolving Fund
LPG	Liquefied Petroleum Gas
NBL	Nairobi Bottlers Limited
NEMA	National Environment Management Authority
NGO	Non-Government Organization
NMS	Nairobi Meteorological Station
NMVOC	Non-Methane Volatile Organic Carbons
PET	Polyethylene Terephthalate
SABCO	South Africa Bottling Company
SHEQ	Safety, Health, Environment and Quality
SVA	Source Vulnerability Assessment
SWPP	Source Water Protection Programme
TPM	Total Productive Maintenance
UAM –V	Variable Grid Urban Airshed Model
USA	United State of America

Chapter 1: Introduction

1.1 Background

Climate change refers to any significant change in measure of climate (such as temperature, precipitation, or wind) and lasting for an extended period (decade or longer). The classical period is three (3) decades, as defined by the World Meteorological Organization (WMO) (http://www.epa.gov/climatechange, accessed on 19th Jan 2014). The causes for climate change can be divided into two categories i.e. human and natural causes. Some of the notorious human activities include incomplete combustion of fossils fuels, such as gasoline, diesel. Natural causes of climate change include volcanic eruptions, ocean currents, earth orbital changes and solar variations. The energy sector is responsible for about three-quarter of the carbon dioxide emissions. The UN study, prepared by the Intergovernmental Panel on Climate Change (IPCC) warns that the world must cut nearly all greenhouse gas emissions by 2100 (Wong, 2009).

This study was conducted at Nairobi Bottlers Limited (NBL) located in Embakasi area of Nairobi County. NBL was selected as study model because it provides classical example of Manufacturing set up: Plant/Factory and Transport/Distribution network.

Food (Manufacturing) industries contribute to greenhouse gas emissions and are vulnerable to the effects of climate change. According to (Muok, 2010), climate change adaptation measures refers to efforts by society or ecosystems to prepare for or adjust to future climate change. These adjustments can be protective (guarding against negative impacts of climate change), or opportunistic (taking advantage of any beneficial effects of climate change. The various adaptation measures employed include altering business process and infrastructure to respond to climate change such as improved technologies, climate focusting, conducting risk assessment, training, reducing energy, water and raw material consumption, training of staff on the need to effectively deploy such measured taken (Mckinsey,2015).

On average, NBL produces about 80,000 -100,000 crates of soft drinks daily. These products are marketed in regions surrounding Nairobi, Machakos, Nakuru, Narok and Isiolo. The company produces PET (Polyethylene terephthalate) bottles from intermediate forms called “preforms”.

Fig 1.1: Sample of Preform

The key major raw materials for the Coca Cola (Nairobi Bottlers Limited) bottling process are sugar and water, both of which are dependent on the availability and amount of rainfall. Sugar and rubber are vulnerable to changes in precipitation and extreme weather condition (Acosta, 2011). With the knowledge of the dwindling and erratic rainfall, in 2010, The Coca Cola Company initiated a program known as Source Water Protection Program (SWPP) to enable each bottling plant to determine and assess all their sources of water in terms of quality and quantity, with a projection of twenty (20) years to determine whether with the current water usage, the sources of water will sustain each bottling operation.

Kenya Meteorological department (at their Head Office in Nairobi and Mount Kenya office) has been measuring, recording and monitoring the trends for surface ozone and carbon dioxide.

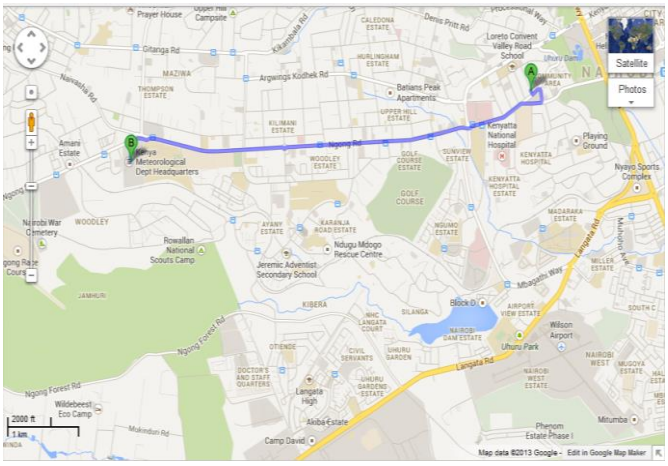


Fig 1.4 Google map - 20/08/2013 (A – Nairobi Bottlers Limited and B – Meteorological Head Office)

There also has been a concerted effort from World Bank and International Monetary Fund (IMF) for projects proposers to include risks of climate change for the project sustainability.

The study focused on the effectiveness of adaptation measures taken by Nairobi Bottlers to the effect of climate change.

1.2 Problem Statement and Justification

The manufacturing sector contributes to climate change since they draw raw material heavily from nature and being impacted by changes in temperature and precipitation.
Manufacturers companies need to be aware of the effects of climate change, and begin to prepare assets and operations for the anticipated impacts. After, knowing the effects of climate change, these companies will then need to know also the adaptation measures and their effectiveness in order to reduce environmental impacts which makes good business sense, the strategies employed will increase resilience and help to protect investor property and supply chains.

The methods that can be used to evaluate the effectiveness of adaptation measures for a manufacturing company will include review the trends or improvement in terms of raw material consumption, energy used ratio, water used ratio, waste generation ratio. Other methods employed is to consider the number and type of training offered to staff in regards to the effects of climate change, how to adapt to the climate changes and how to record key parameters and monitor changes to the identified parameters.
This study is intended to evaluate how Nairobi Bottlers Limited, one of the leading franchise operations of the Coca Cola Company in Kenya whose operations is typical to any other manufacturing industries has adapted to the effects of climate change by providing the trend of surface ozone in Nairobi over a period of years as an iceberg of the climate change and evaluating the effectiveness of the measures already adapted by the company.

This study is useful in the essence that it brings out the connection between the measures that companies have adapted to respond to the effect of climate and how to identify, record and track the effectiveness of such measures.
The methods that can be used to evaluate the effectiveness of adaptation measures for a manufacturing company include; review the trends or Improvement in terms of raw material consumption, energy used ratio, water used ratio, waste generation ratio and type of trainings offered to staff and Model on dispersion of emissions and pollutant

1.3 Objectives

The overall objective of this study was to identify climate change adaptation measures adopted by NBL, evaluate how the manufacturing industries have adapted to the effects of climate change using Nairobi Bottlers as a case study.

Specific objective included:

1. To identify climate change adaptation measures in Nairobi Bottlers between 2009 and 2013.
2. To evaluate the effectiveness of adaptation measures implemented by Nairobi Bottlers Limited to the effect of climate change.

Chapter 2: Literature Review

2.0 Introduction

The term **climate change** is often used interchangeably with that of global warming. The phrase "climate change" is growing in preference use to 'global warming' because it helps convey that there are other changes in addition to rising temperature". Normally, climate change can be viewed as the combination of various natural forces occurring over diverse timescales - the classical period being three (3) decades, as defined by the World Meteorological Organization (WMO). The term global warming is used specifically to refer to any warming of near-surface air during the past two centuries that can be traced to anthropogenic causes (Encyclopaedia Britannica).**Climate** change refers to any significant change in measure of climate (such as temperature, precipitation, or wind) lasting for an extended period (decade or longer). Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere (Muok, 2010). According to (Muok 2010), adaptation to climate change refers to efforts by society or ecosystems to prepare for or adjust to future climate change. These adjustments can be protective (guarding against negative impacts of climate change), or opportunistic (taking advantage of any beneficial effects of climate change. In contrast, **mitigation** is the avoidance of the dangerous extremes of climate change (Muok, 2010).

2.1 Drivers of climate change

Drivers of climate change would be described as any natural or human-induced factor that has direct or indirect cause on climate change. These can be classified as direct and direct drivers. Direct rivers of climate change unequivocally influences ecosystem processes and can therefore be identified and measured to different degrees of accuracy, these include habitat change, invasion species, overexploitation and pollution while indirect drivers are drivers that are operational by altering the level or rate of change of one or more direct drivers of climate change and include things such as population change, change in the economic activity, socio-political factors, cultural factors and technological factors (www.greenfactors.org/glossary)

Most important direct drivers of climate change include:

- Habitat change

- Invasion species
- Overexploitation
- Pollution

Natural and anthropogenic substances and processes that alter the Earth's energy budget are drivers of climate change. Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. These changes are expressed in terms of radiative forcing. Radiative forcing14 (RF) quantifies the change in energy fluxes caused by changes in these drivers - Radiative forcing is a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system. Positive RF leads to surface warming, negative RF leads to surface cooling. Total radiative forcing is positive, and has led to an uptake of energy by the climate system. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO2 (www.climatescience.org.au/content/365-c-drivers-climate-change, accessed on 19th Jan 2016).

Socio-economic processes, including land-use change (e.g., forestry to agriculture; agriculture to urban area) and land-cover modification (e.g., ecosystem degradation or restoration) also affect multiple system(www.ipcc.ch/publications).

Greenhouse gases trap heat and make the planet warmer. Human activities are responsible for almost all the increase in greenhouses gases in the atmosphere. It is notable that the problems relating to environment degradation, land clearance, overgrazing deforestation drought and desertification are placing more and more pressure on dwindling bioenergy resources. Although Kenya is not a net emitter of GHGs, the forest acts as carbon sink (Muok, 2010).

Greenhouse gases include:

- Carbon dioxide
- Methane
- Nitrous oxide
- Surface Ozone
- Chlorofluorocarbon (CFC)
- Hyrdochlorofluorocarbon(HCFC)

The primary sources of greenhouse gases include:

- Electricity production - 20%
- Transportation -28%
- Industry -20%
- Commercial and residential – 11%
- Agriculture -8%
- Land use and forestry – 10% (www.epa.gov, accessed on 19th Jan 2016)

The African Centre for Technology Studies seeks to expound further on linkages relating to enhancement of adaptation to the impacts of climate changes with particular focus on the use of bioenergy (Muok, 2010).It enumerates the impact of climate change to include the melting glaciers, catastrophic floods as witnessed in Pakistan and China in July/August 2010 with subsequent mudslides, loss of life and livelihood, loss of arable land, destruction of biodiversity and desertification.

Food industries contribute to greenhouse gas emissions and are vulnerable to its effects. While the mitigation measures include reducing carbon footprint, saving energy and reducing waste (Evans, 2012).

Ecosystems will also be faced with adaptation challenges. Some species will be able to migrate or change their behaviour to accommodate changes in climate. Other species may go extinct. (www.epa.gov, accessed on 19th Jan 2014).

In Kenya, knowledge of global warming is still wanting with only 56% of Kenyans having some knowledge on global warming or climate change (Pelham, 2009). Kenya government through Treasury has signed a financing agreement with World Bank for phase one of a planned KES 65.25 Billion for the Kenya Water Security and Climate Resilience Project at Treasury Building. This was done on 29th July 2013.The first beneficiary of the financing will include an irrigation scheme on the Lower Nzoia River in Siaya and Busia countries in Western Kenya.

Deal sealed

Nairobi World Bank country director Diarietou Gaye (left) with Treasury secretary Henry Rotich during the signing of financing agreement for phase one of the Kenya Water Security and Climate Resilience Project at the Treasury Building yesterday. With them is Treasury external resources department director Jackson Kinyanjui. See related story on page 20.

Fig 2.2: Business Daily, Tuesday 30th July Page 2

Climate change adaptations need to focus on reducing the impacts of both climate and non-climate factors on important sectors such as coastal areas and water resources. Development that does not recognize and include risks is not good development practice (Mataki, 2007).

2.2 Evidence of climate change

Some of the most dangerous consequences of climate change are considered as; High temperatures: The five hottest years on record have all occurred since 1997.Heat-trapping gases (Greenhouse gases such as Carbon dioxide, carbon monoxide, surface ozone etc.) emitted are warming up the planet. Changing landscapes and species extinction: Global warming is likely to be the greatest cause of species extinctions this century. If the planet warms by more than 3°C, most ecosystems will struggle (www.wwf.org.uk,accessed on 19th Jan 2016). Wildlife at risk: One-fourth of the Earth's species could be headed for extinction by 2050 due to climate change. Rising temperatures are forcing animal species to migrate to new, cooler areas in order to survive (www.nature.org).Melting Ice and Rising seas: Sea level rise from climate change could displace tens of millions of people. As the earth heats up, sea levels rise because warmer water takes up more room than colder water, a process known as thermal expansion (www.nature.org Accessed on March2016). Increased risk of drought, fire

and floods: Climate change is making floods, fires and droughts more frequent and severe. This is intensifies the circulation of water on, above and below the surface of the Earth — causing drought and floods to be more frequent, severe and widespread (www.nature.org, Accessed on March 2016).

Stronger storms and increased storm damages: Climate change will cause storms, hurricanes and tropical storms to become more intense. As sea surface temperatures rise, developing storms will contain more energy (www.nature.org) (www.ec.europa.eu , accessed on 6th March 2016). In 2003, for example, extreme heat waves caused more than 20,000 deaths in Europe and more than 1,500 deaths in India. Scientists have linked the deadly heat waves to climate change (www.nature.org, accessed on 6th March 2016).Economic loss: Between 1980 and 2011 floods affected more than 5.5 million people and caused direct economic losses of more than €90 billion (www.europa.eu, accessed on 6th March 2016).

2.3 Climate change adaptation measures

2.3.1 Climate change adaptation measures in general

In the recent years, the effect of climate change has prompted manufacturing companies to adapt to certain measures as follows: Danisco develops products that enable adaptation to water scarcity (e.g., enzymes for cold- and reduced-water textile washing) and rising energy costs (e.g., ingredients to reduce refrigeration). Unilever harvests rainwater (Wong, 2009). In 2012, for example, Cargill posted its worst quarterly earnings in two decades, in large part because of the US drought. (Mckinsey, 2015).IKEA is in the process of substituting renewables for conventional sources of energy (Mckinsey, 2015).

Diageo conducts quarterly project and business unit risk assessments that are reviewed by an audit and risk committee. It then develops and implements risk and crisis management plans accordingly. Kraft Foods, Whole Foods, and Walgreens have emergency response plans (Wong, 2009)

Coca-Cola, for example, has set for itself a strategy it describes as “me, we, the world,” which encompasses its approach to improving personal health and wellness. The beer company MillerCoors does something similar (Mckinesey, 2015).

Capacity building and technical/financial assistance is provided to key agricultural suppliers to increase yield. PepsiCo partners with the Safe Water Network to use microfinance to enable communities in Ghana and India to access water. (Wong, 2009).

Volkswagen is investing €1 billion in renewable-energy projects and is aiming to power its manufacturing sites mainly through on-site production (Mckinsey, 2015).

Investors are asking for disclosure of carbon emissions and IBM is setting rigorous greenhouse-gas-emission standards for suppliers. (Mckinsey, 2015).

2.3.2 Climate change adaptation measures in Kenya

Kenya has one of the largest manufacturing sectors in Sub-Saharan Africa, serving the local market and exporting to the Eastern and Central African region. There also has been a concerted effort from global financial institutions such as World Bank and IMF for projects proposers in Kenya to include risks of climate change for the project sustainability. This is to protect both the lenders and proposers from loss of investments.

Kenya government has in the past tried to implement adaptation measures to protect the environment through the legislation of Environment Management and Coordination Act 1999 commonly known as EMCA 1999 and specifically Controlled Substance Regulation 2007 and Waste Management Regulation 2003 which regulates ozone depleting substances and waste generation, transportation and final disposal. The draft Kenya Environment Policy in its situational analysis clause 2.4.f has recognized the adverse effect of climate change in frequent drought and water shortages that affect energy supplies. To enable companies, get relevant information on climate change and so as develop relevant adaptation measures, Kenya Meteorological department (at their Head Office in Nairobi and Mount Kenya office) has been measuring, recording and monitoring the trends for surface ozone and carbon dioxide.

Climate change has the potential of to undermine socio – economic development. The Africa region and other Least Developed Countries (LDC) are more vulnerable to climate change despite their relatively insignificant contribution to global warming (Wakhungu, 2012) The return of peace in cattle rustling-prone West Pokot and Turkana counties has seen more than 100,000 residents' embrace irrigation farming. The interest in furrow and drip irrigation follows the revival of 12 schemes, including Elliea, by the government and its agencies. The

rehabilitation of the projects will motivate farmers to venture into horticultural production and invest in drought resistant crops (Bii, 2013).

2.3.3 Studies on effectiveness of climate change adaptation measures

The Coca Cola Company that depend on water (rainfall) and Sugar (rainfall), floods affect its distribution network and also its fleet has impact on the environment through release of carbon monoxide and thermal effect to the environment, with the knowledge of the dwindling and erratic rainfall, in 2010, The Coca Cola Company initiated a program known as Source Water Protection Program (SWPP) which involved also Source Vulnerability Assessment (SVA) to enable each bottling plant to determine and assess all their sources of water in terms of quality and quantity, with a projection of twenty (20) years to determine whether with the current water usage, the sources of water will sustain each bottling operation. After obtaining the findings, each bottling plant was required to put in mitigation measure to the findings. This is known as the environment sustainability policy.

The UN study, prepared by the Intergovernmental Panel on Climate Change (IPCC) warned that the world must cut nearly all greenhouse gas emissions by 2100 in order to head off the worst effects of climate change. U.N. Secretary General Ban Ki-moon urged world leaders to act, saying that "the science is unambiguous" (Wong, 2009).

Food (Manufacturing) industries contribute to greenhouse gas emissions and are vulnerable to its effects. Thus adaptation to climate change is necessary to protect the food chain and the nation's food security today and in the future (Evans, 2012).Businesses are adapting to climate change by protecting assets, collecting weather information, calculating the cost of weather events, strategic decisions to change certain type of crops and diversification of crop production.

2.3.4 Studies on emissions from manufacturing companies

Carbon dioxide is the undoubtable the most important Greenhouse gas in the atmosphere. Surface Ozone which also has a short atmospheric lifetime is a potent greenhouse gas. Chemical reactions create ozone from emission of nitrous oxide and volatile organic compounds, from automobiles, power plants and other industrial and commercial sources in the presences of sunlight.

The factors that determine adaptation to climate change effects and thus contributing to manufacturing companies adapting to the effects of climate change include:

2.4 Operations of Nairobi Bottlers Limited (NBL) to the effect of climate change

NBL having faced challenges of the effects of climate change in its operations incorporated the following adaptation measures onto its daily operation activities.

- It increased the packaging of beverage in plastic bottles (by installing two Krones Machines - Plastic filling lines) and reduced glass-bottles-packaging. This reduced water used to clean the recycled glass bottles.
- It also changed the design of the plastic bottles from 22g to 18g thus reducing the amount of LPG and Diesel used to distribute the products.
- Within the period of study, the company purchased efficient cooler distribution trucks to reduce fuel consumption and environment pollution.
- Soft-starter motors were bought and installed to reduce electricity consumption.
- Nairobi has been participating in annual tree-planting exercise in Ngong hills in conjunction with companies such as Kenya Airways. Where an average 400,000 seedlings were planted to improvement rain catchment
- The company built one million litre capacity storage tank to improve its storage capacity to cushion against unsteady supply of water from Nairobi Water and Sewerage Company.
- A program to harvest rain water was started, in order to reduce fluctuation of water from Nairobi Water and Sewerage Company, rain water is soft and this could be mixed with borehole water
- A robust maintenance program for both Forklift and Trucks was also employed. This reduced fuel consumption and less pollution to the environment.
- A team of staff was selected and trained on the effect of climate change as a capacity building through what is in known as Source Water Protection Program
- A daily monitoring program and team was initiated to track LPG, Diesel and water consumption (this was through management strategy such Operation Excellence and TPM (Total Productive Maintenance).
- It also engaged all the stakeholders involved in protecting water catchment area around Athi Water Catchment Basin.
- The company (NBL) implemented and was certified the following ISO certifications as a mean of maintain operation efficiency and protecting the environment;

- ISO 9001: 2008 for quality management system
- IS0 14000:2004 Environmental management system

Fig 2: Production line - 20/08/2013

Incomplete combustion of diesel leads to release of carbon monoxide to the atmosphere. The general equation for diesel combustion is given below.

$$4C_{12}H_{23} + 71O_2 \rightarrow 48CO_2 + 46H_2O \quad (1.1)$$

where C is Carbon, H is Hydrogen and O is oxygen atoms

Within the company operation, Liquefied Petroleum Gas (LPG) is used by Forklift to move empty and filled crates. The common compositions of LPG contain 60% volume Propane and 40% volume butane. Gases pollutants such as Nitrogen Oxide (NO_X), Carbon monoxide (CO) and organic compounds are produced during combustion of LPG. 99.5% of LPG is converted to Carbon dioxide and 0.5% converted to Carbon monoxide during complete combustion

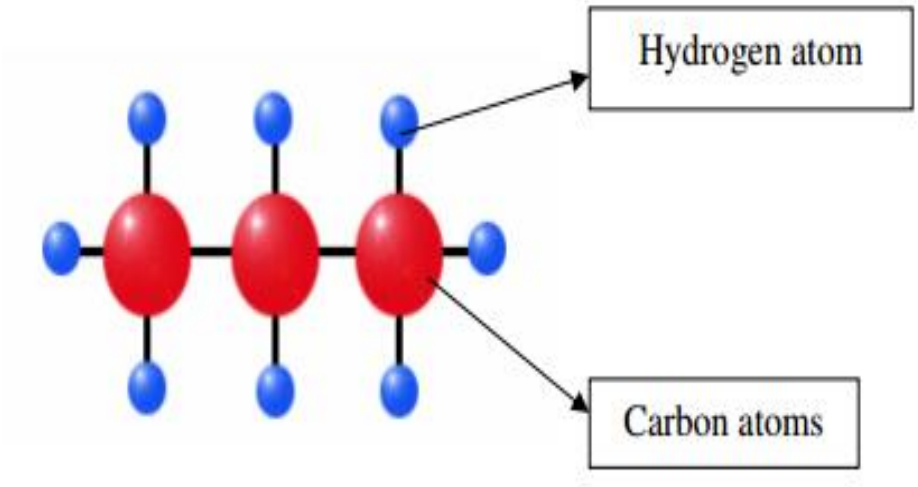


Fig 1.2: Molecular structure for Propane - 20/08/2013

The incomplete combustion equation for LPG combustion is given below (www.ask.com, accessed on 9th 2016)

$$2C_3H_{8(g)} + 7O_{2\ (g)} \rightarrow 2C(s) + 2CO_{(g)} + 8H_2O_{(l)} + 2CO_{2(g)} \quad (1.2)$$

The amount of Carbon monoxide emitted during propane (LPG) combustion is 7.7lb/10^3gal propane (0.22kg CO/Kg Propane) (www.epa.gov/ttnchiel, accessed on 19th Jan,2014). Ozone is produced in the atmosphere by photochemical oxidation of Carbon monoxide (CO). At abnormally high concentrations it is a pollutant and a constituent of smog. The equation of ozone conversation from carbon monoxide is given below.

$$CO_{(g)} + 2O_{2(g)} + hv \rightarrow CO_{2(g)} + O_{3(g)} \quad (1.3)$$

2.5 Dispersion of Surface Ozone Modelling using UAM –V Model

The dispersion/diffusion of surface ozone was represented by the Variable-grid Urban Airshed Model (UAM-V) system which is a three-dimension grid (Eulerian) model designed to calculate the concentration of both inert and chemically reactive pollutants by simulating the physical and chemical process in the atmosphere that affect pollutant concentrations.

The basis for the UAM-V model is the atmospheric diffusion. This equation represents a mass balance in which all the relevant emissions, transport diffusion, chemical reactions and removal processes are expressed in mathematical terms as follows:

$$\frac{\partial ci}{\partial t} + \frac{\partial (uci)}{\partial x} + \frac{\partial (vci)}{\partial y} + \frac{\partial (wci)}{\partial z} = \frac{\partial}{\partial x}\left[Kx\frac{\partial ci}{\partial x}\right] + \frac{\partial}{\partial y}\left[KY\frac{\partial ci}{\partial y}\right] + \frac{\partial}{\partial z}\left[KV\frac{\partial ci}{\partial z}\right] + Ri + Si + Di + Wi \quad \textbf{(3.8)}$$

Time dependant Advection Turbulent diffusion chemical reaction emissions

Where

C_i = concentrations of pollutant i (surface ozone),a function of space (x,y,z) and time (t)

u,v,w = horizontal and vertical wind speed components

K_x,K_y = horizontal turbulent diffusion coefficients

K_v = vertical turbulent exchange coefficients

R_i = net rate of production of pollutant i by chemical reactions

S_i =emission rate of pollutant i

D_i = net rate of change of pollutant I due to surface uptake processes

W_i = net rate of change of pollutant I due to wet deposition processes

Equation 3.8 provides the dispersion/diffusion equation. The measurement and recording of the dispersed surface Ozone is done at the meteorological station in Nairobi where the data in Table 3.2 (Appendix E) was obtained.

Advection in the UAM model is treated by specifying wind fields (i.e. u and v wind components in each grid cell) for each vertical layer and each nested grid. This is shown in the figure below (Figure 3.10)

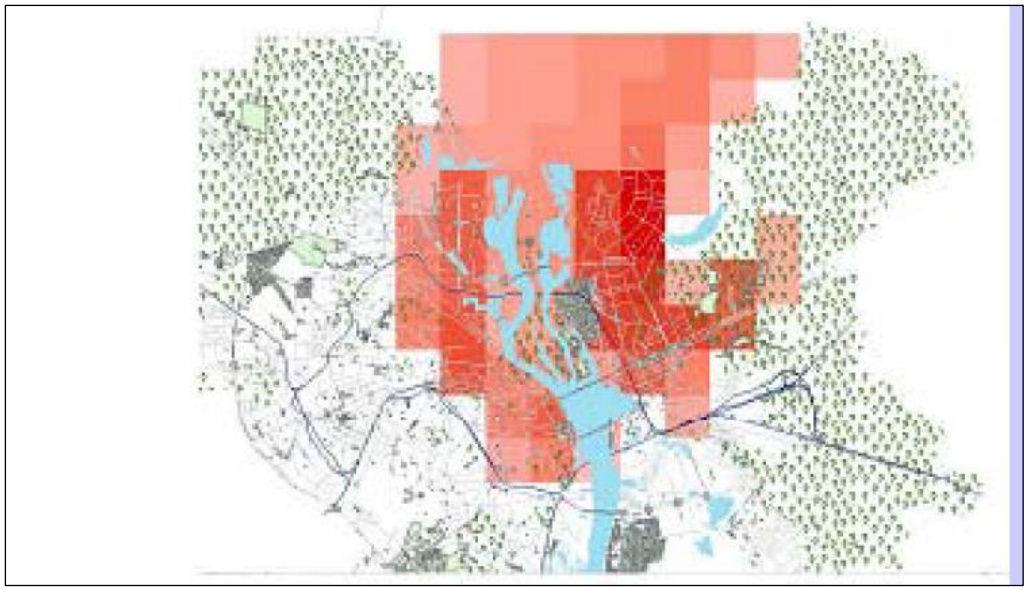


Fig 3.10: Surface ozone exposure estimated for the population of the Kiev city Ukraine August 2000 during modelling episode. Higher risk levels are correspondent to darker cell colour in the central part of the city (Source Shavrina et al 2000).

The meteorological inputs to the UAM V model include:

- Wind Fields (WIND file) which contains the horizontal wind components (u and v)
- Temperature (TEMPERATUR file) which defines the absolute temperature (K)
- Water Vapour (H20 file) which contains the concentration of water vapour in parts per million by volume (ppmv).

The comparison of the ozone measured and calculated for Kiev city in 2000 is shown in the figure below. Ozone measured (red lines) and calculated (lines 2-4) surface ozone concentrations for Aug 19-20, 2000. Lines 2 and 3 are scaled hourly average emissions; line 4 is modulated (using UAM –V) ones according diurnal traffic motion.

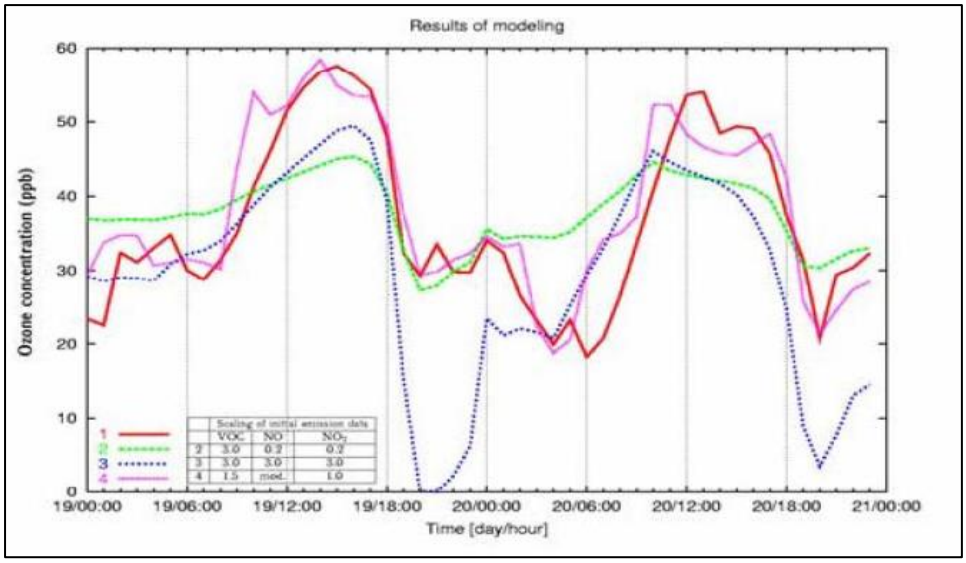


Fig 3.11: Shows Comparison of Measured and calculated surface ozone in Kiev City in 2000 (Source Shavrina et al 2000).

2.6 Conclusion

The dispersion of surface ozone within the City of Nairobi County can be represented by the Urban- Variable Airshed Model (UAM-V) which is a three-dimension grid (Eulerian) model designed to calculate the concentration of both inert and chemically reactive pollutants. The result of such representation can help evaluate the effectiveness of adaptation measures implemented by manufacturing industries to the effect of climate change. This can be done by a combination of meteorological inputs (such as wind speed, temperature and water vapour) around the manufacturing industry and recordings of surface ozone measured. The source of surface of ozone measured for the case of Nairobi Bottlers would be diesel and LPG consumed. Most researches have dwelt on carbon dioxide as greenhouse gas, this study will add highlight into the sector of surface ozone as a component of greenhouse gases.

Chapter 3: Materials and Methods

3.1 Study Area

The research was done in Nairobi (Figure 3.1). Nairobi Bottlers Limited (NBL) is a registered company in Kenya located north of the Jomo Kenyatta International Airport in Embakasi area of Nairobi County along airport north road (Eastern bypass) approximately 4 Kilometres from City Cabanas Junction off Mombasa road.

The company was established in the year 2005 following the merger of Flamingo bottlers Limited, Nairobi bottlers Limited and Machakos Bottlers Limited. It has since established its reputation as the market leader in carbonated soft drinks and still water products in Kenya with fifty per cent market share. The company manufactures products under registered trade mark from Coca Cola Company, Atlanta, USA.

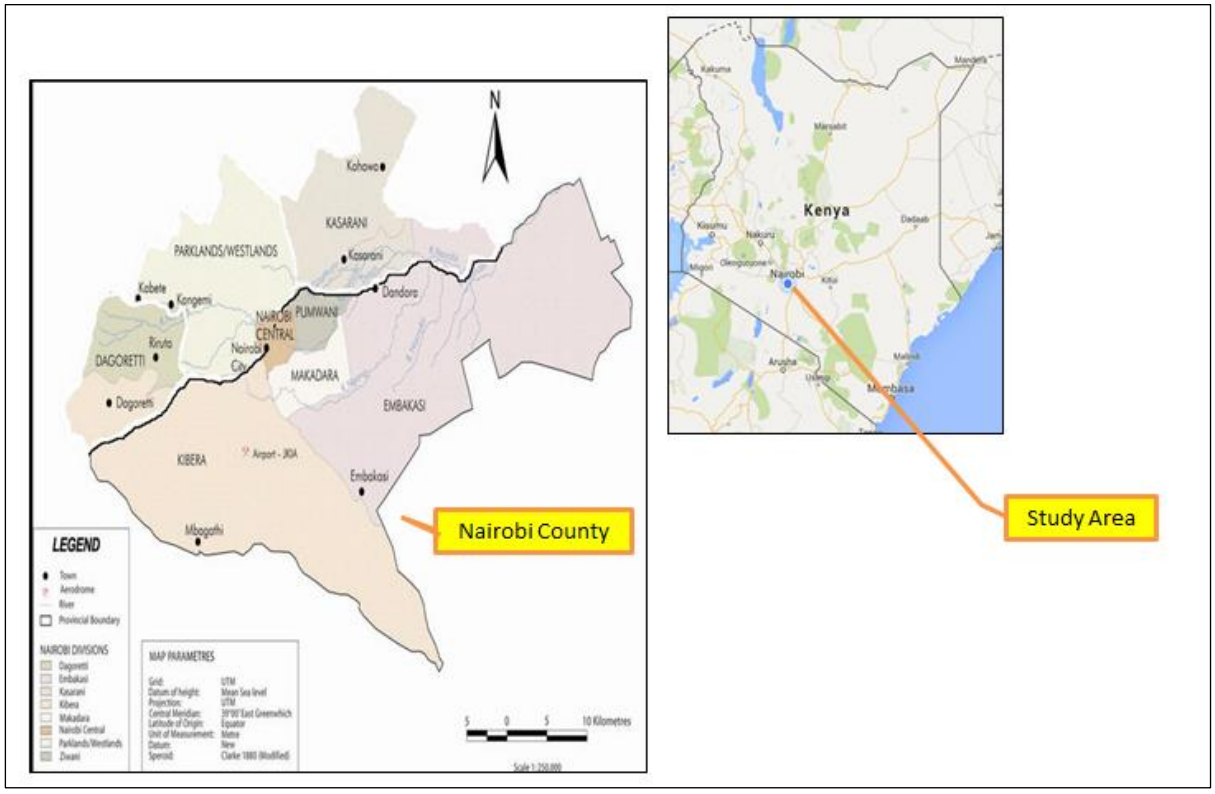


Fig 3.1 Study area

Fig 3.2 Nairobi Bottlers Ltd Office

The weather condition of Embakasi region as 25th August 2013 is given in Fig. 3.3 (www.accuweather.com , accessed on 27th June 2013)

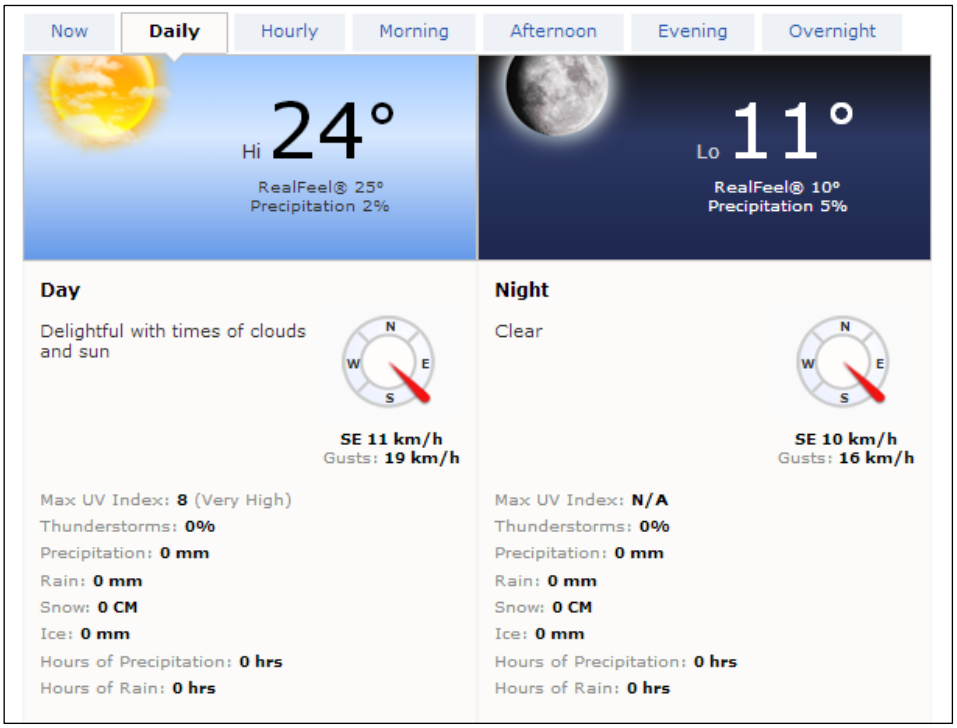


Fig 3.3: Weather condition of Embakasi region (source: accuweather 25th Aug 2013)

Kenya Meteorological department (at their Head Office in Nairobi) has been measuring, recording and monitoring the trends for surface ozone and carbon dioxide.

Fig 3.4 Mount Kenya Global Atmospheric Watch (GAW) station a Meteorological station collecting Surface Ozone data

3.2 Data

3.2.1 Data types and sources

The data type used in this study were both Qualitative and Quantitative. Qualitative data was obtained through key informant interview for specific managers at Nairobi Bottlers Limited and Meteorological Station while Quantitative data was obtained from documents and records from the above two institutions. The data obtained was then used to draw graphs to analyse trend.

Measuring tools used to obtain daily data for Energy are installed Electricity meters, Diesel tank tips, Truck odometers, weighing scales for gas and

for Water, Water meters were installed. The measuring devices were regularly calibrated.

3.2.2 Field Work Survey

This study was conducted at Nairobi Bottlers Limited (NBL) located in Embakasi area of Nairobi County. NBL was selected as study model because it provides classical example of Manufacturing set up : Plant/Factory and Transport/Distribution network.

Site L01: Nairobi Bottlers

The location of study (L01) was Nairobi (Nairobi Bottlers Limited where the data on used LPG and Diesel consumption was collected to determine the amount of carbon monoxide emitted, which was then converted to its Surface Ozone equivalent. The period of data collected was between January 2009 to June 2014.

Site LO2: Nairobi Meteorological Station

The location of study (L02) was Nairobi Meteorological Station which measures and records Surface Ozone (urban data).

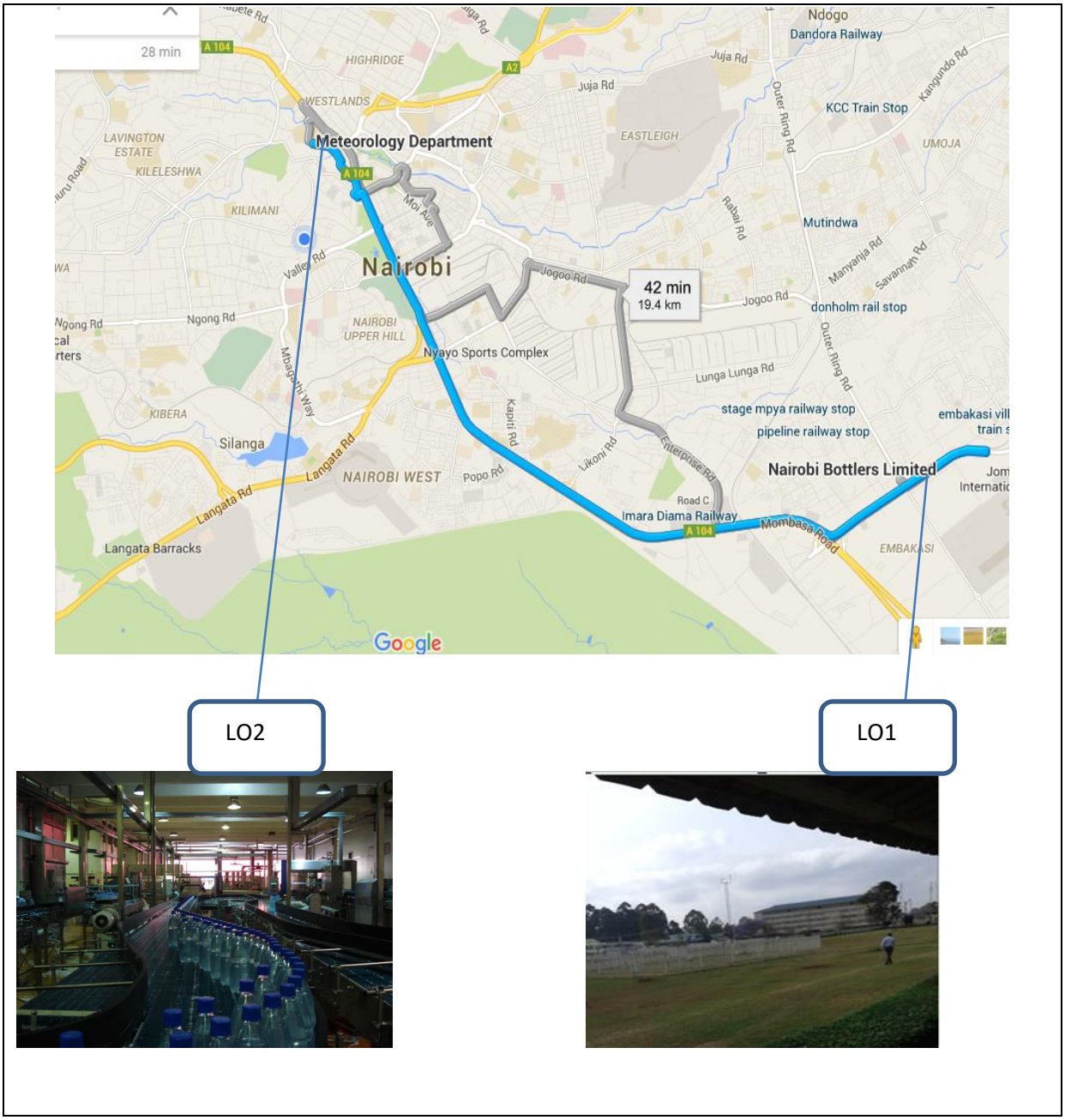


Fig 3:5 Field study sites

3.3 Identification of climate change adaptation measures in Nairobi Bottlers between 2009 and 2013

Nairobi Bottlers Limited (NBL) in their effort to minimize the effect of climate change has adapted the following mechanism;

3.3.1 SWPP – Source Water Protection Program

As a mechanism for climate resilient economic development in terms of sustainability programs. The program was intended to measure the company's water consumption for the 20 years viz-a-viz the Nairobi county supply within the period. A range of measures were put in place to manage the water such as building a one million litre tank, sealing off all water leakages and recycling of water. This is shown in the SWPP annexed in Appendix A.

3.3.2 SVA – Source Vulnerability Assessment

The company in the year 2010 carried the "source risk" in terms of quantity and quality of the raw material. This assessment has enabled the company to control the amount of water drawn from their two boreholes, engage water suppliers in terms of quality and support water conservation measures. The assessment classified Nairobi Bottlers as among the top ten water users within Nairobi County.

Table 5: Top NCWSC Water Users

Rank	Facility Name
1	Kenya Breweries Ltd
2	EP Zones
3	Director of Aerodromes
4	Kenyatta National Hospital
5	The Principal N.Y.S Eng. Inst.
6	Nairobi Bottlers Ltd
7	Commandant G SU
8	The University College NBI
9	Accountant State House
10	Commanding Officer 7 K R

Fig 3:6: Top Ten Nairobi County water users (Source SVA report, 2010).

3.4 Approaches and methodology

3.4.1 Identification of climate change adaptation measures in Nairobi Bottlers between 2009 and 2013

The following approach was employed to identify the adaptation measures employed, by NBL.

1. Obtained data on energy use ratio, water use ratio, diesel and LPG (Liquefied Petroleum gas) consumed. Energy use ratio (J/L) - amount of energy consumed (J)/amount of beverage produced (L) while Water use ratio (L/L) - amount of water consumed (l)/amount of beverage produced (L)

- Key informant staff (SHEQ (Safety, Health, Environment and Quality) Manager, Training Manager, Engineering Manager and Warehouse Manager were interviewed in terms in terms of technology and methods employed to adapt to the effects of climate change. The specific information acquired include training attended, how the capture and review data on electricity, diesel and LPG. SHEQ Manager was interviewed on this areas (Data relating to Energy Use Ratio and Water Use Ratio and their trends, Success or failure of SWPP and SVA programmes; Nature of training accorded to strategic staff, Environment impact emanating from NBL operations, Measure put in place to reduce energy and water consumption) while Warehouse Manager was interviewed on (Data related to Diesel and LPG consumption, Maintenance of Distribution trucks and Forklifts to minimize emission of pollutant gases, Measures put in place to reduce consumption of LPG and diesel)
- Capacity building - Obtained data on training records for trainings conducted related to Source Water Protection program and Source vulnerability assessment. Through awareness training intended to create awareness to its staff about the risks of climate change and what needs to be incorporated in the operation process. To implement the SVA and SWPP programs recommendations, the company has engage strategic staff in various trainings such as TPM, Bullet Proof Manager, Operations Excellence, EMS, Watersheds, Ground water, Surface water, Hydrogeology, Hydrology, Geochemistry, Agriculture Land use, Industrial Land use, Urban land use and

Building the SWWP and Integrated Solid Waste Management. The training plan connected to Climate change is shown below

Table 3.3: Shows the NBL training related to climate change and SWPP

Climate change Training plan					
	Date completed	Quality and Development Manager; Environmental Coordinator	QA Supervisor	OS&H Engineer	Mechanical Engineer
Part 1					
Know your source		x	x	x	x
Public or privately owned water supply		x	x	x	x
Facility owned water supply		x	x	x	x
Watersheds	4/7/2010	x	x	x	x
Groundwater		x	x	x	x
Surface water		x	x	x	x
Land-use		x	x	x	x
Regulators	4/28/2010	x	x	x	x
Community		x	x	x	x
Concept Plan		x	x	x	x
Part 2					
Hydrogeology 1	5/12/2010	x	x	x	x
Hydrogeology 2		x	x	x	x
Hydrology 1		x	x	x	x
Hydrology 2		x	x	x	x
Geochemistry	5/26/2010	x	x	x	x
Agricultural land use 1		x	x	x	x
Agricultural land use 2		x	x	x	x
Urban land use		x	x	x	x
Industrial land use	6/9/2010	x	x	x	x
Natural areas		x	x	x	x
Building the SWPP	6/24/2010	x	x	x	x

3.4.2 Evaluation of the effectiveness of adaptation measures to the effect of climate change implemented by Nairobi Bottlers Limited

The methods used to evaluate the effectiveness include

1. The data from water use ratio and energy use ratio were used to draw trend graphs over the period. Positive trend indicate that the measures employed

were effective in mitigating the effect of climate change while negative trend indicate that methods were defective

2. Diesel and LPG data were converted to surface ozone equivalents and trend analyzed to indicate reduction of contribution to the contributors to climate change. Positive trend would indicate reduction in contribution while negative trend would indicate defectiveness.
3. Completion of training plan was an indicator of effectiveness of adaptation measures
4. Completion of the implementation of the source water protection plan (SWPP) - the percentage completion of the plan had bearing on the water use ratio for the company

The overall grading of the effectiveness of that adaptation measure was done based on the result of each of the above four areas as indicated below

1. Most effective - all the four parameters were either having positive trend or completed as per plan
2. Medium effective - at least two of parameters were either having positive trend or completed as per plan
3. Least effective - only one of parameters were either having positive trend or completed as per plan

Since the company operations in terms of manufacturing and distribution had contributing effect to the overall drivers of climate change, the grading of the effectiveness of the adaptation measures was based on the company out which was driven by implementing the adapted measures. This was verified by comparing the trend of surface ozone equivalent calculated with that of surface ozone measured at the Meteorological station

In order to determine how effective, the adaptation measures adapted by NBL to the effect of the climate change, this study reviewed the trend of Energy Use Ratio - EUR (diesel and LPG consumed) and Water Use Ratio (WUR).

Energy Use Ratio (J/L) = Amount of diesel and LPG consumed monthly/amount of beverage produced in litres. A downward trend indicates that the adaptation measures taken were effective.

Water use ratio (Kg/L) = Amount of water consumed monthly/amount of beverage produced in litres. A downward trend indicates that the adaptation measures taken were effective.

Table 3.4: Shows the WUR and EUR for the period 2009 -2014. Full table is annexed as Appendix D

YEAR	Months (X)	WUR (Water Use ratio)	EUR (Energy Use ratio)
2009	Jan	3.8	0.53
	Feb	3.76	0.55
	Mar	3.79	0.51
	Apr	3.71	0.50
	May	4.1	0.61
	Jun	3.65	0.56
	Jul	3.75	0.56
	Aug	4.07	0.65
	Sep	3.77	0.53
	Oct	3.86	0.41
	Nov	4.05	0.45
	Dec	3.58	0.48

Chapter 4: Results and Discussion

The recordings for the amount of water consumed (measured in Litres) to produces a litres of beverage commonly referred as Water Use Ratio (WUR) and the amount of energy (diesel and LPG and LPG) consumed referred as Energy ratio within the period produce a good trend.

Energy Use Ratio (J/L) = Amount of diesel and LPG consumed monthly/amount of beverage produced in litres. The company had a target to achieve a value of 0.5J/L.A downward trend indicates that the adaptation measures taken were bearing fruit.

4.1 Identification Climate Change adaptation measures by Nairobi Bottlers between of 2009 and 2013

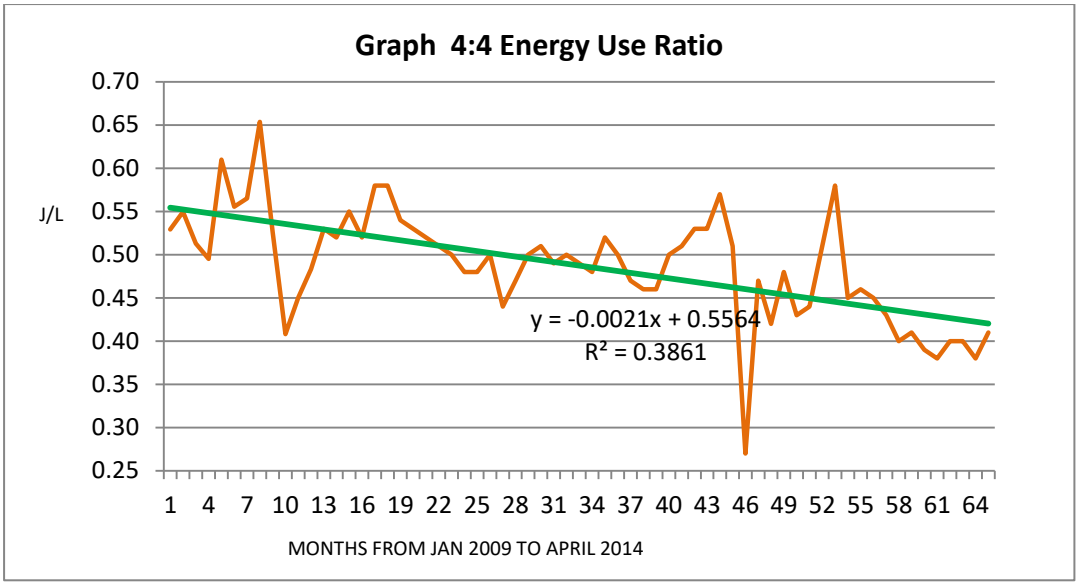
During the study, it was identified that NBL employed the following adaptation measures to minimize the effect of climate change;

4.1.1 Energy Usage (Energy Used Ratio – EUR)

Nairobi Bottlers Limited (NBL) in their effort to minimize the effect of climate change had adapted the following mechanism;

1. It changed the design of the plastic bottles from 22g to 18g thus reducing the amount of LPG and Diesel used to distribute the products. This also reduced the amount of waste generated.
2. Within the period of study, the company purchased efficient cooler distribution trucks and soft-starter motors to reduce diesel and electricity consumption respectively.
3. A robust maintenance program for both Forklift and Trucks was also employed within the period

The above adaptation measures enabled the EUR ratio to positively improve from 0.53J/ltr in 2009 to 0.41J/ltr in 2014. This is captured in the graph below (Graph 4.5)



Graph 4.5: Shows Energy Use ratio between the periods of 2009 -2014

4.1.2 Water Usage (Water Used Ratio – WUR)

Nairobi Bottlers Limited (NBL) in their effort to minimize the effect of climate change had adapted the following mechanism; Water use ratio (Kg/L) = Amount of water consumed monthly/amount of beverage produced in litres

1. It increased the packaging of beverage in plastic bottles (by installing two Krones Machines - Plastic filling lines) and reduced glass-bottles-packaging. This reduced water used to clean the recycled glass bottles. The same result was confirmed by the positive trend in the water user ration result. Packaging in plastic bottles also reduced the amount of fuel (diesel) consumed since plastic bottle is less heavier compared to glass bottler, this eventually lead to less greenhouse gas emitted in terms of surface ozone and carbon dioxide.
2. The use of plastic bottles other than glass bottles contributed to the reduction on the amount of water used to cleaned glass bottles before filling the bottles with beverage.
3. A program to harvest rain water was started, in order to reduce fluctuation of water from Nairobi Water and Sewerage Company.
4. The company built one million litre capacity storage tank. It also engaged all the stakeholders involved in protecting water catchment area around Athi Water Catchment Basin.
5. It participated in annual tree-planting exercise in Ngong hills in conjunction with companies such as Kenya Airways.

6. SVA – Source Vulnerability Assessment

NBL conducted a water vulnerability assessment, this assessment is summarized below and has enabled the company to control the amount of water drawn from their two boreholes, engage water suppliers in terms of quality and support water conservation measures. The assessment also generated the potential vulnerability that NBL was exposed to. This formed the basis for SWPP Management plan

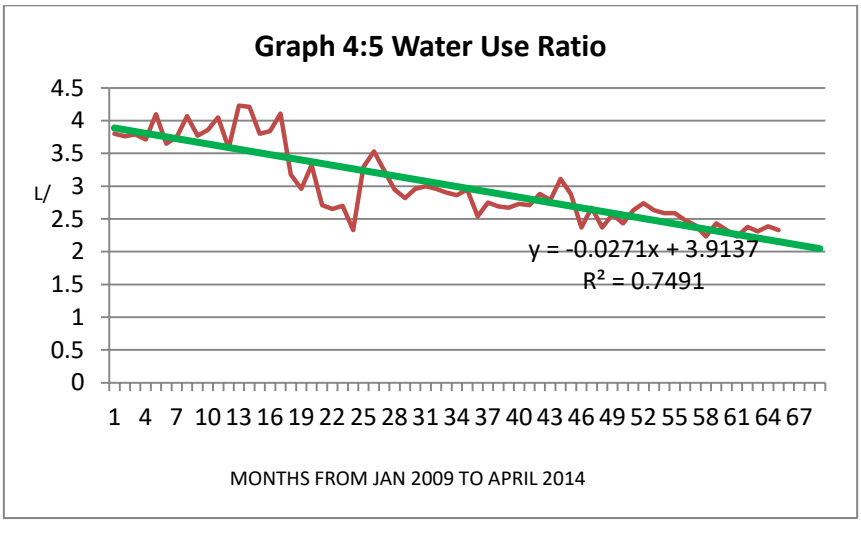
Table 9: Potential Vulnerabilities

Vulnerability	Pollutant/Issue	Risk Ranking	Mitigation Strategy	Goal and/or Objective
Potential Contamination of Groundwater from Surface Water Contamination	Discharges to surface water of: industrial and sanitary effluent; silt; municipal wastewater; illegal discharges; heavy metal contamination; industrial spills.	15	• Engage municipality, NGOs, community, academy in water stewardship. • Implement spill and waste management plans for prevention of environmental release.	Ensure a continuous supply of high quality water.
	Fluoride and pH levels in excess of standards	15	Ensure continued monitoring of incoming groundwater and post-treatment water for fluoride and pH concentration to meet production quality requirement.	Ensure a continuous supply of high quality water.
Water Shortage	Drought and increasing population.	6	• Development of drought management plan. • Implement water conservation measures.	Ensure a sustainable water supply.
Deficiency of Available Groundwater Information	Incomplete groundwater data does not allow for a formal determination of continuous supply or sustainability of the groundwater source.	15	Support NGOs, stakeholders, community and academy in groundwater research. • Watershed Catchment Management Plan • Aquifer monitoring and data collection • Enforce regulation of well registration	Ensure proper and constant discharge test of onsite and off-site supply well according to Ministry regulations and requirements.
Groundwater Permit Violation	Borehole is being pumped in excess of their permit limit	25	• Apply for higher permit limit for borehole; or • Close borehole, and install new borehole with a greater abstraction limit.	Ensure facility is in compliance with local permits.
Municipal Supply Shortages	Inconsistent supply doesn't allow for reliance on municipal supply as a source for entire production.	15	• Identify alternative water supply sources such as rain water harvesting. • Engage municipality to secure a reliable water supply.	Ensure a sustainable water supply.
Water Supply Equipment	Lack of spare equipment.	15	Additional pump. Maintain spare parts inventory.	Ensure a sustainable water supply.
Public Perception as a Water Steward	Lack of awareness of Water Neutrality Initiative, one of the top NCWSC Water users, and stakeholder engagement.	15	• Awareness of TCCC Water Neutrality Initiative. • Identify potential local projects, i.e. rain barrels, rain gardens, stream restoration projects. • Engage municipality, NGOs, community, academy in water stewardship. Increase engagement with Nairobi Water Resource User Association.	Maintain positive public perception

Note: The risk ranking scale ranges from 1 to 25. ***Appendix A*** deta the ranking guidelines.

Fig 4.2 – Shows the results of the SVA (Source - SVA Report, 2010)

The above adaptation measures enabled the WUR ratio to positively improve from 3.8ltr/ltr in 2009 to 2.3ltr/ltr in 2014. This is captured in the graph below (Graph 4.6)



Graph 4.6: Water Use ratio between the periods of 2009 -2014

4.1.3 Source Water Protection Program (SWPP)

In order to implement the SWPP, a team from NBL was selected and trained on the effect of climate change as a capacity building.Appendix 7.1 provides a table of the NBL Management plan developed to achieve the SWPP with following headings. Summary of the action taken is given below.

Table 4:1 shows the Management plan to implement SWPP (Source SWPP report, 2010)

Vulnerability	Pollutant/issue	Objective	Mitigation Strategy	Implementation Team	Implementation Action	Proposed Budget US$	Status
Potential Contamination of quality water. Groundwater from Surface Water Contamination	Discharges to surface water of: industrial and sanitary effluent; silt; municipal wastewater; illegal discharges; heavy metal contamination; industrial spills.	To reduce contaminants to acceptable standards	1.Engage municipalities, NCWSC, Ministry of Environment, NGOs(UNDP), community, academy in water stewardship (Local University) 2.Implement spill and waste management plans for prevention of environmental release.	Sergio Fernendes Benard Wasike..GabrielNvida.Peter Muiruki.Kageenu Mwenda.Julius Gatibi.Mishek Mureithi and Joseph Kimani	PAC to hold discussions with stakeholders in forums, meetings, request for their support and share with NBL progress	$1,235	In progress, on schedule
	Fluoride and pH levels in excess of standards	To reduce Fluoride and pH levels that is already in excess of standards.	Ensure continued monitoring of incoming groundwater and post treatment water for fluoride and pH concentration to meet production	Sergio Fernendes Benard Wasike..GabrielNvida.Peter Muiruki.Kageenu Mwenda.Julius Gatibi.Mishek Mureithi and Joseph Kimani	Quarterlly analysis and monitoring of water pH and fluoride levels	$250	Complete

The table indicates that 6 out of 8 (75%) of the actions are already been completed as also depicted in the pie-chart below.

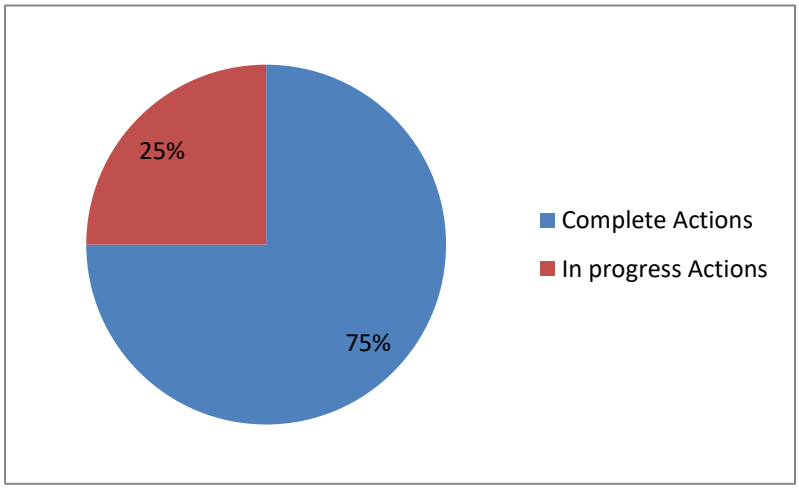
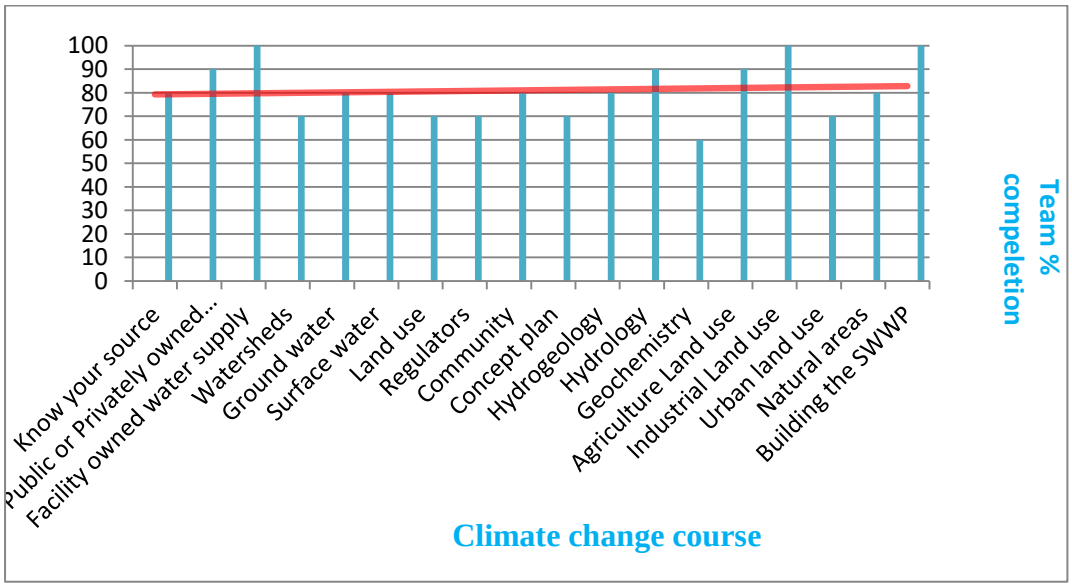


Fig 4.1: Pie chart showing completion of actions

4.1.4 Capacity Building and Recording - awareness training

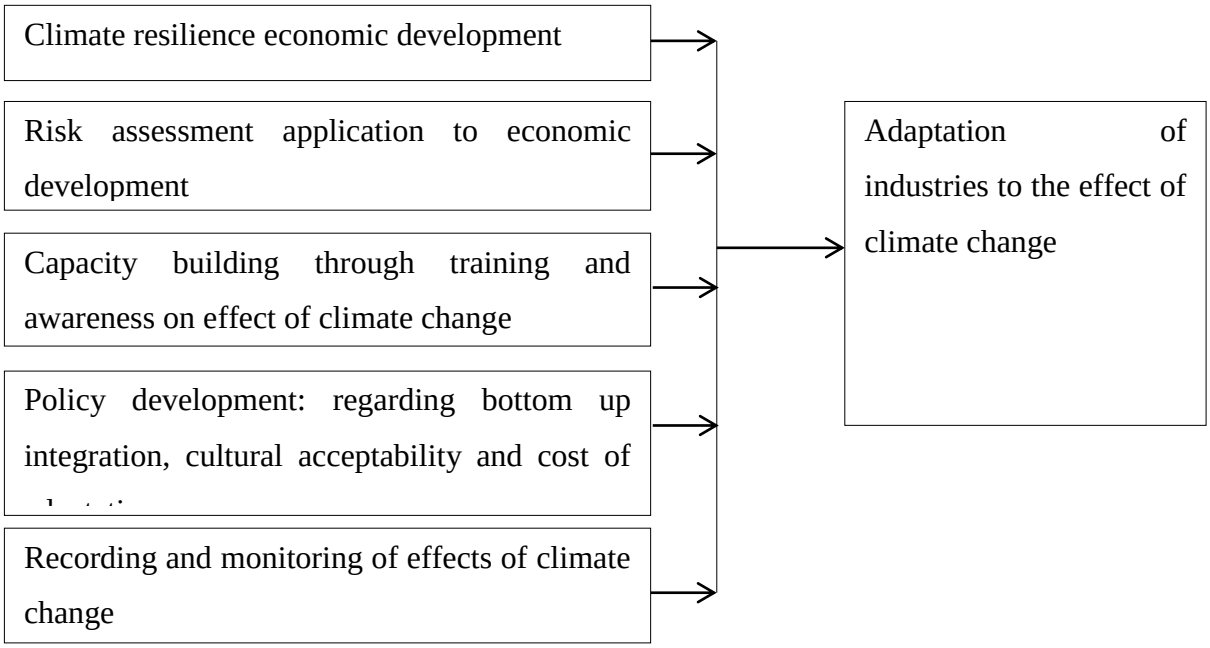
A daily monitoring program and team was initiated to track LPG, Diesel and water consumption (this was through management strategy such Operation Excellence and TPM (Total Productive Maintenance).

Under Capacity building through training, Several training had been conducted within the period of 2009-2014. The training that had correlation with the Climate change impact is shown in the graph below. 81% of the implementation team completed the courses while 100% of the courses were attempted.



Graph 4.2 – Graph showing trainings completed in relation to climate change

The factors that determined adaptation measures to climate change effects can be presented in the conceptual framework below.



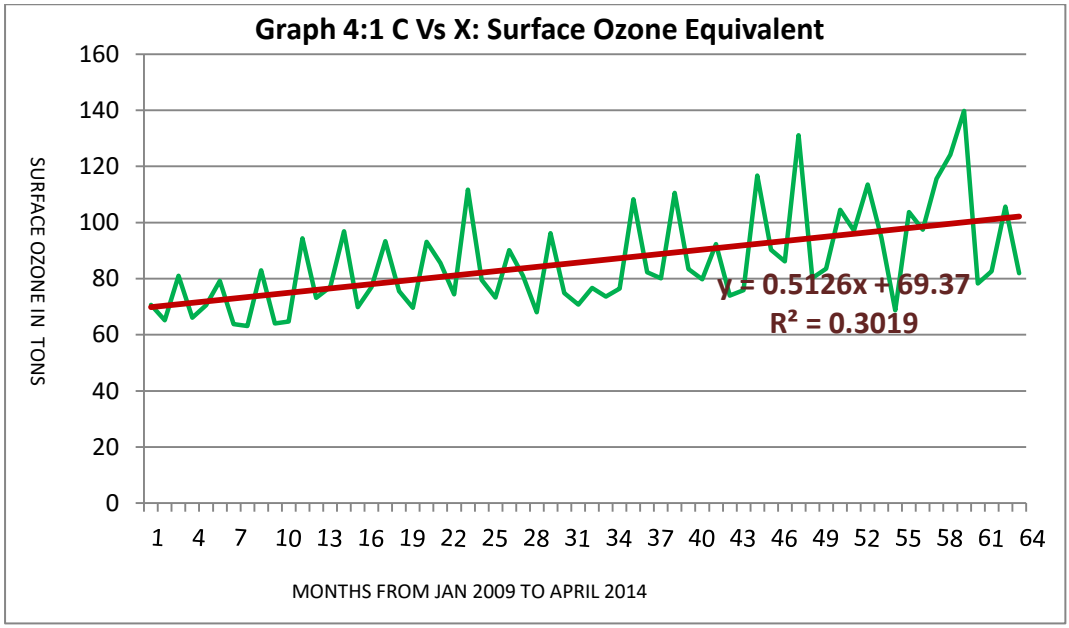
4.1.5 Validation of Surface Ozone Dispersion (equivalent versus measured)

In order to determine correlate and validate the surface Ozone equivalent/generated from NBL operations and Surface Ozone measured at Nairobi Meteorological Station between 2009 and 2014, Surface Ozone equivalent calculation was used. The table below shows the calculated values as fully captured in Appendix F.

Table 4:2 shows the variation surface ozone equivalent between the periods of 2009 -2014

YEAR	Months (X)	Surface Ozone equivalent (C) in Tonnes		YEAR	Months (X)	Surface Ozone equivalent (C) in Tonnes
2009	1	71		2010	13	73
	2	65			14	77
	3	81			15	97
	4	66			16	70
	5	71			17	77
	6	79			18	93
	7	64			19	76
	8	63			20	70
	9	83			21	93
	10	64			22	86
	11	65			23	74
	12	94			24	112
2011	25	80		2012	37	82
	26	73			38	80
	27	90			39	111
	28	81			40	83
	29	68			41	80
	30	96			42	92
	31	75			43	74
	32	71			44	76
	33	77			45	117
	34	74			46	90
	35	76			47	86
	36	108			48	131
2013	49	80		2014	61	78
	50	84			62	83
	51	104			63	106
	52	97			64	82
	53	114			65	
	54	95			66	
	55	69			67	
	56	104			68	
	57	97			69	
	58	116			70	
	59	124			71	
	60	140			72	

This is graphically represented below (the months are from Jan 2009 – representing month 1 while April 2014 representing month 64 in both table and graph).



Graph 4:2 shows the calculated surface ozone equivalent between the periods of 2009 -2014

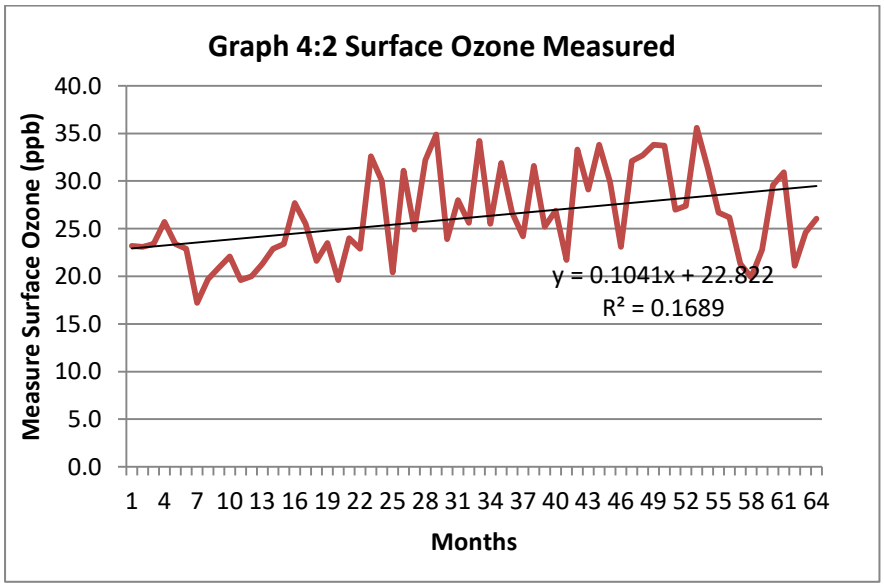
The graph shows an upward trend in the surface Ozone calculated indicating there was a climatic change within the period under consideration. This also infers/indicates that the amount of Carbon monoxide in the atmosphere also increased with the same period as per equation 1.3.

Surface Ozone measured between 2012 and 2014

This ozone measurement at the GAW (Global Atmospheric Weather) station was done every hour. This captured both in the table and graph below.

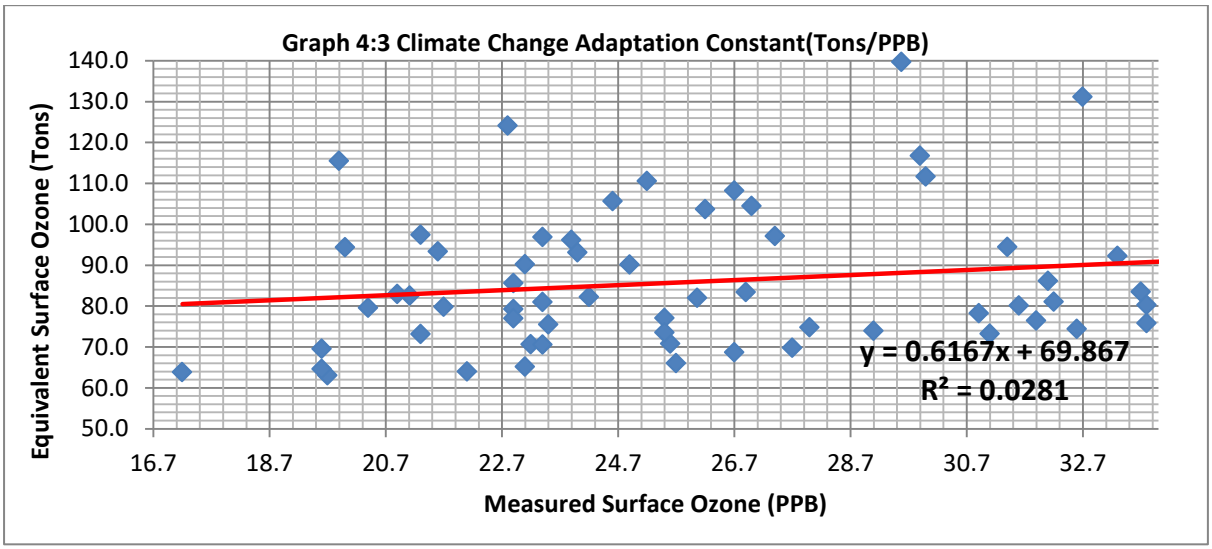
Table 4:3 shows the measured surface ozone between the periods of 2012 -2013

Months (X)	Surface Ozone Measured (ppb)	Months (X)	Surface Ozone Measured (ppb)	Months (X)	Surface Ozone Measured (ppb)
1	23.2	22	22.9	44	33.8
2	23.1	23	32.6	45	29.9
3	23.4	24	30.0	46	23.1
4	25.7	25	20.4	47	32.1
5	23.4	26	31.1	48	32.7
6	22.9	27	24.9	49	33.8
7	17.2	28	32.2	50	33.7
8	19.7	29	34.9	51	27.0
9	20.9	30	23.9	52	27.4
10	22.1	31	28.0	53	35.6
11	19.6	32	25.6	54	31.4
12	20.0	33	34.2	55	26.7
13	21.3	34	25.5	56	26.2
14	22.9	35	31.9	57	21.3
15	23.4	36	26.7	58	19.9
16	27.7	37	24.2	59	22.8
17	25.5	38	31.6	60	29.6
18	21.6	39	25.2	61	30.9
19	23.5	40	26.9	62	21.1
20	19.6	41	21.7	63	24.6
21	24.0	42	33.3	64	26.1



Graph 4:3 shows the measured surface ozone between the periods of 2012 -2013

The graph shows an upward trend indicating there was increase in the amount of surface Ozone measured at the Meteorological department.



Graph 4:4 shows the measured and calculated surface ozone between the periods of 2012 -2013

The graph shows correlation between Measured and Surface Ozone Equivalent for the period under review.

The significance of Graph 4.2 and 4.3 validated the theory that Manufacturing companies contributes to the pollutants in the atmosphere in that as the surface ozone equivalent from Nairobi Bottles increased within the period of study, the surface ozone measured at Meteorological station (within the operation of Nairobi Bottlers) also increased.

4.2 Evaluation of the effectiveness of adaptation measures to the effect of climate change implemented by Nairobi Bottlers Limited

The effectives of the adaptation measures were evaluated by analysis of the data recorded within the bottling plant.

From the methodology described in chapter 3, the overall grading of the effectiveness of the adaptation measure was done based on the result of each of the above four areas

- Most effective - all the four parameters were either having positive trend or completed as per plan
- Medium effective - at least two of parameters were either having positive trend or completed as per plan
- Least effective - only one of parameters were either having positive trend or completed as per plan

The four parameters i.e. Water Used Ratio, Energy Ratio, Implementation of the Source Water Protection Program and Capacity building had the following results

1. Energy Ratio - had positive downward trend from 0.5J/ltr to 0.41J/ltr
2. Water Used Ratio – had positive downward trend from 3.8ltr/ltr to 2.3ltr/ltr
3. Implementation of the Source Water Protection Program – 75% of the programs were completed at the end of study while 25% were completion, giving positive results
4. Capacity building had the following results – 81% of the implementation team completed the courses while 100% of the courses were attempted

Since all the four parameters were having positive result/ trend or completed as per plan, this shows that the adaptation measures taken by Nairobi Bottlers were effective.

Chapter 5: Conclusions and Recommendations

5.1 Conclusions

The results of this study showed that adaptation measures taken by Nairobi Bottlers within the period of study reduced the effects of climate change and improve the process efficiency of manufacturing companies.

The adaptation measures taken by NBL such the Source Water Protection Program (SWPP), Source Vulnerability Assessment (SVA), training staff on climate-change courses and monitoring of the key elements such as Energy Use Ratio (EUR) and Water Use Ratio (WUR) led to positive results in that the values of WUR and EUR dropped within the period of study.

5.2 Recommendations

The following are recommendations based on the study:

1. From the positive effect seen in NBL, other companies within the city should also make use of the adaptation measure undertaken by NBL.
2. It is further recommended the usage of UAM-V model to modulate the data collected both in NBL and Meteorological station.
3. During the course of study, it was observed that data measured at the meteorological station were missing for some days – the reason being that the GAW Station is sponsored by a European Institution, Government of Kenya should start funding some of the projects to ensure steady and consistent data collection of the surface ozone gas.
4. In Kenya, the knowledge of global warming is still wanting and minimal. Manufacturing industries requires more awareness training to implement mitigation measure
5. The Meteorological station in Nairobi has a Mobile Air Laboratory Station that can be utilized to measure Surface Ozone around companies such NBL
6. To use of absolute targets instead of trends while determining the effectiveness of adaptation measures
7. With the increasing awareness of health hazards exposed by increased usage of plastic bottles, the company should enhance its collection and recycling of used plastic bottles

6.0 References

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7.0 Appendices

7.1 Appendix A – SWPP Management Plan

Vulnerability	Pollutant/issue	Objective	Mitigation Strategy	Implementation Team	Implementation Action	Proposed Budget US$	Status
Potential Contamination of quality water. Groundwater from Surface Water Contamination	Discharges to surface water of: industrial and sanitary effluent; silt; municipal wastewater; illegal discharges; heavy metal contamination; industrial spills.	To reduce contaminants to acceptable standards	1.Engage municipalities, NCWSC, Ministry of Environment, NGOs(UNDP), community, academy in water stewardship (Local University) 2.Implement spill and waste management plans for prevention of environmental release.	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	PAC to hold discussions with stakeholders in forums, meetings, request for their support and share with NBL progress	$1,235	**In progress, on schedule**
	Fluoride and pH levels in excess of standards	To reduce Fluoride and pH levels that is already in excess of standards.	Ensure continued monitoring of incoming groundwater and post treatment water for fluoride and pH concentration to meet production quality requirement	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	Quarterlly analysis and monitoring of water pH and fluoride levels	$250	**Complete**
Water shortage	Drought and increasing population	1.To invest in extra water reservoir 2. To engage NCWSC, NEMA, Ministry of Environment in the planns to address drought and population increase	1.Review the IMCR procedure to reflect drought management plan. 2. Implement water conservation programme (WUR reduction, water treatment) 3. Build an extra water reservoir 4.Engage swtakeholders (NCWSC,NEMA, Ministry of Environmant/Foresty,Others applicable) in environmental protection.	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	1. Review IMCR procedure 2. Operational Exellence to continue driving WUR reduction total plant 3. Reservoir construction to commence and be completed as per schedule 4.Quarterlly stakeholder engagement	$10,000	**Complete**

Deficiency of Available groundwater information	Incomplete groundwater data does not allow for a formal determination of continuous supply or sustainability of the ground water source	To gather sufficent data that will assess the sustainability of the ground water source.	Support NGOs, stakeholders, community and academy in groundwater research. • Watershed Catchment Management Plan • Aquifer monitoring and data collection • Enforce regulation of well registration	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	Obtain data on ground water from stakeholders as mentioned in objectives	$1,000	**Complete**
Groundwater permit viloation	Borehole is being pumped in excess of their permit limit	To liase with Authority in increasing the borehole permit	1.Apply for higher permit limit for borehole; 2. Engage and liason with other Borehole water users	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	1. SHE Coordinator to Apply for a new abstraction permit for the two boreholes 2.Visit and hold discussions with borehole users drawing from the same acquifer	$400	**In progress, on schedule**
Municipal supply shortages	Inconsistent supply doesn't allow for reliance on municipal supply as a source for entire production	1.To engage NCWSC so that supply consistency is sustained during rationing period2. To invest in extra water reservoir3. To ensure borehole is running at optimum capacity	1.Identify alternative water supply sources such as rain water harvesting.2.Engage municiplity to secure a reliable water supply3.Build extra water reservoir4. rum boreholes to optimum capacity	1.Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	1. Engineering Manager to complete and seek approval for the Rain Water Harvesting Proposal2.PAC to hold discussions with stakeholders in forums, meetings, request for their support and share with NBL progress3. Reservoir construction to commence and be completed as per schedule	$1,235	**Complete**
Water supply equipment	Lack of spare equipment	1.To ensure the equipment/spairs suppliers have stocks at all times and give a guarantee of purchase when in need. 2. To have back up spares (pumps and related parts)	1. spares availability at the supplier end 2.Have back up spares in house (pump)	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius Gatibi,Mishek Mureithi and Joseph Kimani	1. Buy spare Pump for the water treatment plant 2.Procument to hold discussion with supplier so as to keep spares at their end	$1,000	**Complete**
Public perception as a water steward	Lack of awareness of Water Neeureality Initiative, one of the	To regurlarly create stewardship awareness amongst water	1.Regularly create awareness of TCCC Water Neutrality Initiative.	Sergio Fernendes ,Benard Wasike,.,GabrielNyida,Peter Muiruki,Kageenu Mwenda,Julius	PAC to hold discussions with stakeholders in forums, meetings, request for their	$1,235	**Complete**

	top NCWSC water users, and stakeholde engagemen t.	stakeholders.	2. Identify potential local projects, i.e. community and NGO projects meant to conserve water and its catchment. 3. Engage municipality, NGOs, community, academy in water stewardship. Increase engagement with Nairobi Water Resource User Association.	Gatibi,Mishek Mureithi and Joseph Kimani	support and share with NBL progress		
					TOTAL	**$13,885**	

7.2 Appendix B - Daily LPG records

Mat. Doc.	Pstng Date	Material	Quantity	HeaderText	User name	Amount in LC	Cost Ctr
4931292450	01.01.2013	GAS LPG	-17.3	RF114 RF114	OALPHONCE	-2,625.45	2400
4931292452	01.01.2013	GAS LPG	-17.3	RF126 RF126	OALPHONCE	-2,625.45	2400
4931292453	01.01.2013	GAS LPG	-17.3	RF127 RF127	OALPHONCE	-2,625.45	2400
4931292454	01.01.2013	GAS LPG	-17.3	RF129 RF129	OALPHONCE	-2,625.45	2400
4931292455	01.01.2013	GAS LPG	-17.3	RF131 RF131	OALPHONCE	-2,625.45	2400
4931292456	01.01.2013	GAS LPG	-17.3	RF135 RF135	OALPHONCE	-2,625.45	2400
4931292457	01.01.2013	GAS LPG	-17.3	RF136 RF136	OALPHONCE	-2,625.45	2400
4931292458	01.01.2013	GAS LPG	-17.3	RF137 RF137	OALPHONCE	-2,625.45	2400
4931292459	01.01.2013	GAS LPG	-17.3	RF138 RF138	OALPHONCE	-2,625.45	2400
4931292460	01.01.2013	GAS LPG	-17.3	RF139 RF139	OALPHONCE	-2,625.45	2400
4931292462	01.01.2013	GAS LPG	-17.3	RF140 RF140	OALPHONCE	-2,625.45	2400
4931292463	01.01.2013	GAS LPG	-17.3	RF142 RF142	OALPHONCE	-2,625.45	2400
4931292465	01.01.2013	GAS LPG	-17.3	RF143 RF143	OALPHONCE	-2,625.45	2400
4931292466	01.01.2013	GAS LPG	-17.3	RF136 RF136	OALPHONCE	-2,625.45	2400
4931298652	02.01.2013	GAS LPG	-17.3	RF114 RF114	JMUDAVADI	-2,625.45	2400
4931298653	02.01.2013	GAS LPG	-17.3	RF126 RF126	JMUDAVADI	-2,625.45	2400
4931298655	02.01.2013	GAS LPG	-17.3	RF127 RF127	JMUDAVADI	-2,625.45	2400
4931298656	02.01.2013	GAS LPG	-17.3	RF128 RF128	JMUDAVADI	-2,625.45	2400
4931298658	02.01.2013	GAS LPG	-17.3	RF129 RF129	JMUDAVADI	-2,625.45	2400
4931298759	02.01.2013	GAS LPG	-17.3	RF129 RF129	JMUDAVADI	-2,625.45	2400
4931298760	02.01.2013	GAS LPG	-17.3	RF130	JMUDAVADI	-2,625.45	2400

				RF130			
4931298762	02.01.2013	GAS LPG	-17.3	RF131 RF131	JMUDAVADI	-2,625.45	2400
4931298763	02.01.2013	GAS LPG	-17.3	RF133 RF133	JMUDAVADI	-2,625.45	2400
4931298765	02.01.2013	GAS LPG	-17.3	RF134 RF134	JMUDAVADI	-2,625.45	2400
4931298767	02.01.2013	GAS LPG	-17.3	RF135 RF135	JMUDAVADI	-2,625.45	2400
4931298768	02.01.2013	GAS LPG	-17.3	RF135 RF135	JMUDAVADI	-2,625.45	2400
4931298811	02.01.2013	GAS LPG	-17.3	RF136 RF136	JMUDAVADI	-2,625.45	2400
4931298812	02.01.2013	GAS LPG	-17.3	RF137 RF137	JMUDAVADI	-2,625.45	2400
4931298814	02.01.2013	GAS LPG	-34.6	RF138 RF138	JMUDAVADI	-5,250.89	2400
4931298816	02.01.2013	GAS LPG	-17.3	RF139 RF139	JMUDAVADI	-2,625.45	2400
4931298817	02.01.2013	GAS LPG	-34.6	RF140 RF140	JMUDAVADI	-5,250.89	2400
4931298818	02.01.2013	GAS LPG	-17.3	RF142 RF142	JMUDAVADI	-2,625.45	2400
4931298849	02.01.2013	GAS LPG	-17.3	RF143 RF143	JMUDAVADI	-2,625.45	2400
4931298850	02.01.2013	GAS LPG	-17.3	RF144 RF144	JMUDAVADI	-2,625.45	2400
4931298851	02.01.2013	GAS LPG	-17.3	R1 R1	JMUDAVADI	-2,625.45	2400
4931298852	02.01.2013	GAS LPG	-17.3	R2 R2	JMUDAVADI	-2,625.45	2400
4931298853	02.01.2013	GAS LPG	-17.3	R3 R3	JMUDAVADI	-2,625.45	2400
4931298855	02.01.2013	GAS LPG	-17.3	RF82 RF82	JMUDAVADI	-2,625.45	2400
4931298856	02.01.2013	GAS LPG	-17.3	RF114 RF114	JMUDAVADI	-2,625.45	2400
4931298857	02.01.2013	GAS LPG	-34.6	RF126 RF126	JMUDAVADI	-5,250.89	2400
4931298889	02.01.2013	GAS LPG	-17.3	RF127 RF127	JMUDAVADI	-2,625.45	2400
4931298891	02.01.2013	GAS LPG	-17.3	RF129 RF129	JMUDAVADI	-2,625.45	2400
4931298894	02.01.2013	GAS LPG	-17.3	RF130 RF130	JMUDAVADI	-2,625.45	2400
4931298895	02.01.2013	GAS LPG	-17.3	RF131 RF131	JMUDAVADI	-2,625.45	2400
4931298896	02.01.2013	GAS LPG	-17.3	RF134 RF134	JMUDAVADI	-2,625.45	2400
4931298897	02.01.2013	GAS LPG	-17.3	RF135	JMUDAVADI	-2,625.45	2400

				RF135			
4931298938	02.01.2013	GAS LPG	-17.3	RF136 RF136	JMUDAVADI	-2,625.45	2400
4931298940	02.01.2013	GAS LPG	-17.3	RF137 RF137	JMUDAVADI	-2,625.45	2400
4931298944	02.01.2013	GAS LPG	-17.3	RF139 RF139	JMUDAVADI	-2,625.45	2400
4931298946	02.01.2013	GAS LPG	-17.3	RF140 RF140	JMUDAVADI	-2,625.45	2400
4931298947	02.01.2013	GAS LPG	-17.3	RF143 RF143	JMUDAVADI	-2,625.45	2400
4931299071	02.01.2013	GAS LPG	-17.3	RF143 RF143	JMUDAVADI	-2,625.45	2400
4931308878	03.01.2013	GAS LPG	-17.3	RF126 RF126	MGITONGA	-2,625.45	2400
4931309029	03.01.2013	GAS LPG	-17.3	RF127 RF127	MGITONGA	-2,625.45	2400
4931309031	03.01.2013	GAS LPG	-17.3	RF128 RF128	MGITONGA	-2,625.45	2400
4931309032	03.01.2013	GAS LPG	-17.3	RF129 RF129	MGITONGA	-2,625.45	2400
4931309034	03.01.2013	GAS LPG	-17.3	RF130 RF130	MGITONGA	-2,625.45	2400
4931309035	03.01.2013	GAS LPG	-17.3	RF131 RF131	MGITONGA	-2,625.45	2400
4931309037	03.01.2013	GAS LPG	-34.6	RF133 RF133	MGITONGA	-5,250.89	2400
4931309038	03.01.2013	GAS LPG	-34.6	RF134 RF134	MGITONGA	-5,250.89	2400
4931309079	03.01.2013	GAS LPG	-34.6	RF135 RF135	MGITONGA	-5,250.89	2400
4931309081	03.01.2013	GAS LPG	-34.6	RF136 RF136	MGITONGA	-5,250.89	2400
4931309082	03.01.2013	GAS LPG	-17.3	RF137 RF137	MGITONGA	-2,625.45	2400
4931309083	03.01.2013	GAS LPG	-17.3	RF138 RF138	MGITONGA	-2,625.45	2400
4931309084	03.01.2013	GAS LPG	-17.3	RF139 RF139	MGITONGA	-2,625.45	2400
4931309085	03.01.2013	GAS LPG	-17.3	RF140 RF140	MGITONGA	-2,625.45	2400
4931309086	03.01.2013	GAS LPG	-17.3	RF140 RF140	MGITONGA	-2,625.45	2400
4931309087	03.01.2013	GAS LPG	-17.3	RF142 RF142	MGITONGA	-2,625.45	2400
4931309088	03.01.2013	GAS LPG	-17.3	RF143	MGITONGA	-2,625.45	2400

				RF143			
4931309249	03.01.2013	GAS LPG	-17.3	RF144 RF144	MGITONGA	-2,625.45	2400
4931309253	03.01.2013	GAS LPG	-17.3	R2 R2	MGITONGA	-2,625.45	2400
4931309255	03.01.2013	GAS LPG	-138.4	8 gas cylinders to nakuru	MGITONGA	########	2400
4931309258	03.01.2013	GAS LPG	-17.3	R1 R1	MGITONGA	-2,625.45	2400
4931309369	03.01.2013	GAS LPG	-17.3	C3 Mulwa-26813	MGITONGA	-2,625.45	2400
4931309370	03.01.2013	GAS LPG	-17.3	R2 R2	MGITONGA	-2,625.45	2400
4931309371	03.01.2013	GAS LPG	-17.3	RF114 RF114	MGITONGA	-2,625.45	2400
4931309373	04.01.2013	GAS LPG	-17.3	RF126 RF126	MGITONGA	-2,625.45	2400
4931309441	03.01.2013	GAS LPG	-17.3	RF127 RF127	MGITONGA	-2,625.45	2400
4931309442	03.01.2013	GAS LPG	-17.3	RF128 RF128	MGITONGA	-2,625.45	2400
4931309444	03.01.2013	GAS LPG	-17.3	RF129 RF129	MGITONGA	-2,625.45	2400
4931309445	03.01.2013	GAS LPG	-17.3	RF130 RF130	MGITONGA	-2,625.45	2400
4931309447	03.01.2013	GAS LPG	-17.3	RF131 RF131	MGITONGA	-2,625.45	2400
4931309448	03.01.2013	GAS LPG	-17.3	RF133 RF133	MGITONGA	-2,625.45	2400
4931309489	03.01.2013	GAS LPG	-17.3	RF134 RF134	MGITONGA	-2,625.45	2400
4931309490	03.01.2013	GAS LPG	-17.3	RF135 RF135	MGITONGA	-2,625.45	2400
4931309491	03.01.2013	GAS LPG	-17.3	RF136 RF136	MGITONGA	-2,625.45	2400
4931309492	03.01.2013	GAS LPG	-17.3	RF137 RF137	MGITONGA	-2,625.45	2400
4931309494	03.01.2013	GAS LPG	-17.3	RF138 RF138	MGITONGA	-2,625.45	2400
4931309496	03.01.2013	GAS LPG	-17.3	RF139 RF139	MGITONGA	-2,625.45	2400
4931309498	03.01.2013	GAS LPG	-17.3	RF140 RF140	MGITONGA	-2,625.45	2400
4931309549	03.01.2013	GAS LPG	-17.3	RF142 RF142	MGITONGA	-2,625.45	2400
4931309550	03.01.2013	GAS LPG	-17.3	RF143 RF143	MGITONGA	-2,625.45	2400
4931309551	03.01.2013	GAS LPG	-17.3	RF144	MGITONGA	-2,625.45	2400

				RF144			
4931309554	03.01.2013	GAS LPG	-17.3	RF145 RF145	MGITONGA	-2,625.45	2400
4931309556	03.01.2013	GAS LPG	-17.3	R2 R2	MGITONGA	-2,625.45	2400
4931318642	04.01.2013	GAS LPG	-86.5	nakuru depot	JMUDAVADI	########	2400
4931319080	04.01.2013	GAS LPG	-34.6	RF114 RF114	MGITONGA	-5,250.89	2400
4931319081	04.01.2013	GAS LPG	-17.3	RF127 RF127	MGITONGA	-2,625.45	2400
4931319082	04.01.2013	GAS LPG	-34.6	RF128 RF128	MGITONGA	-5,250.89	2400
4931319083	04.01.2013	GAS LPG	-34.6	RF129 RF129	MGITONGA	-5,250.89	2400
4931319084	04.01.2013	GAS LPG	-17.3	RF130 RF130	MGITONGA	-2,625.45	2400
4931319085	04.01.2013	GAS LPG	-17.3	RF131 RF131	MGITONGA	-2,625.45	2400
4931319338	04.01.2013	GAS LPG	-34.6	RF133 RF133	MGITONGA	-5,250.89	2400
4931319429	04.01.2013	GAS LPG	-17.3	RF134 RF134	MGITONGA	-2,625.45	2400
4931319430	04.01.2013	GAS LPG	-17.3	RF135 RF135	MGITONGA	-2,625.45	2400
4931319431	04.01.2013	GAS LPG	-17.3	RF136 RF136	MGITONGA	-2,625.45	2400
4931319433	04.01.2013	GAS LPG	-17.3	RF137 RF137	MGITONGA	-2,625.45	2400
4931319434	04.01.2013	GAS LPG	-17.3	RF138 RF138	MGITONGA	-2,625.45	2400

7.3 Appendix C - Daily Diesel Records

PO	Mat. Doc.	Postng Date	Material	Quantity	HeaderText	User name	Plnt
	4932148910	08.04.2013	DIESEL	-209.3	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932148912	09.04.2013	DIESEL	-222.7	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932148913	10.04.2013	DIESEL	-214.3	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932148914	11.04.2013	DIESEL	-205.02	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932148915	12.04.2013	DIESEL	-212.85	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932149110	13.04.2013	DIESEL	-177.99	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932149111	14.04.2013	DIESEL	-203.95	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932149112	15.04.2013	DIESEL	-211.67	KBT 458Y KBT 458Y	OALPHONCE	K050
	4932149115	15.04.2013	DIESEL	-69	KAL 942C KAL 942C	OALPHONCE	K050
	4932149116	15.04.2013	DIESEL	-193.58	KAK 259G KAK 259G	OALPHONCE	K050
	4932149284	16.04.2013	DIESEL	-50.33	KAV 839M	OALPHONCE	K050
	4932190334	17.04.2013	DIESEL	-143.32	KAU 375P KAU 375P	SGACHAGA	K050
	4932190336	17.04.2013	DIESEL	-270.54	KBT 367V KBT 367V	SGACHAGA	K050
	4932190337	17.04.2013	DIESEL	-134.78	KAU 471G KAU 471G	SGACHAGA	K050
	4932190338	17.04.2013	DIESEL	-196.41	KBT 719A KBT 719A	SGACHAGA	K050
	4932190970	17.04.2013	DIESEL	-58.54	KAU 467G KAU 467G	SGACHAGA	K050
	4932190971	17.04.2013	DIESEL	-62.41	KBQ 822P KBQ 822P	SGACHAGA	K050
	4932190972	17.04.2013	DIESEL	-198.98	KBJ 670W KBJ 670W	SGACHAGA	K050
	4932190973	17.04.2013	DIESEL	-44.5	KAK 065X KAK 065X	SGACHAGA	K050
	4932190974	17.04.2013	DIESEL	-56.68	KBS 588K KBS 588K	SGACHAGA	K050
	4932190975	17.04.2013	DIESEL	-203.71	KAK 258G KAK 258G	SGACHAGA	K050
	4932190976	17.04.2013	DIESEL	-155	KAG 337L KAG 337L	SGACHAGA	K050
	4932190977	17.04.2013	DIESEL	-315.69	KAT 429C KAT 429C	SGACHAGA	K050
	4932190978	17.04.2013	DIESEL	-266.03	KBJ 669W KBJ 669W	SGACHAGA	K050
	4932191059	17.04.2013	DIESEL	-65.34	KBA 196T KBA 196T	SGACHAGA	K050
	4932191060	17.04.2013	DIESEL	-316.04	KAT 431C KAT 431C	SGACHAGA	K050
	4932191061	17.04.2013	DIESEL	-125.06	KAU 469G KAU 469G	SGACHAGA	K050
	4932191062	17.04.2013	DIESEL	-226.44	KBT 457Y KBT 457Y	SGACHAGA	K050
	4932191063	17.04.2013	DIESEL	-219.05	KAK 469Z KAK 469Z	SGACHAGA	K050
	4932191064	17.04.2013	DIESEL	-289.16	KAH 583E KAH 583E	SGACHAGA	K050
	4932191065	17.04.2013	DIESEL	-105	KAU 822J KAU 822J	SGACHAGA	K050
	4932191066	17.04.2013	DIESEL	-85.21	KBS 041X KBS 041X	SGACHAGA	K050
	4932191067	17.04.2013	DIESEL	-242.24	KBT 046S KBT 046S	SGACHAGA	K050
	4932191068	17.04.2013	DIESEL	-64.19	KAM 824T KAM 824T	SGACHAGA	K050
	4932191079	17.04.2013	DIESEL	-202.13	KBT 458Y KBT 458Y	SGACHAGA	K050
	4932191080	17.04.2013	DIESEL	-70.07	KAT 432C KAT 432C	SGACHAGA	K050
	4932191081	17.04.2013	DIESEL	-93.25	KAU 497G KAU 497G	SGACHAGA	K050
	4932191082	17.04.2013	DIESEL	-119.69	KAK 232X KAK 232X	SGACHAGA	K050
	4932191083	17.04.2013	DIESEL	-42.59	KAM 639C KAM 639C	SGACHAGA	K050
	4932191084	17.04.2013	DIESEL	-175.29	KAU 374P KAU 374P	SGACHAGA	K050
	4932191085	17.04.2013	DIESEL	-265.02	KBT 366V KBT 366V	SGACHAGA	K050

	4932191086	17.04.2013	DIESEL	-164.22	KAU 406S KAU 406S	SGACHAGA	K050
	4932191087	17.04.2013	DIESEL	-50.01	KBJ 665W KBJ 665W	SGACHAGA	K050
	4932191088	17.04.2013	DIESEL	-202.01	KBS 042X KBS 042X	SGACHAGA	K050
	4932191099	17.04.2013	DIESEL	-294.56	KBJ 673W KBJ 673W	SGACHAGA	K050
	4932191100	17.04.2013	DIESEL	-244.23	KBT 456Y KBT 456Y	SGACHAGA	K050
	4932191101	18.04.2013	DIESEL	-217.14	KBJ 670W KBJ 670W	SGACHAGA	K050
	4932191102	18.04.2013	DIESEL	-250.24	KAJ 920Z KAJ 920Z	SGACHAGA	K050
	4932191103	18.04.2013	DIESEL	-96.96	KBJ 472R KBJ 472R	SGACHAGA	K050
	4932191104	18.04.2013	DIESEL	-159.3	KAN 047H KAN 047H	SGACHAGA	K050
	4932191105	18.04.2013	DIESEL	-132.73	KBJ 672W KBJ 672W	SGACHAGA	K050
	4932191106	18.04.2013	DIESEL	-60.21	KAL 942C KAL 942C	SGACHAGA	K050
	4932191107	18.04.2013	DIESEL	-52.25	KBJ 456W KBJ 456W	SGACHAGA	K050
	4932191108	18.04.2013	DIESEL	-119.85	KBH 559C KBH 559C	SGACHAGA	K050
	4932191119	18.04.2013	DIESEL	-69.26	KAJ 361B KAJ 361B	SGACHAGA	K050
	4932191120	18.04.2013	DIESEL	-49.65	KAJ 360B KAJ 360B	SGACHAGA	K050
	4932191121	18.04.2013	DIESEL	-56.1	KAL 910G KAL 910G	SGACHAGA	K050
	4932191122	18.04.2013	DIESEL	-56.68	KAL 605E KAL 605E	SGACHAGA	K050
	4932191123	18.04.2013	DIESEL	-228	KAH 748G KAH 748G	SGACHAGA	K050
	4932191124	18.04.2013	DIESEL	-61.01	KAT 431C KAT 431C	SGACHAGA	K050
	4932191125	18.04.2013	DIESEL	-72.81	KAL 539C KAL 539C	SGACHAGA	K050
	4932191126	18.04.2013	DIESEL	-215.35	KBT 457Y KBT 457Y	SGACHAGA	K050
	4932191127	18.04.2013	DIESEL	-210.99	KBT 458Y KBT 458Y	SGACHAGA	K050
	4932191128	18.04.2013	DIESEL	-235.8	KBS 644Z KBS 644Z	SGACHAGA	K050
	4932191149	18.04.2013	DIESEL	-5,058	KAW 236Y KAW 236Y	SGACHAGA	K050
	4932191150	18.04.2013	DIESEL	-147.73	KAU 375P KAU 375P	SGACHAGA	K050
	4932191151	18.04.2013	DIESEL	-280.01	KBT 071S KBT 071S	SGACHAGA	K050
	4932191152	18.04.2013	DIESEL	-47.07	KAV 898M KAV 898M	SGACHAGA	K050
	4932191153	18.04.2013	DIESEL	-52.12	KAW 131Y KAW 131Y	SGACHAGA	K050
	4932191154	18.04.2013	DIESEL	-77.13	KAU 374P KAU 374P	SGACHAGA	K050
	4932191155	18.04.2013	DIESEL	-38.21	KAM 617T KAM 617T	SGACHAGA	K050
	4932191156	18.04.2013	DIESEL	-214.88	KBT 456Y KBT 456Y	SGACHAGA	K050
	4932191157	18.04.2013	DIESEL	-58.08	KBS 589K KBS 589K	SGACHAGA	K050
	4932191158	18.04.2013	DIESEL	-376.08	KAT 427C KAT 427C	SGACHAGA	K050
	4932191169	18.04.2013	DIESEL	-196.88	KAT 429C KAT 429C	SGACHAGA	K050
	4932191170	18.04.2013	DIESEL	-118.36	KAU 505S KAU 505S	SGACHAGA	K050
	4932191171	18.04.2013	DIESEL	-44.47	KAM 627E KAM 627E	SGACHAGA	K050
	4932191172	19.04.2013	DIESEL	-342.07	KAL 327E KAL 327E	SGACHAGA	K050
	4932191173	19.04.2013	DIESEL	-96.02	KAU 406S KAU 406S	SGACHAGA	K050
	4932191174	19.04.2013	DIESEL	-98.01	KAG 313E KAG 313E	SGACHAGA	K050
	4932191175	19.04.2013	DIESEL	-220.14	KBT 458Y KBT 458Y	SGACHAGA	K050
	4932191176	19.04.2013	DIESEL	-132.5	KAK 469Z KAK 469Z	SGACHAGA	K050
	4932191177	19.04.2013	DIESEL	-393	KAT 426C KAT 426C	SGACHAGA	K050
	4932191178	19.04.2013	DIESEL	-217.91	KBT 457Y KBT 457Y	SGACHAGA	K050
	4932191179	19.04.2013	DIESEL	-255.05	KAK 258G KAK 258G	SGACHAGA	K050
	4932191180	19.04.2013	DIESEL	-45.19	KAM 589T KAM 589T	SGACHAGA	K050

	4932191181	19.04.2013	DIESEL	-250.05	KBT 386V KBT 386V	SGACHAGA	K050
	4932191182	19.04.2013	DIESEL	-255.87	KAJ 696X KAJ 696X	SGACHAGA	K050
	4932191183	19.04.2013	DIESEL	-240	KBT 208U KBT 208U	SGACHAGA	K050
	4932191184	19.04.2013	DIESEL	-175.35	KBT 719A KBT 719A	SGACHAGA	K050
	4932191185	19.04.2013	DIESEL	-267.15	KAK 259G KAK 259G	SGACHAGA	K050
	4932191186	19.04.2013	DIESEL	-45.38	KAK 065X KAK 065X	SGACHAGA	K050
	4932191187	19.04.2013	DIESEL	-183.25	KBJ 672W KBJ 672W	SGACHAGA	K050
	4932191188	19.04.2013	DIESEL	-50.64	KAV 841M KAV 841M	SGACHAGA	K050
	4932191189	19.04.2013	DIESEL	-321.27	KAL 331B KAL 331B	SGACHAGA	K050
	4932191190	19.04.2013	DIESEL	-169.03	KAU 376P KAU 376P	SGACHAGA	K050
	4932191191	19.04.2013	DIESEL	-42.63	KBM 045H KBM 045H	SGACHAGA	K050
	4932191192	19.04.2013	DIESEL	-63.96	KBQ 822P KBQ 822P	SGACHAGA	K050
	4932191193	19.04.2013	DIESEL	-177.73	KAU 372P KAU 372P	SGACHAGA	K050
	4932191194	19.04.2013	DIESEL	-145.99	KAU 545J KAU 545J	SGACHAGA	K050

7.4 Appendix D – Water Used Ratio (WUR) and Energy Used Ratio data

Nairobi Bottlers Ltd

YEAR	Months (X)	WUR	EUR
2009	Jan	3.8	0.53
	Feb	3.76	0.55
	Mar	3.79	0.51
	Apr	3.71	0.50
	May	4.1	0.61
	Jun	3.65	0.56
	Jul	3.75	0.56
	Aug	4.07	0.65
	Sep	3.77	0.53
	Oct	3.86	0.41
	Nov	4.05	0.45
	Dec	3.58	0.48
2010	Jan	4.23	0.53
	Feb	4.21	0.52
	Mar	3.8	0.55
	Apr	3.84	0.52
	May	4.11	0.58
	Jun	3.18	0.58
	Jul	2.96	0.54
	Aug	3.32	0.53
	Sep	2.71	0.52
	Oct	2.65	0.51
	Nov	2.7	0.5
	Dec	2.33	0.48
2011	Jan	3.29	0.48
	Feb	3.53	0.5
	Mar	3.24	0.44
	Apr	2.95	0.47
	May	2.82	0.5
	Jun	2.96	0.51
	Jul	3	0.49
	Aug	2.96	0.5
	Sep	2.9	0.49
	Oct	2.86	0.48
	Nov	2.95	0.52
	Dec	2.54	0.5
2012	Jan	2.75	0.47
	Feb	2.69	0.46
	Mar	2.67	0.46

WUR - Water Used Ration

EUR - Energy Used Ratio

	Apr	2.73	0.5
	May	2.71	0.51
	Jun	2.88	0.53
	Jul	2.79	0.53
	Aug	3.11	0.57
	Sep	2.88	0.51
	Oct	2.37	0.27
	Nov	2.67	0.47
	Dec	2.37	0.42
2013	Jan	2.57	0.48
	Feb	2.43	0.43
	Mar	2.63	0.44
	Apr	2.74	0.51
	May	2.63	0.58
	Jun	2.59	0.45
	Jul	2.59	0.46
	Aug	2.48	0.45
	Sep	2.4	0.43
	Oct	2.23	0.4
	Nov	2.43	0.41
	Dec	2.33	0.39
2014	Jan	2.23	0.38
	Feb	2.38	0.4
	Mar	2.31	0.4
	Apr	2.39	0.38
	May	2.33	0.41
	Jun		
	Jul		
	Aug		
	Sep		

7.5 Appendix E - Surface Ozone measured (ppb)

	2012									2013						
	JAN	JUN	JUL	AUG	SEP	OCT	NOV	DEC		Jan	Feb	Mar	Apr	May	Jun	Dec
1				16.6	23.4	31.5	24.2			26.1	30.3		25.8			
2				16.6	25.8	24.9	24.1			30	24.9		25.3			
3				17.5	22.2	30.6	19.9			30.3	19.5		33.8			
4				18	29.5	35.4	21.3			30.9	21.9		35.7			
5				21.6	27.7	32.3	25.2			35	26		37.1			
6				20.7	24.4	31.9	35.9			30.5	25.2		36.1			
7				18.8	19.3	30	29.6			26	27.3		32.8			
8				18.1	26.3	31.2	30.9			23.1	32.1		32.1			
9			24	28.6	25.5	37.8	21.1			21.1	32.6		33.5			
10			20.8	14.8	19.8	29.9	24.6			25.2	36.6		27.2			
11			21.4	19.6	23.1	25	26.1			27.6	32.8		22.4			
12			26.9	20.8	21.6	17.1	29.5			26.5	35.5		30.3			
13			23.4	20.8	21.6	17.5	36.2			28.7	31.3		29.9			
14			25.8	15.5	22.4	22.1	38.1			25.4	31.6		24.4			
15			23.8	26.9	21.8	27.1	33.2			18.7	36.6		21.6			
16			19.3	25.4	25.8	38.9	28.1			21.3	34.3		25.7			
17			23.4	18.9	23.5	30.2	21.1			21.5	31.9		25.1			
18			24.1	17.5	23.8	28.4	22.1			34	32.5		32.4			
19			17.8	23.3	21.3	27.4	30.5			32.7	33.8		23.9			
20			28.4	19	20.1	32.2	31.3			33.6	32.5		19.5			
21			24	20.8	18.9	20.8	31.4			33	35.4		25.3			
22			27.8	19.8	16.7	19.4	32.4			30.5	33.5		16.5			
23			29.3	19.8	24.4	22.6	32.3			28.7	31.7		20.6			
24			21.9	19.6	18.4	22.4	29.1			29.3	28.7		20.0			
25			23.4	25.2	23.8	34.4	26.2			28.3	25.4		19.6			
26			18.9	22.2	29.6	49.4	25			34.5	22.3		19.8			
27			21.5	17.8	22.6	41.4	26.5			30.9	25.7		26.3			
28			22.9	19.8	20.1	33.2	14.6			39.5	33		19.2			
29			21.7	22.9	16.7	31.5	29.2			30.3			22.3			
30			24.8	26.5	18.6	33.7	27			29.5			23.5			
31			22.1	32.1		27.4				35.1						
			23.4	20.8	22.6	29.6	27.6			29	30.2		26.3			

7.6Appendix F – Surface Ozone Equivalent Calculations (Kg)

YEAR	Months (X)	Amount of Diesel Consumed (D)	Amount of LPG Consumed (P)	Amount of CO produced during diesel combustion (Xd =0.29D)	Amount of CO produced during LPG combustion (XP =0.22P)	Total amount of CO produced (XT =(0.29D+0.22P)	Surface Ozone equivalent (C) C=1.7136(0.29D+0.22P)
2009	1	133936	10887	38842	2395	41237	70663
	2	124047	9457	35974	2080	38054	65210
	3	155217	10217	45013	2248	47261	80986
	4	126275	8777	36620	1931	38551	66060
	5	135345	8777	39250	1931	41181	70568
	6	153079	8423	44393	1853	46246	79247
	7	123649	6305	35858	1387	37245	63823
	8	121708	6961	35295	1532	36827	63106
	9	157164	12859	45578	2829	48407	82950
	10	122418	8489	35501	1868	37369	64035
	11	123604	8628	35845	1898	37743	64677
	12	177510	16312	51478	3589	55066	94362
2010	13	131909	20155	38254	4434	42688	73150
	14	139187	20774	40364	4570	44935	77000
	15	176410	24393	51159	5366	56525	96862
	16	124640	20949	36146	4609	40754	69837
	17	138936	21292	40291	4684	44976	77070
	18	169566	24187	49174	5321	54495	93383
	19	137161	19549	39777	4301	44077	75531
	20	128468	15221	37256	3349	40604	69580
	21	169987	23065	49296	5074	54370	93169
	22	156651	20604	45429	4533	49962	85615
	23	137088	16674	39756	3668	43424	74411
	24	204631	26486	59343	5827	65170	111675
2011	25	145880	18865	42305	4150	46456	79606
	26	135195	16073	39207	3536	42743	73244
	27	164493	22315	47703	4909	52612	90156
	28	150920	16088	43767	3539	47306	81064
	29	125513	15079	36399	3317	39716	68058
	30	179533	18442	52064	4057	56122	96170
	31	139634	14397	40494	3167	43661	74818
	32	132633	12949	38464	2849	41312	70793
	33	142789	15224	41409	3349	44758	76697
	34	137557	13833	39892	3043	42935	73573
	35	140214	18050	40662	3971	44633	76483
	36	195832	29032	56791	6387	63178	108262

2012	37	151964	17818	44070	3920	47990	82235
	38	148121	17247	42955	3794	46749	80110
	39	204456	23935	59292	5266	64558	110626
	40	153047	19634	44384	4319	48703	83457
	41	150161	13783	43547	3032	46579	79818
	42	172077	18045	49902	3970	53872	92315
	43	138734	13248	40233	2915	43148	73938
	44	140069	16556	40620	3642	44262	75848
	45	215340	25822	62449	5681	68130	116747
	46	165558	21105	48012	4643	52655	90229
	47	158120	20235	45855	4452	50307	86205
	48	237435	34907	68856	7680	76536	131152
2013	49	143492	23751	41613	5225	46838	80262
	50	148580	25751	43088	5665	48754	83544
	51	189871	26902	55063	5918	60981	104497
	52	164994	40256	47848	8856	56704	97169
	53	210758	23282	61120	5122	66242	113512
	54	176750	17684	51257	3890	55148	94501
	55	122697	20461	35582	4501	40084	68687
	56	193813	19649	56206	4323	60529	103722
	57	176897	25263	51300	5558	56858	97432
	58	210244	29401	60971	6468	67439	115564
	59	226669	30503	65734	6711	72445	124141
	60	258134	30398	74859	6688	81546	139738
2014	61	143492	18474	41613	4064	45677	78272
	62	148580	23183	43088	5100	48189	82576
	63	189871	30034	55063	6608	61670	105678
	64	164994		47848	0	47848	81993
	65			0	0	0	0
	66			0	0	0	0
	67			0	0	0	0
	68			0	0	0	0
	69			0	0	0	0