ROOFTOP RAINWATER HARVESTING AS ADAPTATION TO CLIMATE CHANGE: THE CASE OF MURANG'A EAST DISTRICT PRIMARY SCHOOLS IN MURANG'A COUNTY, KENYA

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A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ENVIRONMENTAL STUDIES (CLIMATE CHANGE AND SUSTAINABILITY) IN THE SCHOOL OF ENVIRONMENTAL STUDIES OF KENYATTA UNIVERSITY

August, 2013

DECLARATION

Student's Declaration

This Research Project Report is my original work and has not been presented for a degree or in any other university or any other award

Signature: ..... Date: 9/12/2013

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Supervisors' Declaration

We confirm that the work reported in this Research Project was carried out by the candidate under our supervision

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DEDICATION

This work is dedicated to my dear husband Mr. Wahogo Kimani and our daughters Faith and Hope whose love and encouragement has been pivotal throughout my course.

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LIST OF ABBREVIATIONS AND ACRONYMS

IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IRHA	International Rainwater Harvesting Alliance
KRA	Kenya Rainwater Association
MDGs	Millennium Development Goals
NGO's	Non-Governmental Organizations
NEMA	National Environment Management Authority
ROK	Republic of Kenya
RwH	Rainwater Harvesting
RRwH	Rooftop Rainwater Harvesting
SIDs	Small Island Developing states
SED	Seychelles Environment Department
SIF	Seychelles Islands Foundation
SPSS	Statistical Package for the Social Sciences
UN	United Nations
UNEP	United Nations Environmental Programme
UNICEF	United Nations International Children Emergency Fund
USAID	United States Agency International Development
WHO	World Health Organisation
WSSD	World Summit on Sustainable Development

ABSTRACT

Climate Change has a wide range of impacts and exacerbate existing poverty related problems such as availability of fresh water in developing countries. Kenya is one such country that experiences ramifications of climate change which heavily impact on the populace. This research was conducted in Murang'a East district in Murang'a County in Kenya. The study was primarily to establish the level of awareness on climate change and Rooftop Rainwater Harvesting (RRwH) in public primary schools. The main objective was to find out factors affecting the adoption of RRwH with a focus on level of awareness on climate change issues, awareness of RRwH among decision makers, sources of water supply and the constraints against adoption of RRwH. Using a descriptive survey design, a sample of 384 respondents was randomly selected. Data obtained from constructed questionnaires was collated and statistically analysed by use of SPSS. Results showed that there was a correlation between level of climate change awareness, economic activities, at (r_s = -.181, p = .000), and leadership the calculated statistic $\chi^2 = 7.890$ was found to be less than the tabled critical value of $\chi^2 = 8.132$ at α 0.080. Sources of water were significant to the assurance of supply $\chi^2 = 45.481$; df = 44.916, p= 2.61. The study found out that, lack of funds was the major hindrance to the adoption of RRwH in all the education zones. Lack of awareness and low education were other major factors contributing to non adoption of RRwH. The study concluded that the media was the leading medium of climate change effect information dissemination. Climate change effect has been felt on the ground with the respondents confirming that they had been affected. Climate change had affected water supply to schools leading to disruption of supply leading to increased waterborne diseases, lower standards of hygiene and reduced learning time. This study recommends that a multi-prolonged approach which entailed incorporation of climate change awareness into the education curriculum, greater sensitization, exploitation of church and the involvement of community leaders would serve the purpose of awareness creation. There is also a need to develop and to legislate for a framework for buildings to include provisions for RRwH.

CHAPTER ONE: INTRODUCTION

1.1 Background to the problem

Climate Change has a wide range of interrelated impacts on the environment. Its impacts are becoming an extra hardship to the existing poverty related problems. Extreme climate events such as increasing aridity, drought, floods, and stormy rainfall are expected to leave an impact on human society. For instance climate change is likely to produce a drastic decline in the amount of water available per person in many parts of the developing world (Thomas and Martinson, 2007). This is expected to generate widespread response to adapt to the sufferings associated with these extremes. Where these events are experienced communities will be forced to adopt new strategies to optimize the utility of available water (Pandey *et al.*, 2003).

Lack of water of adequate quality and quantity is a major constraint to development in many areas of the world. It affects every aspect of human life. Water quality and scarcity problems have therefore become of particular concern especially in the tropical regions of the world where many countries are less developed (WHO, 2010, Aroka, 2010). The UN (United Nations) recognise the role of water as a key to development. The 7th UN MDG (Millennium Development Goals) (insuring Environmental Sustainability) states that nations must work progressively to halve the number of people without access to safe drinking water and acceptable sanitation (Natharn, 2009a). In relation to this, UN Water asserted that, water scarcity issues and the way they are addressed will affect the successful achievement of the MDGs (Narthan, 2006). It is for this reason that "Water Scarcity" was identified as the theme of World Water Day in 2007. However while access to safe water and sanitation have been recognized as priority targets through the Millennium Development Goals (MDGs) and the Johannesburg plan of action of the World Summit on Sustainable Development (WSSD) in 2002, there is increasing recognition that this is not enough (Button 2007). It is for this reason that at the WSSD in 2002, the international community acknowledged the importance of the water scarcity challenge by adopting the short-term target of developing "integrated water resources management and water efficiency plans by 2005, with support to developing countries, through actions at all levels".

Agenda 21 also highlights the protection of quality and supply of fresh water resources where the general objective is to make certain that adequate supply of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors related diseases (Narthan, 2009b).

The Inter governmental Panel on Climate Change (IPCC 2007) also reported that water stressed regions are further threatened by climate change. It is predicted that climate change is a potential danger to future water and food security (IPCC, 2007). However one would concur with the assertion that it is imperative that the situations in many African countries are neither hopeless nor unmanageable (Aroka, 2010).

Rainwater harvesting (RwH) in response to climate extremes will most likely enhance the resilience of communities towards the resultant impacts. The world is confronting numerous changes due to climate variability one of them being the increasing risk of water stress. Communities must therefore have to build resilience to absorb these shocks and one way would be having sound knowledge on rainwater harvesting systems. This is because it is argued that where there is water on earth, virtually no matter what the physical conditions, there is life (Zhu, 2003).

Rainwater harvesting is not a new phenomenon as people from time immemorial have collected water from rooftops and from gullies that are filled by rain (Singwane and Kunene, 2010). It is asserted that the capture and utilization of rainwater is an ancient tradition dating back to similar techniques used in present day Iraq around 5000 years ago and modern methods usually represent improvements with respect to technical variations (Mbilinyi *et al.*, 2005). Archeological evidence attests to the capture of rainwater as far back as 4,000 years ago. It is reported that the concept of rainwater harvesting in China is as old as 6,000 years. Evidence has it that ruins of cisterns built as early as 2000 B.C. for storing runoff from hillsides for agricultural and domestic purposes are still standing in Israel (Dwivedi and Bhadauria, 2009)

Current experience has shown the effectiveness of RWH in poverty alleviation in developing countries. In China, the poor people do not even have access to these infrastructures in as much as they are located in the most unfavorable geographical

and topographical conditions. The experiences, not only in China, but also in Sri Lanka, India, Brazil and Kenya have shown that with rainwater harvesting, even the poor can have water because rain falls everywhere (Zhu, 2003).

The use of RwH is not only prevalent in developing countries but also in developed ones. For instance European countries are using rainwater harvesting for water supply for non potable use and irrigation and for ground water seepage. In fact, UK reported that the value of RwH industry doubled every year between 2005 and 2008. Germany reported 50,000 RwH professionals supporting the RwH industry (Salas, 2008) and also installation of over 80,000 systems per year (Roebuck *et al.*, 2011).

In Africa an example of RRwH school based project has been attempted in Seychelles. The country is one of the Small Island Developing states (SIDS) which are facing not only the challenge of rainfall variability but also contamination of fresh water resources due to sea water intrusion. The RwH project in local schools was developed as a means of adapting to the climate change and of dealing with water problems. The project has also been referred to as one which can be adopted in other countries and also as one of the "best practices" for climate change education projects (Larue, 2010).

Other examples within the African context include projects from the International rainwater Harvesting Alliance (IRHA) Blue Schools Programme. The project in schools in Mali and Ghana has shown a clear example on how to adapt to climate changes, assuring at the same time the necessary conditions for the healthy and safe development of children. Other projects in Nigeria, Ghana, and Mali are building on the achievements in these two pilot experiences for preparing better the population to adapt to the new climate reality (Taneja, 2010).

According to Kenya Rainwater Association (KRA), Kenya is among the water scarce countries of Africa and has also seen her water storage per capita deteriorate with time to critical levels. It is for this reason that The Government of the Republic of Kenya (RoK) is promoting rainwater harvesting and utilization (RoK, 2007). Rainwater harvesting is not new, as communities in Kenya have practiced it for a long time. There are many success stories that can be cited particularly in the arid and semi-arid areas of Kenya where rainwater harvesting has been replicated. Though it is not mandatory for institutional buildings to have rainwater harvesting facilities, many

institutional and government buildings such as hospitals have installed rainwater-harvesting facilities. To make rainwater harvesting sustainable, there is need to include the initiative in the national Integrated Water Resources Management strategy (Mati, 2010).

In epitome, adaptation should be recognized as a vital component of any policy response to climate change in our education institutions in Kenya in order to address the problem of water scarcity. RRwH can become a key intervention in adaptation (Barron, 2009) and is most likely going to reduce vulnerability of children in schools. Administrators in public primary schools in Kenya may be placed under considerable stress by the problem of water scarcity during prolonged droughts. It is against this background that this research was conducted with the intent of assessing the relationship between the level awareness of climate change issues and adoption of RRwH in public primary schools in Murang'a East District.

1.1.2 Benefits of roof water harvesting

The collection of rain water not only leads to conservation of water but also energy since the energy input required to operate a centralized water system designed to treat and pump water over a vast service area is bypassed. Rainwater harvesting also lessens local erosion and flooding caused by runoff from impervious cover such as pavement and roofs, as some rain water is captured and stored.

Roof water quality almost exceeds that of other conventional water sources like rivers and groundwater as it does not come into contact with soil and rocks where it dissolves salts and minerals. It is also not exposed to many of the pollutants that often are discharged into surface waters such as rivers, and which can further contaminate groundwater (Dwivedi and Bhadauria, 2009).

1.1.3 Water scarcity and children' vulnerability

Millennium Development Goal No. 7 addresses environment and water and one of its targets is to halve by 2015 the proportion of the population without sustainable access to save drinking water and basic sanitation. In relation to this implies provision of safe water for drinking as well as for hygiene. It is targeted that by 2015, integration of the

principles of sustainable development into country policies and programmes to reverse loss of environmental resources will have been achieved (RoK, 2007).

There is large potential to exploit rainwater in this context of human well being and especially of young children whom in most cases are more vulnerable than adults to environmental diseases, pollutants and environmental stresses. Children are more easily killed by a harsh environment and that is why there is very high child mortality rate, especially in developing countries. They need a lot of protection. It was suggested that all governments should be familiar with methods of providing clean water and education to children and where there is lack of resources, international co-operation is required (UNICEF, 1987). It is imperative that this would apply even in this era when the world is facing new challenges such as Climate Change.

Rainwater harvesting from roofs is a simple, low cost technique that has been practiced for hundreds of years. Rainwater can be collected from rooftops of schools and other public facilities and stored. Adoption of RRwH technology in public primary schools particularly in rural areas will most likely benefits vulnerable groups in the society especially children. The availability of potable drinking water and water for sanitation may reduce the incidence of water borne diseases, and also save children from the tedious work of fetching water (SED, 2010).

Connecting rainwater harvesting structures to primary schools and other community places will have an immediate capacity building effect and can easily be linked to environmental educational programme. Providing water in schools, through RRwH would also ensure that children go to school and learn without any interference that would result from frequent water shortages (Larue, 2010). In this sense, it would contribute to some extent toward the achievement of MDG 2 which relate to access to primary and secondary education. It is also argued that provision of rainwater and sanitation would increase girls' attendance in school. A study conducted among the Maasai community in Kenya reported that bringing water closer to their homes and to the school in particular had made their girls more confident. They no longer stayed away from school each time they had a monthly period which used to make them lose out on many lessons (Seidel, 2010).

1.2 Statement of the problem

Murang'a East district is vulnerable to particular climate change effects and challenges which include increase in temperatures and changes in rainfall patterns with short periods of heavy rainfall during the rainy season and severe droughts during the dry season being common occurrences (National Environment Management Authority, 2006). These effects have adverse impacts on the health and functioning of ecosystems and institutions as they affect the social and economic systems that are central to human existence (Seychelles Environment Department, 2010). Water scarcity is one of the problems resulting from climate change which is further compounded by the ever increasing demand for water occasioned by increased economic and social development as well as population growth. It is asserted that water is indeed an integral part of ecosystems functioning (UNEP, 2009).

One way of dealing with this global problem locally is by harvesting rainwater which is a free resource. It is argued that in the past people collected rainwater for their own home use and stored it for future use. Unfortunately with the development of treated water and distribution systems by public water supplies rainwater harvesting has been neglected (Larue, 2010) yet not all places have access to public water supply. This challenge is even worse in institutions that accommodate relatively larger numbers of people like schools and hospitals. If rainwater is harvested it is most likely going to bring several benefits such as cutting down on water bills, reducing dependency on water distributed by water supplying companies, help to conserve water sources and may also mitigate climate change through energy savings due to reduced pumping (UNEP, 2009). Therefore this study sought to establish whether awareness on climate change issues and on RRwH has any influence on the adoption of RRwH technology by decision makers in public primary schools. The administrators especially in public primary schools may be undergoing considerable stress due to water scarcity during the dry season. There is need to find out whether decision makers in public primary schools have considered harvesting rainwater as a matter of urgency.

1.3 Research questions

This research was guided by the following research questions:

(i) What is the level of awareness on climate change issues among decision makers in public primary schools in Murang'a East District?

(ii) What is the level of awareness on Rooftop Rainwater Harvesting among decision makers in public primary schools in Murang'a East District?

(iii) How are sources of water supply to public primary schools in Murang'a East District influenced by perceived climate change?

(iv) How are constraints against adoption of Rooftop rainwater Harvesting in public primary schools in Murang'a East District related to climate change awareness?

1.4 Research objectives

The objectives of this study were to:

(i) Establish the level of awareness on climate change issues among decision makers in public primary schools in Murang'a East District.

(ii) Investigate on the level of awareness on Rooftop rainwater harvesting among decision makers in public primary schools in Murang'a East District.

(iii) Find out if the sources of water supply to public primary schools in Murang'a East District are influenced by perceived climate change.

(iv) Determine the relationship between constraints against adoption of Rooftop rainwater Harvesting and climate change awareness in public primary schools in Murang'a East District.

1.5 Research hypotheses

The study intended to test the following hypotheses:

(i) Majority of decision makers in public primary schools in Murang'a East District are not aware of climate change issues.

(ii) There is no relationship between climate change awareness and adoption of RRwH by decision makers in public primary schools in Murang'a East District

1.6 Justification of the study

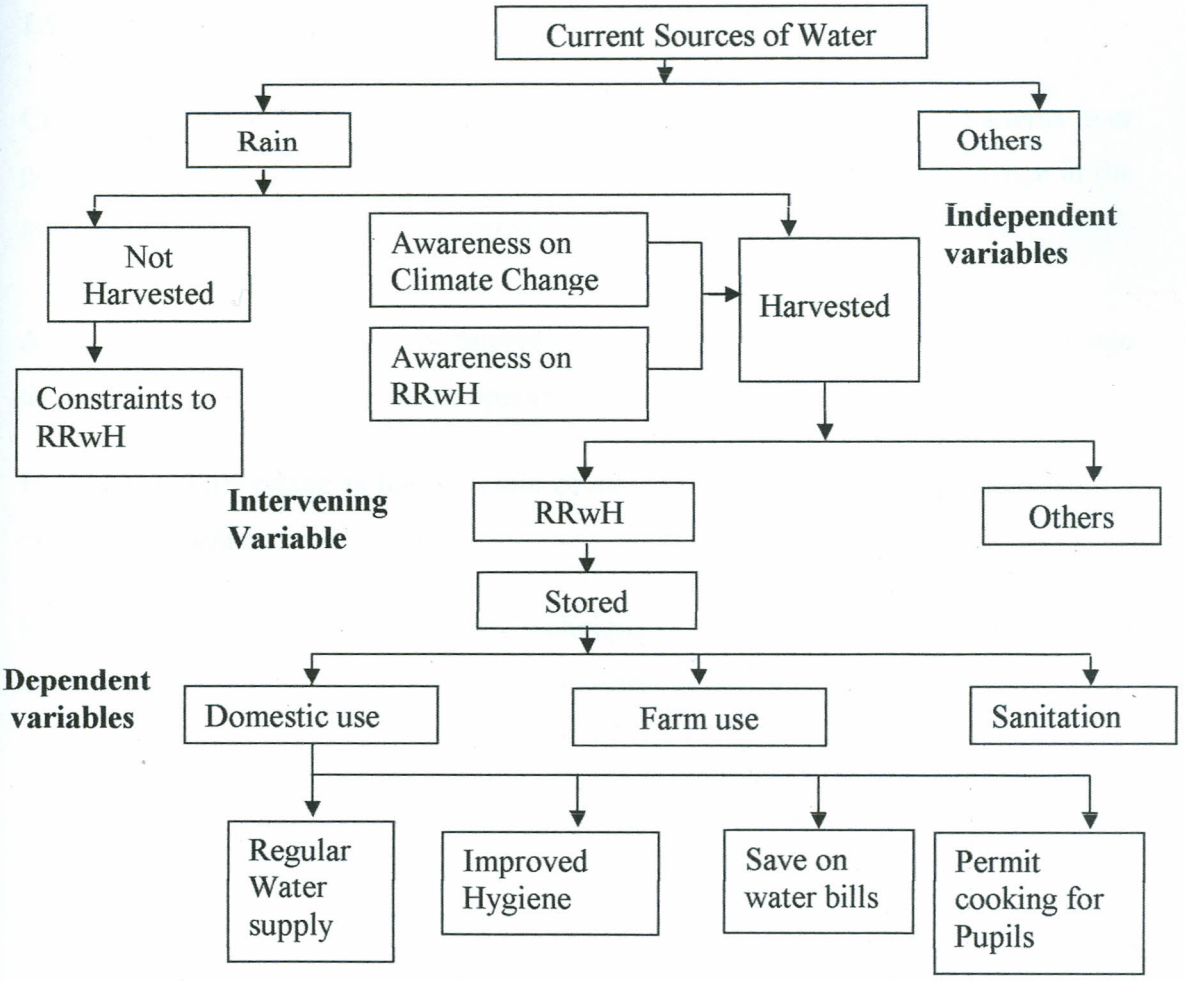
There is an urgent need for awareness on climate change in order to enlighten people on the dynamics of climate variability. Research on climate change will most likely promote awareness hence enabling advocacy. It is these facts that this work intended to provide. The study has provided decision makers in public primary schools with an assessment of the scope for intervention to hasten and in some cases unlock the process of adaptation in their schools. The study has revealed that our education institutions are suffering severe water shortages while they have high concentration of buildings from which they can harvest rain water. In most schools pupils obtain water from alternative sources which may be contaminated thus becoming a health hazard to school children. One can foresee the need for the ministry of education to integrate RRwH system in the design and construction of schools and other training institutions (UNEP, 2009). There is need to raise awareness on RRwH through all possible means as a matter of urgency.

1.7 Scope of the study

This study was conducted in Murang'a East district of Murang'a County. Murang'a County is in one of the 47 Counties in Kenya. The district lies in the eastern part of the county. These eastern lower parts of the county receive relatively low rainfall as compared to other parts of the county (National Environmental Management Authority, 2006).

1.8 Conceptual frame work

Rooftop rainwater harvesting may be considered as a mitigation measure towards water scarcity. It is asserted that to solve the problem of limited water supply, alternative measures of obtaining water have to be considered (Larue, 2010) by the decision makers in the Ministry of Education as a matter of urgency in order to supplement conventional methods of water supply.



Source: Author 2013

Figure 1.1 Conceptual frame work

1.9 Definitions of terms

Climate change is the long term change in the distribution of weather patterns over periods of time that range from decades to millions of years. It may be change in the average weather conditions i.e. a change in the distribution of weather events

Adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate.

Rain water harvesting is the principle of collecting and using precipitation from a catchments surface.

Rooftop rainwater harvesting is the technique through which rainwater is captured from the roof catchments and stored in reservoirs.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Rooftop rainwater Harvesting is the technique through which rainwater is captured from the roof catchments and stored in reservoirs for future use (Thomas and Martinson, 2007). This section provides a review of books, report, journals and dissertations that are related to rooftop rainwater harvesting as adaptation to climate change. More attention is given to schools as it is asserted that the climate change adaptation should and can start in schools. On one hand, decision makers should aim at forging the consciousness and habits of the future citizens. On the other hand, they must transform the project site, a school in a village or in a town, in a platform for work with the population (Taneja, 2010). Therefore this shows that the most important work at grassroots level will most likely begin in schools.

2.2 Climate change awareness

In this era of the global crisis represented by the climate change, its causes and consequences must become more and more important in the public debate agenda. Majority now consider climate change as the most relevant problem at global level, second to poverty in the developing world. It is argued that climate change impacts are now likely to rank before other potential sources of worry such as economic crisis (Grasso *et al.*, 2011). Promoting social change to address climate change is likely to face challenges but is ever more pressing. As argued earlier, involving the youngster is of crucial importance to help transforming the culture of future generations, showing them the impacts of human activities on earth resources (Moser and Dilling, 2007).

A major concern is that public awareness creation on climate change themes is not constant as it tends to increase or decrease following weather fluctuations especially in the media. For instance media attention has demonstrated peaks in public concern during hot summers in Europe (Grasso et al., 2011) therefore the topic of climate change is poorly understood. This is likely going to pose unique challenges in terms of public attitudes and responses to actions that would affect global climate change (Bord *et al.*, 1998).

Information plays an important role in awareness rising but it is not enough for attitudes and behaviour change. Climate change awareness in schools will most likely provide an opportunity for stakeholders and students to meet with experts who illustrate to them "how and why" the global climate change starts and "what and where" the mark of local impacts are evident in their territory (Hargreaves *et al.*, 2003). This would mean localizing the information to make it relevant and make both the stakeholders and youngsters in schools feel more engaged. Some research on climate change perception show that one difficulty in engaging people with climate change issue and environmental-friendly behaviour is related to the global dimension of climate change phenomena. It has been argued that intangible global effects became real only when put in local terms (Lowe *et al.*, 2006).

Another approach that has been suggested is the use of visual language to raise attention through exhibitions as a way of communicating information on climate change. It is asserted that visual representation can convey strong messages and make complex concepts easier to remember; they also raise awareness and can play a fundamental role in motivating people (Nicholson-Cole, 2005). This can be done using big images accompanied by short text to illustrate the problem. These can be pictures of local environment and visualization of future impacts at regional and local level. These will most likely involve students and emotionally engage them to act (Grasso *et al.*, 2011). This has been demonstrated by a project in Seychelles where through the participation of both teaching and non teaching staff climate change knowledge reached the general public through exhibitions in schools where stakeholders were invited (Larue, 2010).

It has also been suggested that teachers and experts can make climate change information fun by engaging the youngsters in quizzes and contests. For instance by presenting easy statements on climate change and impacts and then inviting students and other stakeholders in schools to guess if they are true or false. Such quizzes not only can help experts to have a quick idea on their views on climate change but it can also be a fun way to seize their attention. It can be a good start (Bord *et al.*, 2000).

In Kenya Part III of the Climate Change Authority Bill, 2012 which covers 'climate change programmes and response strategies' puts emphases on formulating and coordinating the implementation of national and county climate change programmes. This will be made available to the public in both print and electronic form. There is also a plan for education and creation of awareness including integration in the education curricula (RoK, 2012).

Kenya is one of the countries that is in the forefront of establishing a Climate Change Management Authority. The process of establishing the authority has been put in place by way of legislation (RoK, 2012). The bill seeks to put in place the legal framework for the ensuring of a product management and coordination of the climate change awareness activities nationally. It equally seeks to put in place a national register for carbon and a comprehensive law to mitigate carbon emissions and ensure improved energy efficiency. This is with the aim of having well regulated climate change awareness creation form without duplicity of roles and a defined structure for the scene.

The lack of linkage and acknowledgement between the phenomena of climate change and climate variability is a tough call for all the stakeholders. This has been a cause for lack of awareness as regards, the opportunities that abound. Greater sensitization and the involvement of the corporate sector player in varying initiatives to mitigate climate change may go a long way towards the changing the face of the country (Atsiaya, 2011). Opportunities abound in the carbon trading only in the event of the awareness creation as regards climate change and the essence of having mitigating efforts in place to help arrest the situation. Exploitation of the same on awareness creation will create a new revenue stream for the nation with regard to foreign exchange.

The national strategy for climate change of the year 2005, envisaged the mainstreaming of climate change information in the schools curricular. It sought the involvement of bodies charged with the mandate of climate change awareness creation and mitigation like NEMA to form linkage with the curricula developers with an aim of actualization of the programme, (RoK, 2005). This concurs with works by (Ashimalla, 2011) who argued that the proactive approach by the institutions of

higher learning by way of having disciplines identifying with climate change has changed the situation by way of having greater sensitization and awareness creation.

A concerted approach whereby the policy makers are sensitized on the need to give impetus and greater emphasis to issues of climate change has served the purpose of creating greater awareness. This has seen the members of parliament with the seriousness that they deserve (Otichillo, 2012). This has aided the fast-tracking of the climate change issues on the floor of the house and aided the committee on energy and climate change of the house have a better focus on the issues that pertain and concern the citizenry in relation to climate change. This is in agreement with the national climate change managers like the permanent secretaries and other professionals in the quest of climate change awareness creation and management.

Finally it has been argued that even if people seem to have a general knowledge for climate change, it seems there is a low level of commitment to change behavior in relation to its cause. If people cannot see the relation between their actions and climate change, they would not feel enough engaged in doing any change (Lorenzoni and Langford, 2001).

2.3 Climate change impact on water supply

Climate change has had the implications of bringing along water scarcity. Pastoralists communities have had the pain of fighting for the available meager resources at their disposal at many times. Perennial conflicts over pasture and water have risen and this can be attributed to climate change, (International Fund for Agricultural Development (IFAD, 2012). The presence of hostilities among pastoralists communities has become a threat to national stability owing to the fights for the available resources and the lack of a clear-cut plan of management with regard to putting in place effective mitigation measures. Process of awareness creation and efforts to conserve the available resources may help reduce the pressure on the already minimal resources and check the situation of intercommunity fights.

The destruction of the five-water towers in Kenya which are Mt. Kenya, Mt. Elgon, Aberdare Ranges, Mau Complex and Cherangani Hills has had bad implications on the supply of water to institutions and households. This can be attributed to the fact that with less supply from the water towers, the water sources like rivers, underground

sources like wells, springs and aquifers have to bear the brunt of over-exploitation, (Kisia, 2010).This has caused many households the pain of spending a lot of resources in ensuring the supplies which would have been best put into more pressing needs for the households. The need to enlighten the masses on capacity to harness resources from the rain may translate to lesser costs for them.

Many households in the arid areas of the country suffer from the pain of having the members walk long distances and in many instances around five kilometers or more in search of water. Time which would have otherwise been put into more productive activities is instead channeled into looking for water for the households. The event impacts negatively on the capacity of the households to grow their economic bases by virtue of the fact that time are a very precious resource (Kande, 2009). Women and children are deprived of quality time to study and attend to other chores. This way may cause great pain and retardation to the households and the communities at large and it can only be checked by way of the adoption of more eco-friendly ways of sourcing for the precious commodity like the harvesting of rainwater in the rainy seasons from the rooftops.

2.4 Rooftop rainwater harvesting awareness

Climate change has continued to transform flourishing landscapes into deserts. Communities must start to collect the precious raindrops as they are now faced by new conditions of emergency like water scarcity. People may be willing but they do not know where to start from to improve the water situation in the world. Few states in the world have existing regulations facilitating the wide spreading of rainwater harvesting (Taneja, 2010).

Many schools presently do not have a reliable source of water for drinking and other use. The school rooftop rainwater harvesting system seeks to provide a source of water for all purpose such as toilet flushing, cooking, washing hands before eating and after toilet use, hygiene and finally if the rainwater is treated well for drinking purpose (Larue and Dupres, 2009).

The successful implementation of rainwater harvesting in a school will be the best way to access to people's consciousness however there is limited technical capacity to

support rainwater harvesting best practices (International Resource Group, 2009). RRwH will most likely lead to reduction of monthly water bills, improve hygiene and thus preventing the risks of waterborne diseases outbreaks among school children and this illustrates the economic benefits of the adaptation action to the national healthcare system (Barron, 2009). Children would also have the opportunity to participate in a variety of climate change activities such as tree planting. These can help them understand the relationship between climate change and water better hence building skills of young people to take actions to adapt to climate change. It is also suggested that training and capacity building workshops to all stakeholders in the schools would be of great importance as this would create awareness on climate change and its impact on the water sector. Another effort that that has been suggested is training local masons to build up simple rainwater harvesting systems in institutions as they construct buildings as this may also work at enhancing rainwater harvesting (Larue, 2010).

When it rains the children cannot go into the garden or play games in the field. It is asserted that devices like rainwater harvesting systems and water storage tanks can help children become aware of the environmentalism aspects of rain which they would otherwise regard as negative. For example during a student conference in Germany a reporter was proud to announce that after half a year of reliance on harvested water, bills reduced by 30 %. The money saved was given to a water project of development in Guinea/Africa (Koenig, 2003).

Another initiative also cited is the schools irrigation projects by the rainwater from the roof of the school for irrigation of vegetables. The vegetables which are harvested are used in the kitchen of the school's kitchen. Such projects can be exhibited during parents meetings or environment awareness days. Teachers can encourage youngsters to give presentation to the public on how the school can make some contribution to the natural water cycle. Through such projects students are proud to show the adult world what can be done for environmental protection as the basic provision for the continuing existence of mankind (Koenig, 2003).

In Karnataka in India there is one of the world's largest rainwater harvesting project. In this state a systematic training and awareness programme was conducted for all the stake holders across the state at various levels. This involved officers at the planning

level in the government to plumbers and masons in the field at a remote village. A series of training programmes were conducted at divisional level and subsequently at district level during the beginning of the programme. In addition to building capacities and training technicians, education and communication materials were developed to support the programme (Shivakumar, 2007). This shows that in this Indian state trained engineers, planners, contractors, plumbers and officials are involved in the installation of RWH systems in schools and monitoring the programme.

In Kenya an expert in KRA reported that through group discussions with Community Based Organizations, they have identified some challenges and constraints that affect replication and sustainability of RWH technology. Though RWH technology is an old established art in Kenya according to KRA it has not been applied to its fullest potential. This is due to existing by-laws, lack of awareness by planners, policy makers, beneficiaries and engineers (Wanyonyi, 2002).

Rooftop rainwater harvesting has had the effect of changing the economic mainstays of many households in the areas that it is practiced. It has greatly affected the capacity of the populace to have effective afforestation programmes at the households' levels and equally improved the sanitation facilities and capacities at the households' levels. This has impacted positively on the household budgets in that a lot of savings have been realized in terms of the cost of fetching water from unknown and unreliable sources (Ngera, 2010). This has allowed the pupils in the households more ample time for study on their own privately and their good health by way of reduced incidences of water borne diseases.

Engagement in agroforestry has raised the profiles of households and communities at large on the adoption of rooftop rainwater harvesting. A test-case of Subukia in Nakuru County whereby we have had sandy loam soils prone to erosion and the lack of fodder for the available livestock has changed with the initiative to have large brick water storage tanks with a capacity to hold fifty thousand liters put up (Mbilinya 2011). The tanks are an initiative of the local women groups whose members had borne the brunt of the lack of water but whose innovativeness has changed their fortunes for the better on the availing of manpower to get up the tanks and infrastructure provision for the collection of water. This has seen better output for

their dairy projects and reduced soil erosion owing to the afforestation efforts. Greater emphasis should be made to create awareness to local communities on their capacity to exploit the power in numbers and realize their own reawakening.

The KRA emphasizes on information documentation and dissemination to increase awareness on the benefits of Rainwater Harvesting Management among stakeholders. The association also stresses on the improvement of rainwater harvesting information through exhibitions, electronic and print media and demonstration training in schools and other public places. The objective is to advocate for rainwater harvesting policy among decision makers, develop collaborative linkages with other organizations like government departments, private sector, NGOs CBOs (Community Based Organizations), Faith Based Organizations and development partners (Mati, 2010).

2.5 Sources of water to schools

According to a KRA report the horn of Africa experienced one of the most severe droughts in the last 60 years in 2011. KRA works with communities throughout Kenya to provide technologies that will increase their resilience to the effects of climate change. Without clean water communities including schools in rural areas open themselves to outbreaks of water borne diseases like cholera, typhoid, hepatitis A, and diarrhea which are caused by inadequate water and sanitation. Drying water sources forces people to use heavily contaminated. This may result to waterborne diseases if ingested. The problem with access to clean water and sanitation go beyond health and sanitation and uniquely affect learners' performance (Aura, 2011). Children have been spotted drawing water from rivers and dams oblivious of the danger they are exposed.

Some of the problems existing in schools in rural Kenya are lack of access to safe water. They depend on frequently interrupted central water supply system from the government. This causes children to spend more time going to fetch water, in the long run they end up skipping valuable learning time as they have to walk long distances to search for water. If the issue of shortage is addressed and solved completely, many of the school going children would be able to comfortably go to school without worrying about caring water from home or going to fetch water from the river.

2.6 Constraints to water harvesting in schools

Many decision makers in education institutions may not be aware that climate change impacts such as water scarcity is not short-term. Earlier projections had estimated that 400 million people would live in countries facing severe water scarcity in Sub Saharan Africa (Singwane and Kunene, 2010). Today the situation is likely to be worse and therefore as it is asserted, the new conditions of emergency call for consideration of alternative measures of obtaining water. However few states in the world have existing regulations to facilitate the wide spreading of Rainwater Harvesting (Taneja, 2010).

The national economic scene is awash with success stories of rooftop rainwater harvesting. A housing project in Athi-River, Kenya which is within the metropolis has excelled by way of having rainwater harnessed, qualified and stored in underground water tanks for the purpose of augmenting the commercial supply and sewerage company. The initiative has had the benefit of the members of the scheme greatly saving a lot of money in their monthly bills, (Owino, 2012). The initiative is a test-case of how the rooftop rainwater can be harnessed and exploited to ease the cost of living for households especially so in the urban and peri-urban areas. It is an indication of how investors should plan and execute their projects with an open mind and with innovativeness with regard to utilities provision as the driving factor.

The need to design more eco-friendly buildings cannot be underscored. Greater emphasis should be placed on the harnessing of the natural resources like solar and rainwater on the provision of the basic utilities in the name of light and water. Exploitation of the natural resources will ease the pressure on the national power grid and water supply pipeline. It will ensure the consumers of lesser disruptions of supply on the periods of shortage and equally have cleaner and more efficient supply systems, (Okal, 2011). Provisions for legislation to only approve building plans of eco-friendly buildings would do the building and development industry good in that many developers are fully aware of the essence of it but are just ignorant and oblivious of the need and this is an attitude which they certainly need to overcome.

Lack of awareness on the use and application of rainwater harvesting among stakeholders and the benefits of rainwater harvesting could be a major drawback that leads to loss of the precious rain drops from the roofs in education institutions.

2.7 Adaptation to climate change by adopting rainwater harvesting

Today there is no doubt that the environmental health of the planet is in a critical state. Water, is becoming inaccessible for many people and it is obvious that old patterns of its management must be changed. This is the case because conventional water supply systems are now not adequate to meet the water demands of large and rapidly expanding human populations (Singwane and Kunene, 2010). The impacts are more severe in institutions like schools and hospitals which deal with relatively large populations. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change.

Adaptation is now widely recognized as a vital component of any policy response to climate change. It refers to adjustment made in natural or human systems in response to actual or expected climate stimuli or their effects in order to moderate harm or make use of beneficial opportunities (Bryan *et al.*, 2011). It is asserted that efforts must be made to increase the adaptive capacity to increase resilience by enabling the changes caused by climate variability to have positive or limited impacts. Building resilience of human society to deal with impacts such as water scarcity will very likely depend on sound knowledge on rainwater harvesting systems. This is because it is asserted that where there is water on earth, virtually no matter what the physical conditions, there is life (Pandey *et al.*, 2003). Rainwater harvesting has been recognized as a coping strategy for variable rainfall. This is because it is argued that the present and the future climate change will most likely increase rainfall variability and evaporation, and population growth will increase demand on ecosystem services, in particular for water (Barron, 2009). Rainwater harvesting is therefore likely to become a key intervention in adaptation and reduced vulnerability. Awareness must be increased by practitioners and decision makers alike, to realize the potential of rainwater harvesting and its benefits. In fact rainwater should never be wasted and allowed to flow out of any community or institution facing a shortage of drinking water.

2.8 Historical adaptation to water scarcity in relation to climate change

The use of RWH is not only prevalent in developing countries but also in developed countries. The successful rainwater harvesting experiences, in China, Sri Lanka, India and Brazil showed that with rainwater harvesting, even the poor can have water because rain falls everywhere (Zhu, 2003). Many European countries are using rainwater harvesting for water supply for non potable use and irrigation and for ground water seepage. In fact, UK reported that the value of RWH industry doubled every year while Germany reported 50,000 RWH professionals supporting the RWH industry (Salas, 2008).

Rooftop rainwater harvesting is mandated by law for all buildings in Bermuda and is the primary source of water for domestic supply. This British overseas territory is located in the North Atlantic, 1,015 km west of North Carolina in the United States (U.S.). Every building in this island has a roof catchment to collect rainwater and associated water storage (Rowe, 2011). It is worth noting that this is mandated under The Public Health (Water Storage) Regulation in this small island territory. It is reported that in many households, this system of rainwater harvesting meets all of their water supply needs although supplementary water is required, either on a regular basis, due to a small catchment area. The Indian government has also passed a legislation whereby no houses can be built without the provision of a rainwater-harvesting technology (Singwane and Kunene, 2010).

In Kenya rainwater harvesting and storage for domestic, animals and irrigation was cited central to food security, livestock production and improved health of our people (RoK, 2011). It is argued that rainwater harvesting would provide water for domestic use and farming, thereby enhancing food security and moving the country toward achieving the Millennium Development Goals. Ksh. 475 million as a conditional grant under the Ministry of Education for 1,900 schools was allocated (RoK, 2011). This initiative is expected to expand access to clean drinking water thereby improving the health of our children.

The Kenya Vision 2030 also recognizes that efficient water management will not only contribute to sustainable long term economic growth, but also to poverty reduction, health and security. This is because Kenya is a water-scarce country with renewable

water per capita at 647 m^3 against the United Nations recommended minimum of 1,000m^3 (RoK, 2007). In relation to this strategic thrusts towards ensuring water and sanitation availability and access to all have been laid one of them being developing innovative community based methods and technology for water harvesting. This is what this study hope to address with specific focus being placed on public primary schools capturing and storing run-off water from rooftops in an effort to ensure access to clean drinking water for our children.

2.9 Gaps in knowledge and the specific gap that the study investigated

Past attempts to address this issue failed to reveal the level of awareness on climate change issues among decision makers in learning institutions that adopted Rainwater harvesting. The review of literature has revealed that most of the projects especially in Africa were initiated either by domestic organizations or Non Governmental Organizations. There was no attempt to find out if the communities or institutions had either any awareness of climate change issues or on RRwH. This is the first question this study sought to answer. The study also investigated whether the respondents were able to link water scarcity and climate variability. The constraints to adoption of RWH technology were also identified and the study sought to find out if they were related to awareness to climate change issues.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter focuses on the research design and the methodology adopted. It defines the research design and outlines the sample used and the criteria for selection. It also describes the research instruments used and procedures for their administration to the target population. Finally it outlines the methods adopted in the analysis of data.

3.2 Study area

This study was based in Murang'a East district in Murang'a County (Appendix 6). This is one of the 47 Counties in Kenya. It lies between 0° S and 1° S and longitudes 36°E and 37°E. Murang'a East district lies in the eastern part of the county which experiences semi arid conditions where most parts correspond to agro ecological zone 4,5 and 6 (low potential). The area also receives less rainfall as compared to other regions in the county (NEMA, 2006). There are 53 public primary schools with a total enrolment of 21580 pupils at the time of collecting data. The area has 5 administrative locations. Majority of the residents live in rural areas and their children attend public primary schools.

3.3 Research design

Descriptive survey design was used in this study. This was considered as a relatively better approach that could be used to get the results of the study without manipulating the results. The descriptive design can be used when research problem is specific and the emphasis is determination of how the problem is influenced by the different variables being looked at in the study (Orodho, 2009). The researcher used both primary and secondary data. Primary data was obtained using questionnaires and secondary data was gathered from the internet, journals and books.

3.4 Target population

These were all the public primary schools in Murang'a East district Table 3.1. The study targeted public primary schools because decision makers in these institutions may differ with those of private schools. The district is divided into 5 locations namely Kimathi, Gaturi, Gikindu and Mbiri and Township Table 3.1.

3.5 Sampling procedures

Proportionate sampling was done to get the number of respondents required per location so as to get 384 respondents. The number of respondents per school was then be determined by dividing the number of respondents required per location by the number of schools in each location.

Table 3.1 Target population and sample size

Administrative locations	No. of public primary schools	No. of students	No. of respondents per Loc.	No. of respondents per school.
Township	7	5905	105	15
Mbiri	11	3947	70	6
Kimathi	12	3169	56	5
Gikindu	11	2788	50	5
Gaturi	12	5781	103	9
Totals	53	21580	384	

Pupils were selected through systematic random sampling using class registers. The classes were selected by simple random sampling. The selected pupils were matched with parents who were the respondents. This study chose parents because they are the key decision makers in public primary schools and teachers are most likely to be parents in primary schools where they are teaching and are likely to be picked.

3.6 Sample size

At the time of collecting data there were over 10,600 primary school pupils in Murang'a East District. To ensure that the characteristics of the sample reflect the characteristics of the population, a proportionate sample was considered. In this study the expression below was used to determine the sample size. Since there is no estimate available of the proportion in the target population assumed to have the characteristics of interest, 50% was used (Mugenda and Mugenda, 1999) of the population of pupils.

Where,

$$N = \frac{Z^2 pq}{d^2}$$

Where N is the desired sample size (if the target population is greater than 10600),

Z is the standard normal deviate at the required confidence level, p is the proportion in the target population estimated to have characteristics being measured, q is (1-p) and d, the level of statistical significance set.

For this case, if the proportion of a target population with is 0.50, the z-statistic is 1.96, and desired accuracy at 0.05 level then the sample size is: $\frac{(1.96)^2(0.50)(0.50)}{(0.05)^2}$;

Therefore N=384

3.7 Research instruments

Structured and semi structured questionnaires were prepared and administered to the respondents. Questionnaires have the benefits of ease of analysis and are easy to administer as compared to others like interview schedules in terms of time as one may cover a wide area (Kombo and Tromp, 2009). Guided direct observation was done to compliment information solicited through the questionnaires. Checklists were prepared and used to assess the presence of rooftop rainwater harvesting infrastructures in the schools. Focus group discussions were conducted with 10 teachers from each location who were selected randomly in order to capture their views. An interview was also conducted between the researcher and the County Director of Environment.

3.8 Data collection procedure

Data was collected using structured and semi-structured questionnaires. Focus groups discussions were organized to get the views of teachers. Checklists were used to assess rooftop rainwater harvesting infrastructure in selected schools. Guided direct observation was also done to compliment information solicited through the questionnaires. An interview with the County Director of Environment was also conducted.

3.9 Data analysis

Data obtained from questionnaires were collated and statistically analysed by use of Statistical Package for the Social Sciences (SPSS). Results were discussed and presented in graphs and tables.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Preview

In this chapter the results of the present investigation are presented. The research set out to explore rooftop rainwater harvesting as adaptation to climate change; a case of Murang'a east district primary schools in Murang'a County. The study sought to answer the research questions as set out in Chapter One Section 1.3.

4.2 Characteristics of the Respondents

The study sought views from 384 respondents with a wide range of demographic characteristics. These characteristics are summarized and presented in this section.

4.2.1 Pupil's enrolment and their distribution in education zones in the district

The distribution of learners in the five education zones in Murang'a East district was as captured in fig. 4.1.

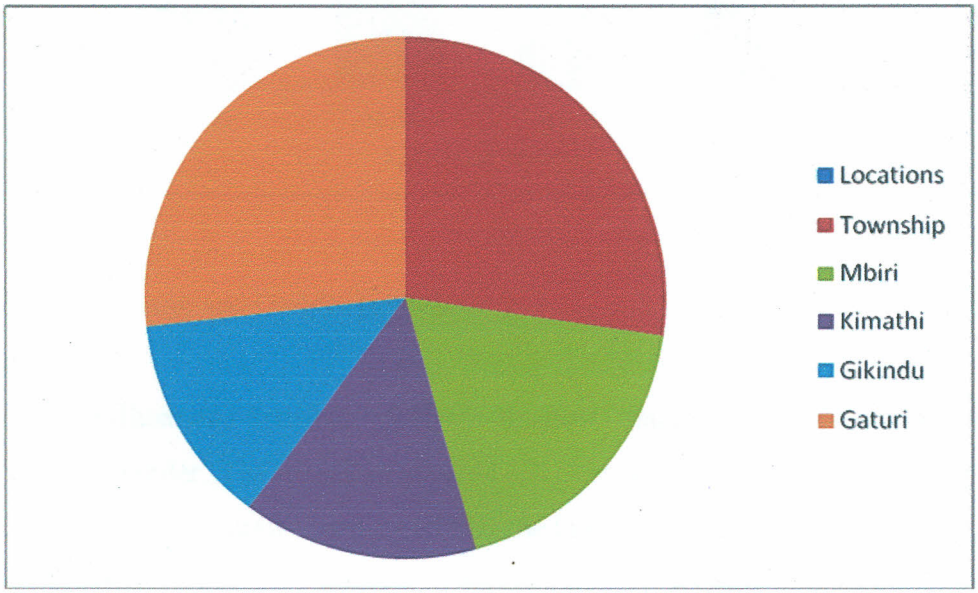


Figure 4.1 Pupil's enrolment and their distribution in the education zones

The responses as shown in fig. 4.1. above indicated that township education zone had 5905 pupils who accounted for 27%, Mbiri had 3947 pupils accounting for 18%,, Kimathi had 3169 accounting for 15%, Gikindu 2788 accounting for 13% while Gaturi had 5781 pupils accounting for 27%. The total population of primary school

pupils in the district was thus 21580. This is an indicator of a critical mass in terms of numbers requiring water for their daily use while in schoool to ensure nourishment and proper sanitation. It calls for the need to innovate and work towards enssuaring a regular supply of water.

4.2.2 Age and gender

Distribution of the respondents in terms of age and gender was as captured in fig. 4.2.

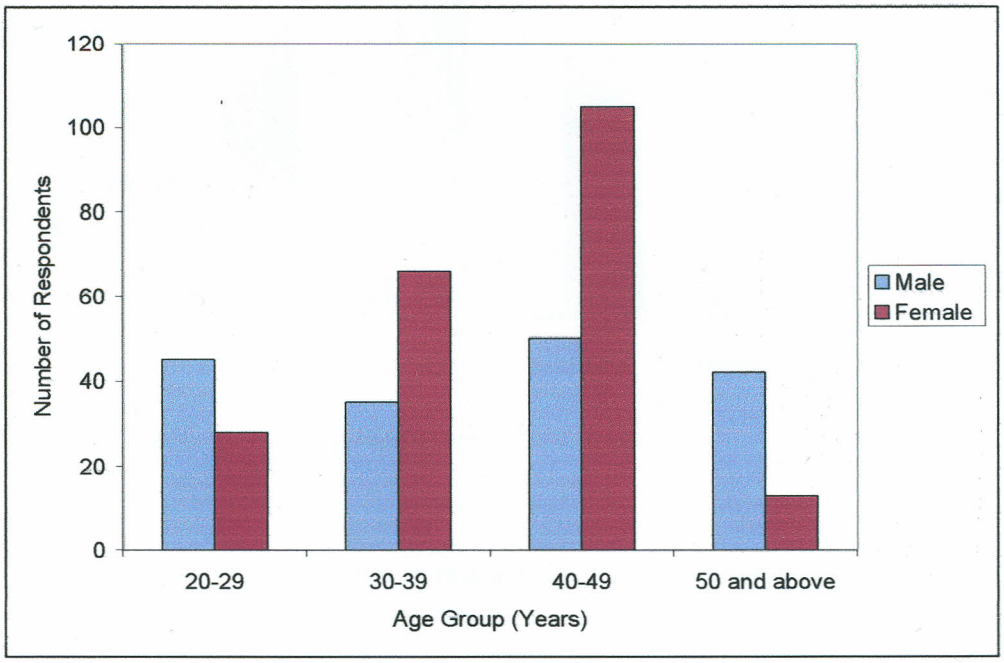


Figure 4.2 Age and Gender (n=384)

Fig. 4.2 illustrates distribution of the sampled respondents in the varying age groups for each gender. The response showed a higher participation of female respondents in the study and it equally confirmed that the bulk of the respondents were aged between 40-49 years. This may suggest a more assertive female population than the male population owing to their greater participation in the study. Majority of the respondents were aged between 40 – 49 years and they fall in the middle age bracket. This is reflective of a situation whereby the members of the age group are more informed and responsible.

4.2.3 Level of education in relation to climate change awareness

The respondents' levels of education in relation to climate change awareness was as shown in fig. 4.3.

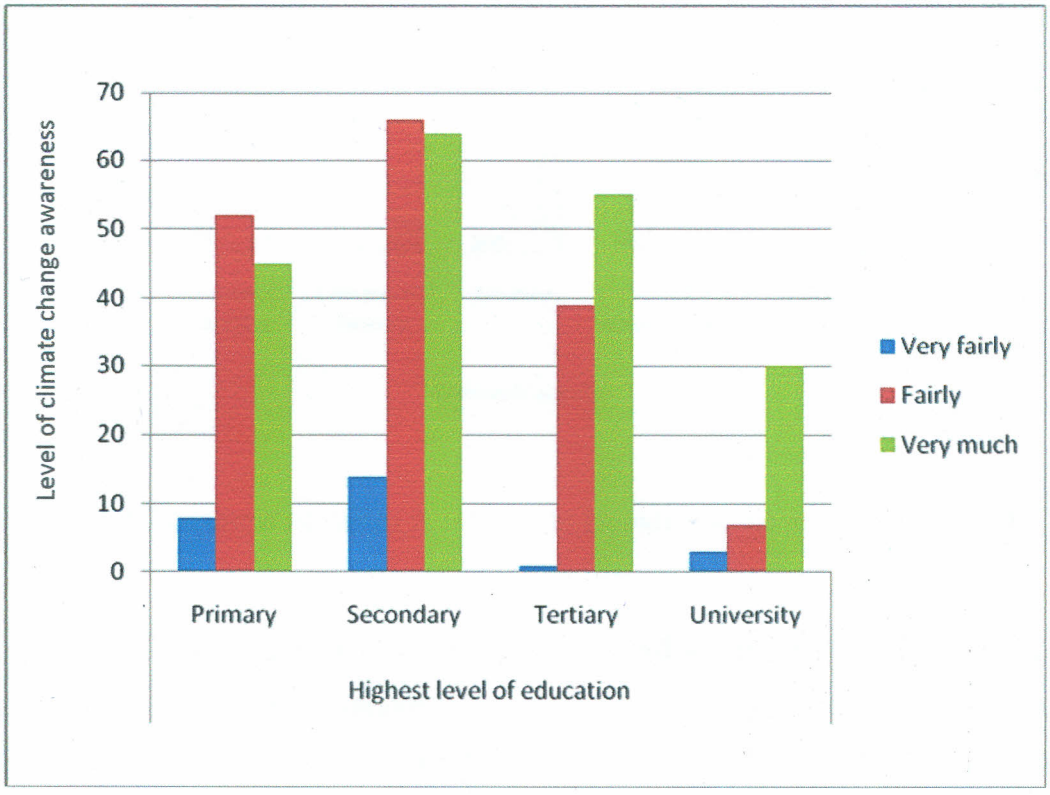


Figure 4.3 Level of education in relation to climate change awareness (n=384)

Fig. 4.3 shows that most of the sampled respondents had secondary school education as the highest level. The study confirmed that education levels greatly impacted on awareness level by virtue of the fact that the higher the level of education the greater the awareness as shown. A Spearman's Rank Order correlation was run to determine the relationship between level of climate change awareness and level of education. There was a correlation between level of climate change awareness and economic activities, which was statistically significant ($r_s = -.181, p = .000$).

4.2.4 Economic activities in relation to climate change awareness

Fig. 4.4 shows the relationship between the respondents' economic activities and climate change awareness.

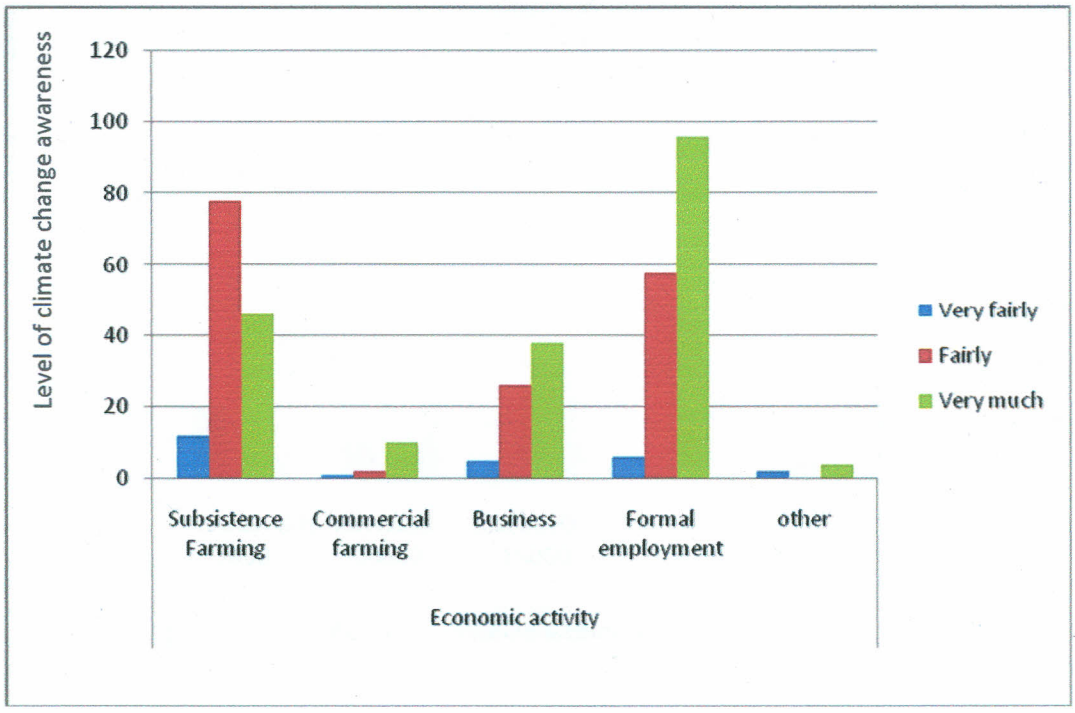


Figure 4.4 Economic activities in relation to climate change awareness (n=384)

The study confirmed that economic activities had an impact on the climate change awareness levels. The respondents engaged in formal employment and subsistence farming had the greatest awareness levels respectively. This may be attributed to levels of enlightenment and special interest to the prevailing weather and climatic patterns. A Spearman's Rank Order correlation was run to determine the relationship between level of climate change awareness and economic activities. There was a correlation between level of climate change awareness and economic activities, which was statistically significant (r_s = -.214, p = .000).

4.2.5 Household incomes in relation to climate change awareness

Fig. 4.5 shows how the respondents' household incomes per month relate to climate change awareness

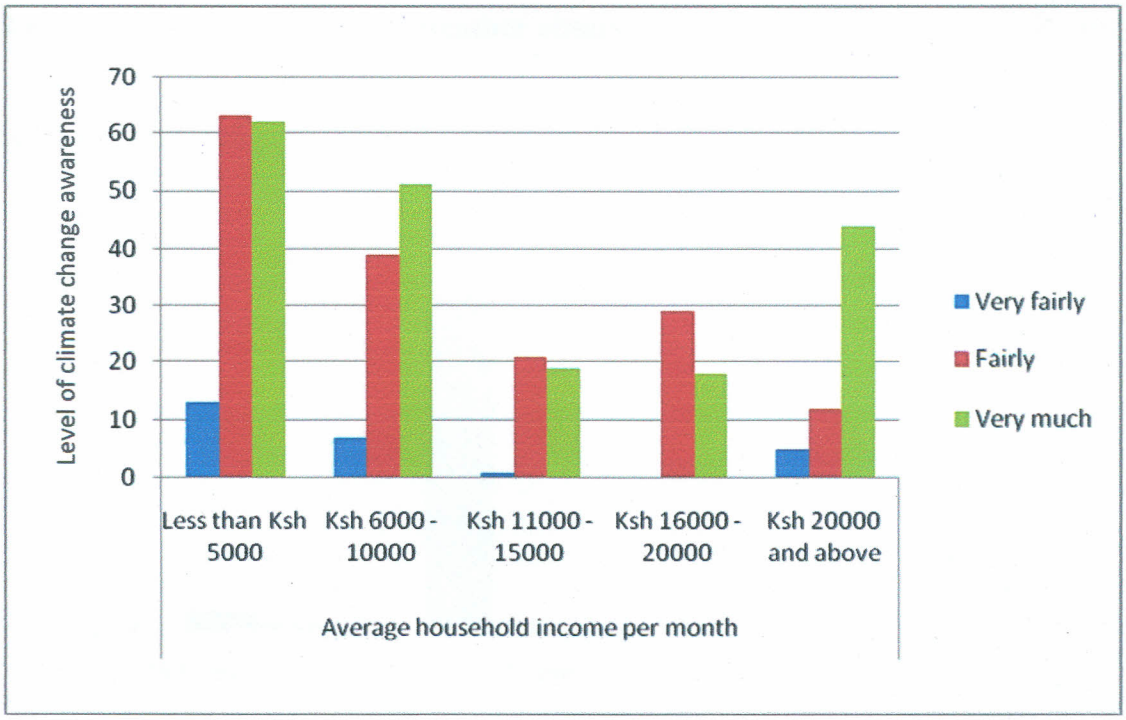


Figure 4.5 Average household incomes per month in relation to climate change awareness

The study found out that the household incomes had an impact on the climate change awareness levels. This is confirmed by fig. 4.5 which shows greater awareness levels in line with the increase in household incomes. It thus confirms a relationship between the capacities and levels of earnings as a factor influencing climate change awareness level. A Spearman's Rank Order correlation was run to determine the relationship between level of climate change awareness and household income. There was a correlation between level of climate change awareness and the level of household income, which was statistically significant (r_s = -.121, p = .017).

4.2.6 Religion and the level of weather observation

The respondents' religions vis-à-vis weather observation was as shown in fig. 4.6.

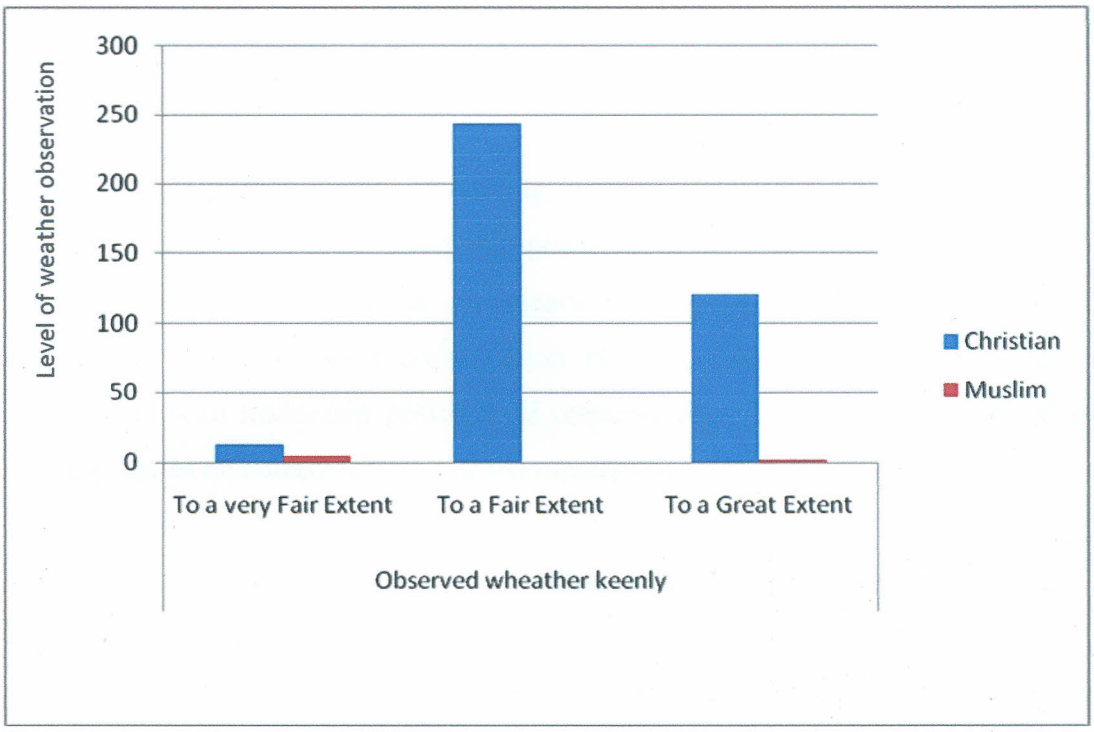


Figure 4.6 Religion and the level of weather observation

Religion came out as a factor influencing the levels of observation of weather patterns. A Spearman's Rank Order correlation was run to determine the relationship between weather observation and respondents' religion. There was a correlation between level of weather observation and the respondents' religion, which was statistically significant (r_s = -.136, p = .008).

4.2.7 Leadership Positions in School in relation to climate change awareness

An account of the respondent's leadership positions in the schools sampled shows that parents in all education zones held leadership positions. They were distributed in the sampled locations as follows:- Kimathi 16, Gikindu 20, Township 17, Gaturi 16 and Mbiri 16. This was a confirmation that most of the sampled respondents were responsible parents who had been conferred with positions of responsibility in their schools. Cross tabulation was done between leadership positions in schools and climate change awareness which gave a Chi-square value of χ^2 = 7.890 at a

significance level of 0.019. The calculated statistic $\chi^2 = 7.890$ was found to be less than the tabled critical value of $\chi^2 = 8.132$. The response showed a situation whereby the leadership position was insignificant to climate change awareness at α 0.080.

4.2.8 Leadership Position in Community

The parents further confirmed holding other positions in the communities with 6 of them attesting to holding leadership positions in the constituency development fund programmes, 8 in religious organizations while 4 in community development programmes. This was a confirmation of the capacity of the respondents to be entrusted with leadership positions of responsibility. This confirmed their ability to grasp issues on current affairs and the rapidly changing times.

4.2.9 Length of stay in relation to climate change awareness

Fig.4.7 shows the length of the respondents stay in relation to climate change awareness in the study area.

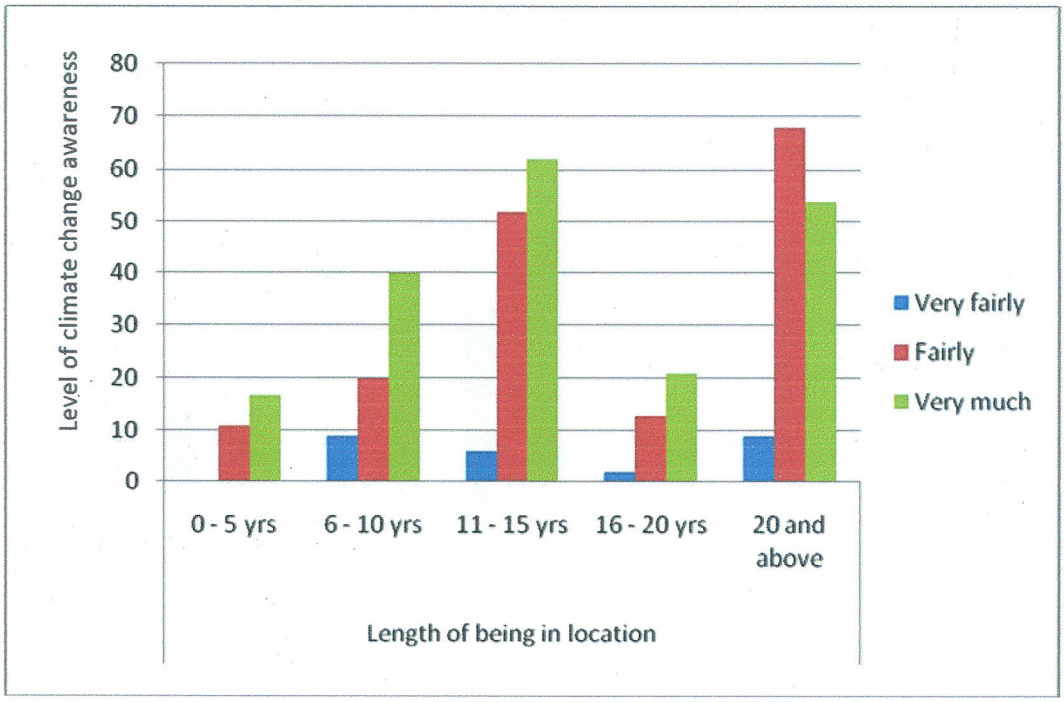


Figure 4.7 Length of stay in years in relation to climate change awareness

Fig. 4.7 shows that the length of stay was a significant factor in relation to climate change awareness levels. This is attributed to the fact that the longer the stay the

greater the climate change awareness levels. A Spearman's Rank Order correlation was run to determine the relationship between the length of stay and climate change awareness. There was a correlation between the length of stay and climate change awareness, which was statistically significant ($r_s = .114, p = .026$).

4.3.1 Average annual rainfall and temperature distribution in the district

The average annual rainfall for the twelve years considered was 1084mm. This data confirms the presence of adequate rainfall in the district to justify RRwH. This is an avenue that the schools and allied institutions, households and all buildings with suitable roofs which serve as a catchment area for the RRwH can exploit to ensure assured water supply.

Water consumers can thus ably exploit the RRwH in the two rainfall seasons. This will assure them of supplies enough to last them from one season to the other guided by their water storage capacities (Murang'a Regional Development Plan 2009 – 2014) as shown in fig. 4.8.

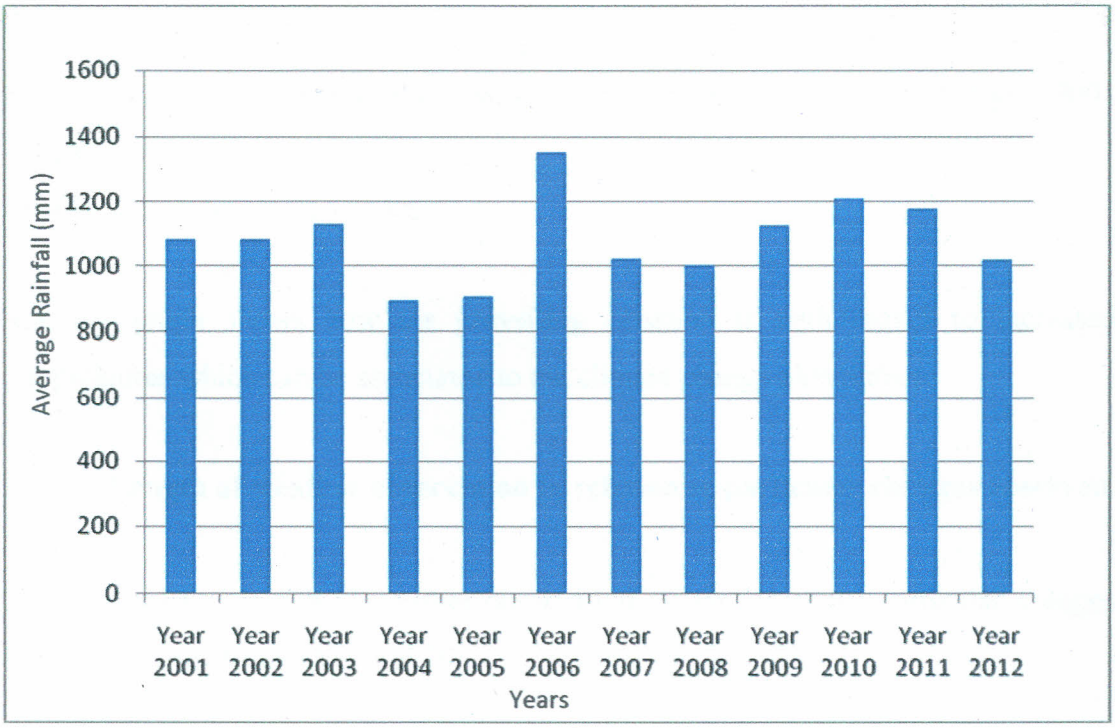


Figure 4.8 Average rainfall distributions in Murang'a East district for the period of year 2001 to year 2012.

Source: http:/www.meteo.go.ke.

The rainfall distribution shows a relative stagnation in the rainfall amounts in the period under review.

The average temperatures for the period of year 2001 to year 2012 were as shown in fig. 4.9.

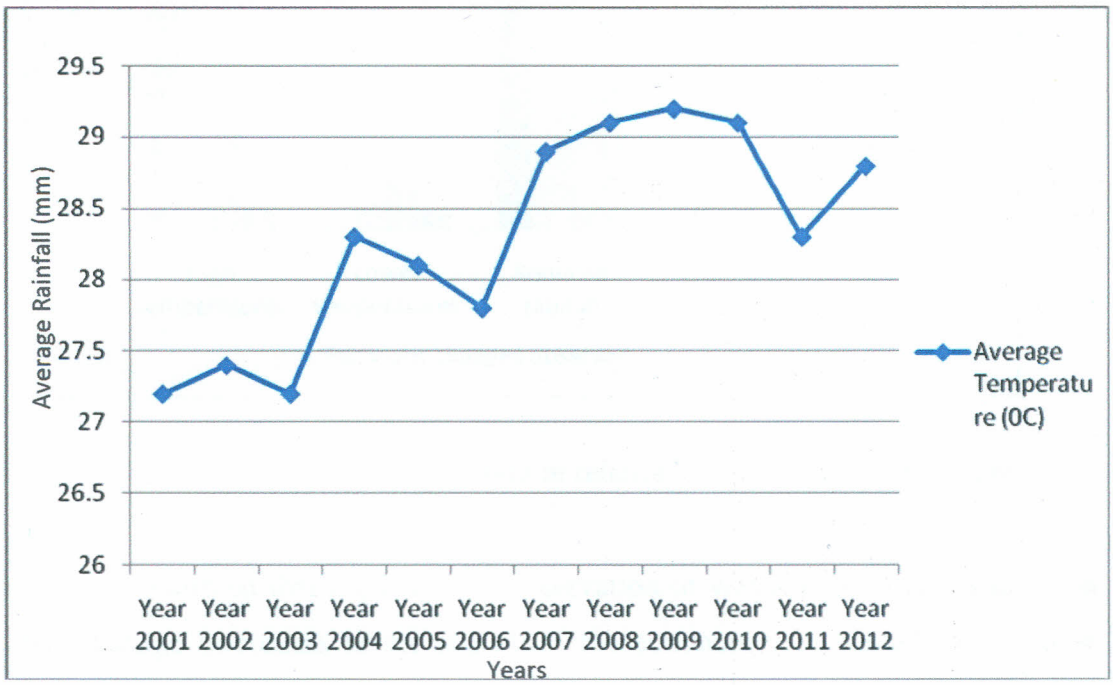


Figure 4.9 Average temperatures in Murang'a East District for the period of year 2001 to year 2012.

Source: http:/www.meteo.go.ke.

The bar graph shows how the prevailing situation is with regard to increased temperatures which can be associated to the climate change phenomena.

4.3.2 Length of weather observation in relation to particular changes observed

The respondents' length of weather observation in relation to the particular changes observed was as shown in fig. 4.10.

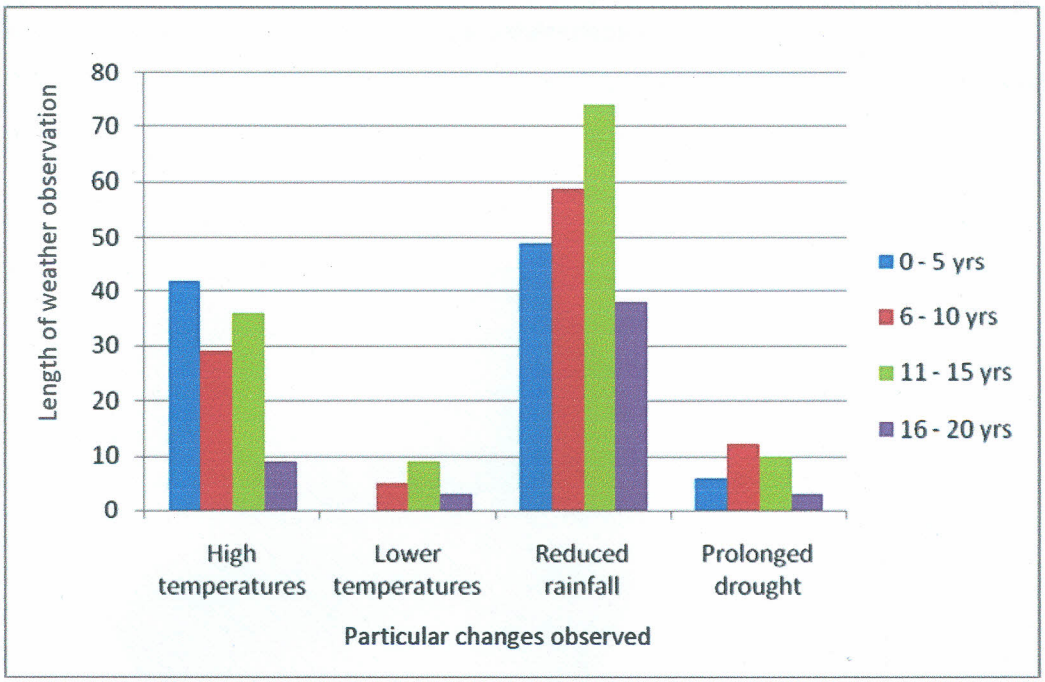


Figure 4.10 Length of weather observation in relation to particular changes observed

The study confirmed that the length of observation of weather patterns impacted on climate change awareness levels and aided the community to perceive observable changes. Findings from the study showed reduced rainfall and high temperatures were more pronounced in the study area gauging from the response. The response was a good account of the relationship between the age of the parents and the length of the observation period. This is a reflection of the fact that most of the parents were aged 40-49 years and most of the respondents had observed weather for 11-15 years. Cross tabulation was done which gave a Chi-square value of χ^2= 20.440 at a significance level of 0.015. The calculated statistic χ^2 = 20.440 was found to be less than the tabled critical value of χ^2 = 24.175. The response was indicative of a situation whereby the length of weather observation was insignificant to the particular changes observed at α 0.013.

4.3.3 Forums for climate change awareness dissemination

The forums that the respondents identified in the climate change awareness dissemination avenues were as shown in fig. 4.11.

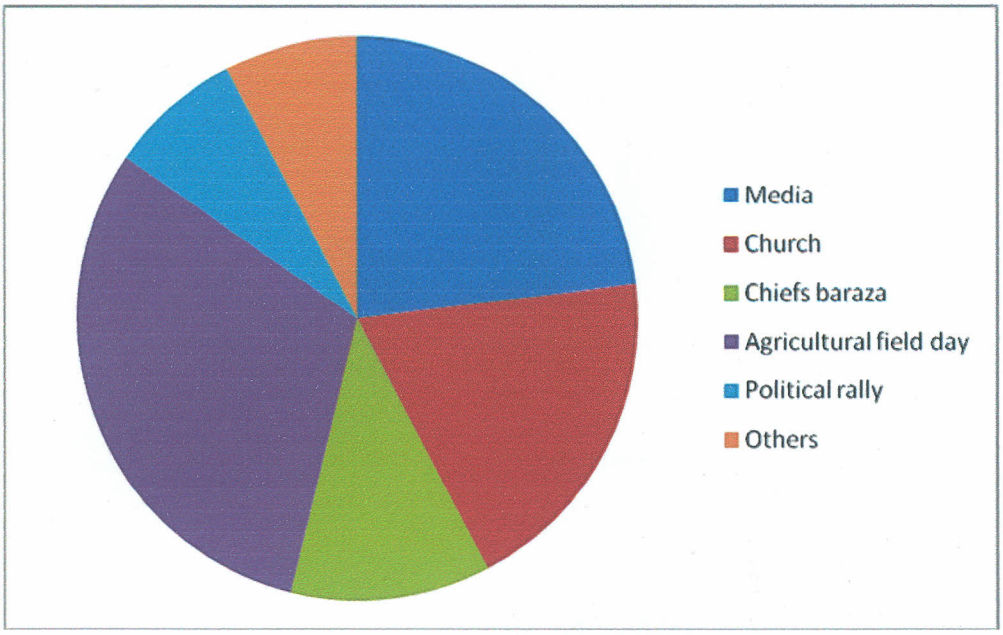


Figure 4.11 Forums of climate change awareness information dissemination

Fig.4.11 shows that majority of the respondents assessed climate change information through the media at 49%, the provincial administration at 20%, agricultural officers at 14%, church at 11%, political rallies at 4 % and others at 2%. This identifies with the local situation whereby in Kenya Part III of the Climate Change Authority Bill, 2012 which covers 'climate change programmes and response strategies' puts emphases on formulating and coordinating the implementation of national and county climate change programmes. This will be made available to the public in both print and electronic form. There is also a plan for education and creation of awareness including integration in the education curricula (RoK, 2012).

4.3.4 Climate change reality and the particular effects to the schools

The climate change reality and the particular effects to the schools were as shown in fig. 4.12.

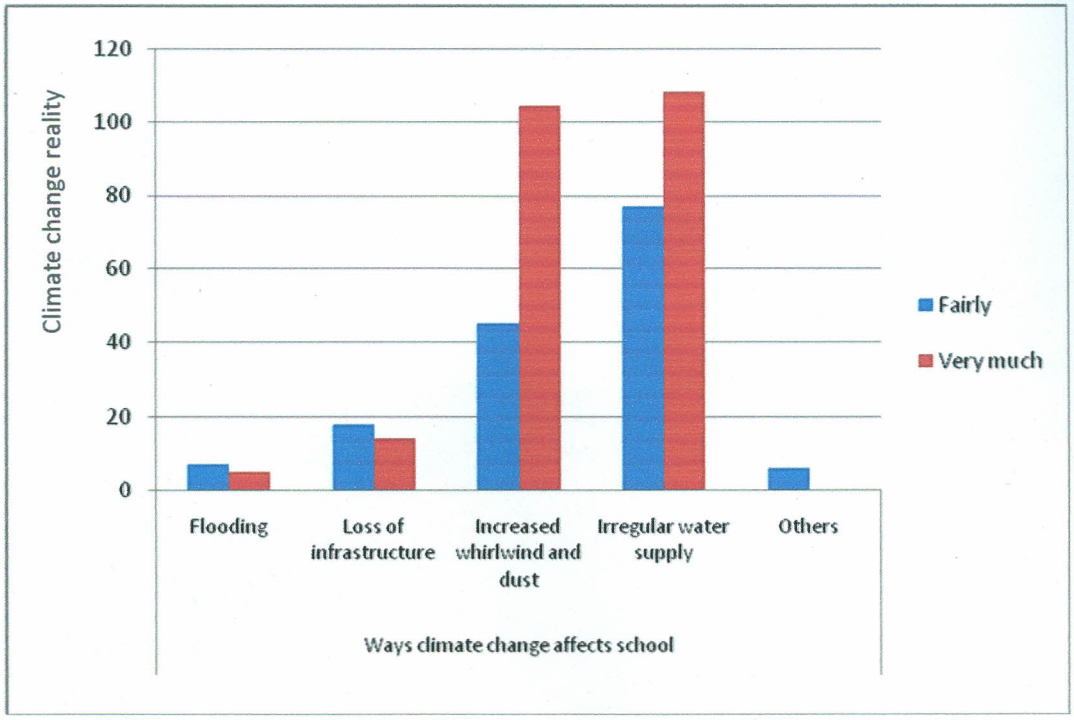


Figure 4.12 Climate change reality and the particular effects to the schools

The study found out that climate change had impacted on the schools attended by the respondents' children. The most debilitating effect came out as irregular water supply and increased whirlwind and dust. The response was thus a confirmation on the impact of climate change on the water supply situation to schools and the loss of vegetation thus exposure to dust and whirlwind. Plate 4.1 below captures the gravity of climate change which has brought forth loss of vegetation and increased dust exposing the learners to risks of contracting eye and respiratory tract infections. This may portend a great loss to the households when resources are spent on medication and may also lead to increase in absenteeism leading to loss of learning time.

Plate 4.1 Muchungucha Primary School loss of vegetation and increased dust in September 2012.

Fourteen of the visited schools were in hilly areas with a very steep terrain. This exposed the schools to situations of water runoff and the risk of soil erosion at the advent of heavy rains. Ten of the schools were in relatively flat areas with no major risk of water runoff as confirmed during the physical visits to the schools.

4.3.5 Observed climate change effects in the education zones

The response shows that increased rainfall was an attribute that a majority of the respondents did not agree with. Most of the respondents confirmed the occurrence of increased temperature same case with increased dust, disruption of economic activities, disruption of learning process and water supply. The responses are a true

indicator of the climate change effects and the observed changes attested to by the sampled respondents as shown in Table 4.2 below.

Table 4.1 Observed climate change effects in the education zones

		Location of the school					
		Mbiri	Gikindu	Gaturi	Kimathi	Township	% Response
Increased rainfall	Strongly Disagree	23	8	54	12	12	23
	Disagree	45	17	31	28	54	45
	Undecided	4	7	0	0	5	4
	Agree	23	18	18	11	27	23
	Strongly Agree	5	5	0	0	7	5
Total		70	100	103	51	105	100
Increased temperature	Strongly Disagree	1	2	0	0	0	1
	Undecided	5	4	4	3	4	5
	Agree	76	38	81	28	93	76
	Strongly Agree	18	11	18	20	8	18
Total		70	100	103	51	105	100
Increased Dust	Strongly Disagree	5	0	0	8	0	5
	Disagree	12	3	4	12	12	12
	Undecided	6	3	0	3	8	6
	Agree	44	28	35	22	58	44
	Strongly Agree	33	21	64	6	27	33
Total		70	100	103	51	105	100
Disrupted economic activities	Strongly Disagree	3	0	0	2	0	3
	Disagree	4	3	0	6	4	4
	Undecided	4	0	5	3	5	4
	Agree	49	22	50	22	58	49
	Strongly Agree	40	30	48	18	38	40
Total		70	100	103	51	105	100
Learning process affected	Strongly Disagree	8	0	0	11	12	8
	Disagree	6	0	4	0	8	6
	Undecided	7	0	4	0	14	7
	Agree	55	40	36	37	60	55
	Strongly Agree	24	15	59	3	11	24
Total		70	100	103	51	105	100
Disruption of water supply	Strongly Disagree	4	0	0	0	4	4
	Disagree	13	0	0	8	33	13
	Undecided	2	0	0	3	0	2
	Agree	52	36	46	31	46	52
	Strongly Agree	29	19	57	9	22	29
Total		70	100	103	51	105	100

The response as shown in table 4.2 is a reflection of the gravity of reduced rainfall with majority of the respondents affirming to it. Increased temperatures were equally confirmed by most of the respondents similarly to increased dust and the disruption of economic activities which has equally affected the learning process. Water supply was equally confirmed as to having been disrupted. This shows that the respondents had seen the ramifications of climate change and its impacts on the community and the social-economic activities that the society depends on.

The situation is in agreement with previous works by (Singwane and Kunene, 2010) who said that there is no doubt that the environmental health of the planet is in a critical state. Water, is becoming inaccessible for many people and it is obvious that old patterns of its management must be changed. This is the case because conventional water supply systems are now not adequate to meet the water demands of large and rapidly expanding human populations. The impacts are more severe in institutions like schools and hospitals which deal with relatively large populations. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change.

This was equally a confirmation of previous works by (Larue and Dupres, 2009) who said that many schools presently do not have a reliable source of water for drinking and other use. The school rooftop rainwater harvesting system seeks to provide a source of water for all purpose such as toilet flushing, cooking, washing hands before eating and after toilet use, hygiene and finally if the rainwater is treated well for drinking purpose.

4.3.6 Climate change effects in the education zones

The respondents confirmed a great occurrence of river flooding, drying up of rivers, drying up of wells and low volumes of water from springs. The responses were an indicator of the impact of climate change and its effects on water sources which the schools rely on for their supplies. This is a confirmation of the impact of climate change on the water supply sources Table 4.3 below.

Table 4.2 Climate change effects in the education zones

		Location of the school					%
		Mbiri	Gikindu	Gaturi	Kimathi	Township	Response
River flooding	Strongly Disagree	6	5	45	2	12	18
	Disagree	10	13	11	12	17	16
	Undecided	8	13	4	6	4	9
	Agree	34	15	20	22	66	41
	Strongly Agree	12	9	23	9	6	16
Total		70	55	103	51	105	100
Drying up of rivers	Strongly Disagree	6	0	19	11	0	9
	Disagree	4	0	0	15	12	8
	Undecided	4	0	0	0	0	1
	Agree	24	25	42	25	67	48
	Strongly Agree	32	30	42	0	26	34
Total		70	55	103	51	105	100
Drying up of wells	Strongly Disagree	6	0	0	2	0	2
	Disagree	4	0	0	3	8	4
	Undecided	8	6	4	3	0	5
	Agree	32	25	35	19	75	48
	Strongly Agree	20	24	64	24	22	41
Total		70	55	103	51	105	100
Low volumes from springs	Strongly Disagree	8	2	54	0	5	18
	Disagree	10	4	0	5	9	8
	Undecided	8	25	8	18	5	17
	Agree	24	18	25	16	64	38
	Strongly Agree	20	6	16	12	22	19
Total		70	55	103	51	105	100

The response as shown in table 4.3 indicates that majority of the respondents had evidence of river flooding. Similarly, most of the respondents agreed to having had seen situations of drying up of rivers, wells and low volumes from springs. The responses were a confirmation of the dwindling of water supply sources owing to the situation of climate change. The variation of weather patterns was equally confirmed driven by the fact of river flooding as evidenced by the respondents giving an indication of situations of extremities of the weather. This may be attributed to changes in climate and the degradation of the environment leading to situations of flooding as confirmed by the study.

4.4.1 Sources of water in relation to assurance of supply

The sources of water in the schools in relation to the assurance of supply were as shown in fig. 4.13.

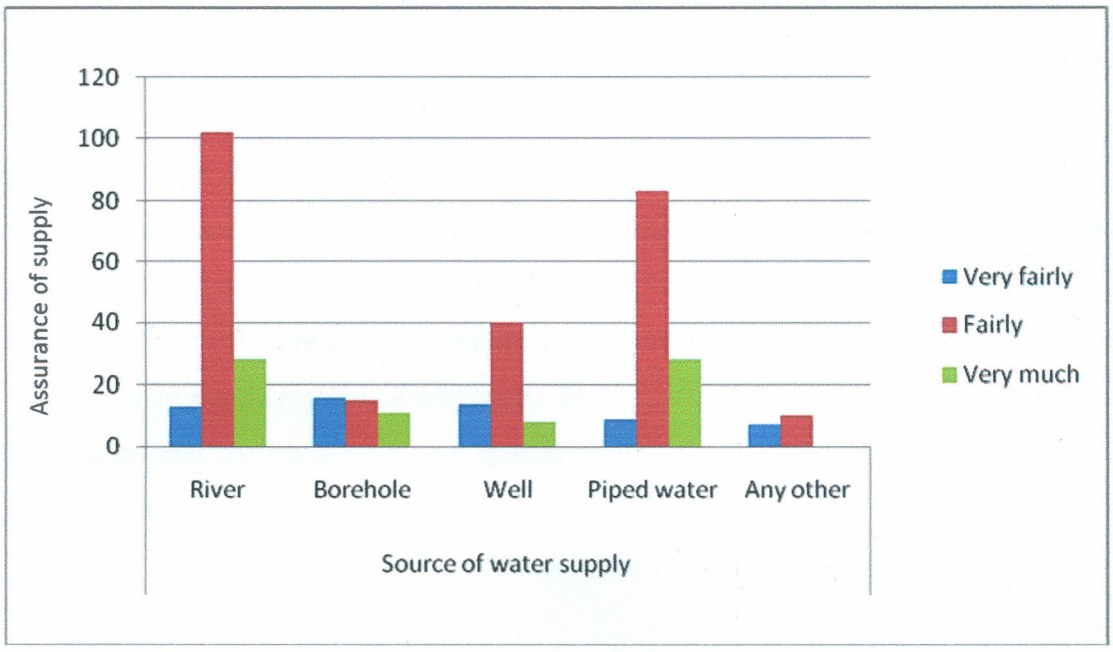


Figure 4.13 Sources of water in relation to assurance of supply

Fig.4.13 shows that most of the respondents considered rivers and piped water as the sources of water with the greatest assurance as pertains supply. This shows that most of the schools relied on rivers and piped water for their supply. On the other hand the study found that no source of water supply was considered as very assured by the respondents gauging from the responses. Cross tabulation was done which gave a Chi-square value of $\chi^2 = 45.481$ at a significance level of 0.000. The calculated statistic $\chi^2 = 45.481$ was found to be more than the tabled critical value of $\chi^2 = 44.916$. The response was indicative of a situation whereby the sources of water were significant to the assurance of supply at α 2.61.

The researcher confirmed from the schools physically visited that they had varying sources of water supply. From the twenty four schools visited and checked by use of a checklist, nine had their water sources from a communal point, eleven had piped water while two relied on water harvested from the roof and the other two had drilled boreholes. This shows that the level of adoption of rooftop rainwater harvesting was very negligible in the schools visited. This is in contrast to previous works by the

United States Agency International Development, (2009) which argued that the successful implementation of rainwater harvesting in a school will be the best way to access to people's consciousness however there is limited technical capacity to support rainwater harvesting best practices. RRwH will most likely lead to reduction of monthly water bills, improve hygiene and thus preventing the risks of waterborne diseases outbreaks among school children and this illustrates the economic benefits of the adaptation action to the national healthcare system.

One school was reported to spend a lot of money in the course of purchasing water from a vendor and it has a large roof which can be exploited as a catchment area for harvesting rooftop rainwater. The water supply situation is equally not assured. This is because daily purchases are unsustainable and instances of misunderstanding between the vendor and the institution may greatly expose the learning process to a big risk Plate 4.2 below.

Plate 4.2 Marewa Primary School children fetching water from a vendor in October 2012

The researcher confirmed during the school visits that eleven schools with piped water had the commodity supplied readily to the schools the same case the four schools which relied on rooftop harvesting and drilled boreholes respectively. The nine schools relying on water from the communal points had the children fetch water and deliver it to school thus heavily inconveniencing the learners owing to having them spend a lot of time searching for water.

4.4.2 Coping mechanism of water disruption in relation to assurance of supply

The coping mechanisms of water disruption in relation to the assurance of supply were as shown in fig. 4.14.

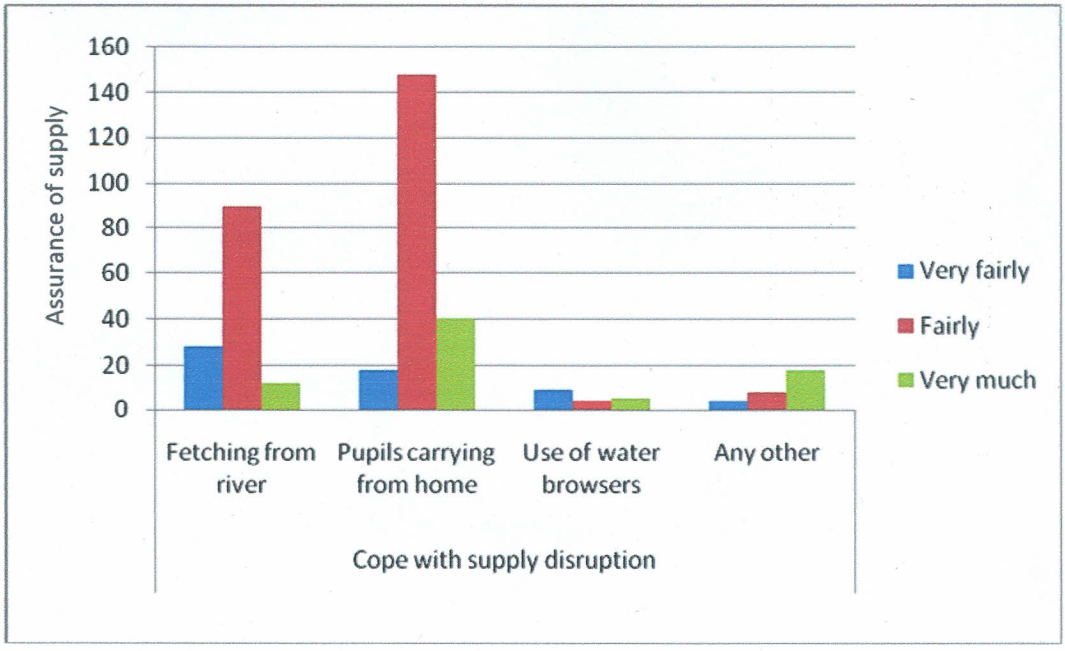


Figure 4.14 Coping mechanism of water disruption in relation to assurance of supply

Fig.4.14 shows that the most preferred coping mechanism to the disruption of water supply was considered as having pupils carry water from home. Fetching from the river was the other alternative. The coping mechanisms employed expose the learners to the risk of exposure to fatigue and minimal concentration in class owing to carrying water for long distances. The risk of fetching contaminated water from rivers is equally imminent. This may portend grave danger to the learners. This identifies with previous works by (Larue and Dupres, 2009) who attested that many schools presently do not have a reliable source of water for drinking and other use. The school

rooftop rainwater harvesting system seeks to provide a source of water for all purpose such as toilet flushing, cooking, washing hands before eating and after toilet use, hygiene and finally if the rainwater is treated well for drinking purpose.

The situation identifies with Rurii Primary School whereby the school depends on a community dam which may not have a very assured and constant supply all year round. The risk of lack during periods of droughts and undue exposure of the affected children to strenuous activity in the name fetching water at the expense of undertaking academic activities may impact negatively on the pupils' academic performance Plate 4.3 below.

Plate 4.3 Rurii Primary School children fetching water from a community dam in October 2012

4.4.3 Effects of disruption of water supply in the education zones

An increase of water borne diseases was confirmed owing to disruption of water supply to the schools. Similarly the hygiene standards fell occasioned by water supply disruption and pupils had reduced learning time in their quest to find water for the schools. This reflects the essence of an assured supply devoid of disruption for the wellness of the pupils and enhanced academic performance Table 4.4 below

Table 4.3 Effects of disruption of water supply in the education zones

		Location of the school					%
		Mbiri	Gikindu	Gaturi	Kimathi	Township	Response
Increased water borne diseases	Strongly Disagree	10	0	0	3	8	5
	Disagree	18	3	8	10	24	17
	Undecided	18	3	4	9	17	13
	Agree	16	25	49	9	48	38
	Strongly Agree	8	24	42	20	8	27
Total		70	55	103	51	105	100
Low standards of hygiene	Strongly Disagree	8	3	0	3	8	6
	Disagree	6	0	4	4	8	6
	Undecided	2	3	0	3	12	5
	Agree	42	19	42	27	62	50
	Strongly Agree	12	30	57	14	15	33
Total		70	55	103	51	105	100
Learning time reduced	Strongly Disagree	8	0	0	12	10	8
	Disagree	6	0	4	8	25	11
	Undecided	8	3	0	0	9	5
	Agree	48	45	54	17	49	55
	Strongly Agree	0	7	45	14	12	21
Total		70	55	103	51	105	100

The response as shown in table 4.4 indicates an increase in waterborne diseases in the education zones in the district, low standards of hygiene and reduced learning time which can all be attributed to water scarcity. This is an indication of the gravity of water scarcity associated to the climate change situation.

The situation in Murang'a East district identifies with a report from KRA which stated that the horn of Africa experienced one of the most severe droughts in the last

60 years in 2011. It was asserted that without clean water communities including schools in rural areas open themselves to outbreaks of water borne diseases like cholera, typhoid, hepatitis A, and diarrhea which are caused by inadequate water and sanitation. Drying up water sources forces people to use heavily contaminated water. This may result to waterborne diseases if ingested. The problem with access to clean water and sanitation go beyond health and sanitation and uniquely affect learners' performance (Aura, 2011). The researcher spotted children drawing water from rivers and dams oblivious of the danger they are exposed to.

4.5.1 Rooftop Rainwater harvesting awareness in relation to initiative provider

The response as regards rooftop rainwater harvesting in relation to RRwH implements initiative provider was as shown in fig. 4.15.

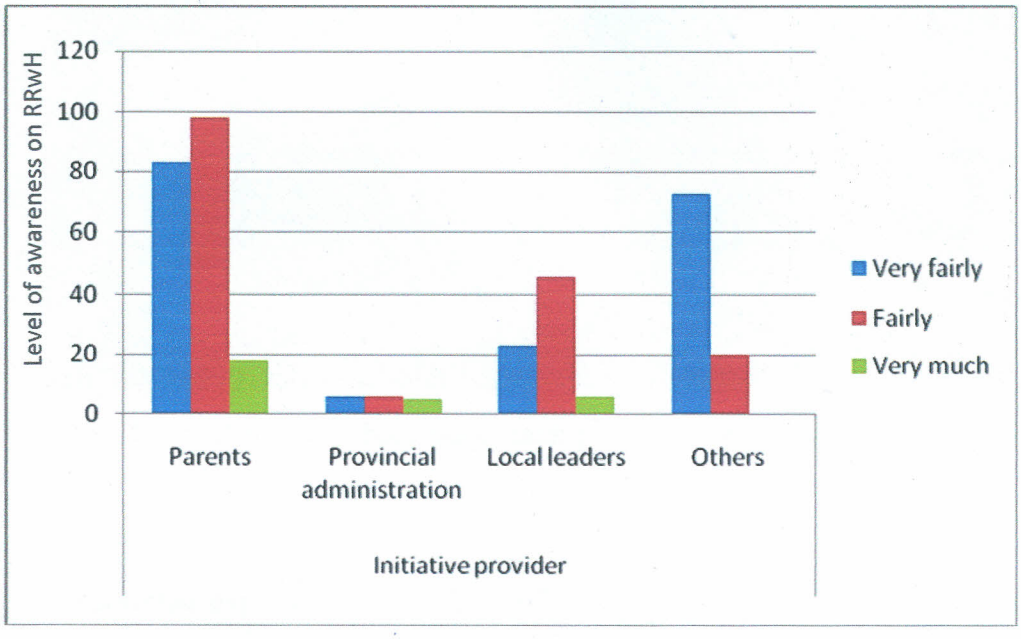


Figure 4.15 Rooftop Rainwater harvesting awareness in relation to initiative provider

Fig.4.15 shows that parents played a major role as regards provision of RRwH infrustructure. The local leaders and other organisations like donor agencies, the Church World Service, Safaricom, Barclays Bank and the Rotary Club play a significant role too. The local leaders and the provincial administration played peripheral roles. The response showed a fair level of awareness of RRwH from the sampled respondents. Most schools can thus be considered to have the input of parents geared towards the realisation of RRwH capacity.

This can be confirmed by evidence captured on plate 4.4 which shows a water tank put up through an initiative of the Rotary Club of Murang'a. This shows the immense contribution of the Rotary Club towards the realization of water storage capacity occasioned by the RRwH.

Plate 4.4 Mbiri Primary School water tank provided by the Rotary Club in February 2012

The researcher explored the condition of the roofs in the schools with a capacity to harvest water and found that it was deplorable. The roofs were dusty and three of the schools had no filters to guard against contamination of the water as seen in Plate 4.4 During the visits there had not been any recent rainfall occurrence. This was in the month of September 2012. Only two of the visited schools with capacity to harvest and store water had the commodity in their tanks. One school had clean and non-contaminated water attributed to the capacity to ensure cleanliness while the other schools had contaminated water.

4.5.2 Benefits accrued from rooftop rainwater harvesting in the education zones

The response was an indication of the respondents understanding the benefits accruing from rooftop rainwater harvesting. Most of the respondents considered the harvested water as safe. They equally considered RRwH as cost effective. An appreciation of the fact that the community had embraced RRwH was equally a confirmation of the level of acceptance of the practice in the community. This confirmed the essence of RRwH in aiding the assurance of water supply in the community Table 4.4 below.

Table 4.4 Benefits accrued from rooftop rainwater harvesting in the education zones

		Location of the school					%
		Mbiri	Gikindu	Gaturi	Kimathi	Township	Response
Water harvested is sate	Strongly Disagree	0	0	4	0	0	1
	Disagree	12	0	8	2	8	8
	Undecided	8	16	33	3	0	16
	Agree	38	30	35	20	77	52
	Strongly Agree	12	9	23	26	20	23
Total		70	55	103	51	105	100
Water harvesting is cost effective	Strongly Disagree	2	0	0	3	8	4
	Disagree	12	3	12	4	13	11
	Undecided	4	0	26	2	9	11
	Agree	38	42	30	30	56	51
	Strongly Agree	14	10	35	12	19	23
Total		70	55	103	51	105	100
Community embrace water harvesting	Strongly Disagree	6	3	0	0	4	4
	Disagree	8	3	4	8	13	9
	Undecided	0	6	0	3	11	5
	Agree	42	36	83	8	65	61
	Strongly Agree	14	7	16	32	12	21
Total		70	55	103	51	105	100

The response as shown in table 4.5 indicates that most of the respondents agreed that water harvested from the rooftops is safe. They equally affirmed that water harvesting is cost effective and the acknowledged that the community has embraced water

harvesting. The response reflects a situation whereby the community at large identifies rooftop rainwater harvesting as a viable solution to the situation of water scarcity attributed to climate change.

4.6.1 Constraints to adoption of rooftop rainwater harvesting

The constraints to the adoption of rooftop rainwater harvesting in the five education zones were as captured in fig. 4.16.

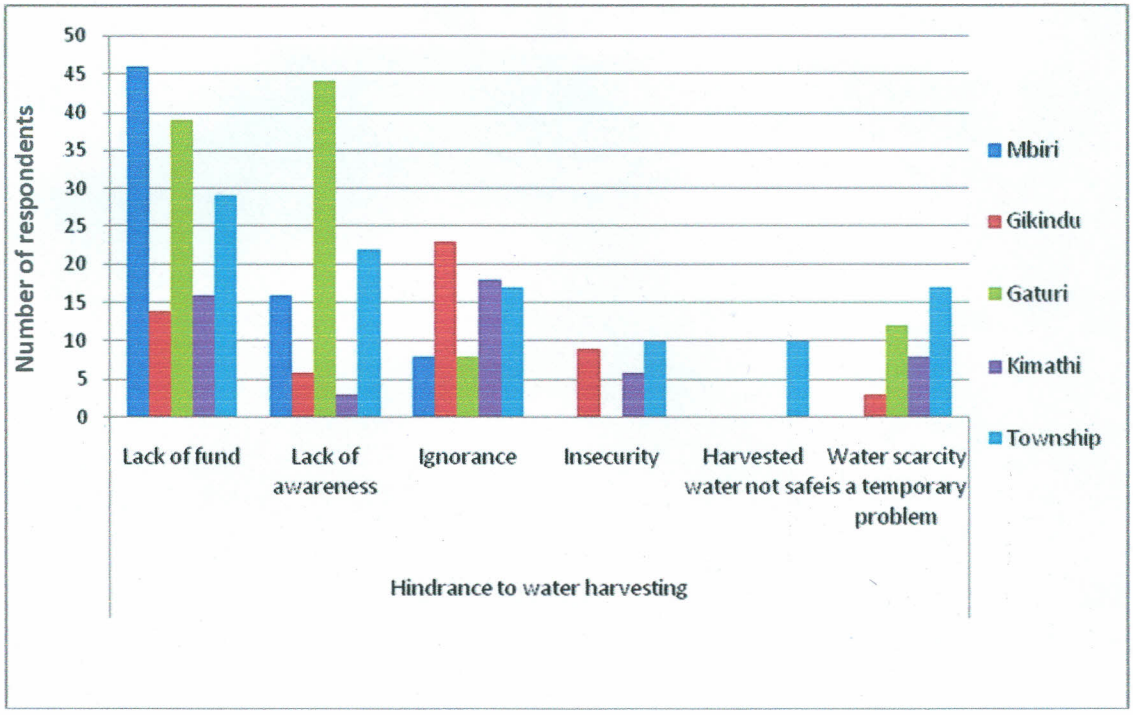


Figure 4.16 Constraints to adoption of rooftop rainwater harvesting

Fig.4.16 shows that, lack of funds was the major hindrance to the adoption of RRwH in all the education zones. Lack of awareness and ignorance were the other major factors contributing to non adoption of RRwH. Perception that water scarcity is a temporal problem equally held a major sway to the non adoption of RRwH. Insecurity as regards in the investment in water harvesting equipment equally discouraged the adoption of RRwH. The assertion that water harvested from the roof is not safe heavily discouraged RRwH in township education zone.

A large roof catchment area with no infrastructure for harvesting rooftop rain water Plate 4.5 below.

Plate 4.5 Rurii Primary School roof catchment with no water harvesting infrastructure in October 2012

This mirrors works posited by the (United States Agency International Development, 2009) which stated that the successful implementation of rainwater harvesting in a school will be the best way to access to people's consciousness however there is limited technical capacity to support rainwater harvesting best practices. RRwH will most likely lead to reduction of monthly water bills, improve hygiene and thus preventing the risks of waterborne diseases outbreaks among school children and this illustrates the economic benefits of the adaptation action to the national healthcare system (Barron, 2009). Children would also have the opportunity to participate in a variety of climate change activities such as tree planting. These can help them understand the relationship between climate change and water better hence building skills of young people to take actions to adapt to climate change. It is also suggested that training and capacity building workshops to all stakeholders in the schools would

be of great importance as this would create awareness on climate change and its impact on the water sector. Another effort that that has been suggested is training local masons to build up simple rainwater harvesting systems in institutions as they construct buildings as this may also work at enhancing rainwater harvesting (Larue, 2010).

A donor funded gate project at the expense of a better alternative like the laying of infrastructure for rooftop water harvesting in the school which would have been far much cheaper than the gate. The plate also captures the vagaries of soil erosion in the school compound attributed to heavy rains Plate 4.6 below.

Plate 4.6 Rurii Primary School lopsided priority in decision making

There was another scenario whereby the school has earned a donation of a large water storage tank but there has been no initiative to purchase gutters to harvest water to put the tank into the right use Plate 4.7 below.

Plate 4.7 Muchungucha Primary School roof without gutters and an empty water storage tank donated by Safaricom in May 2012

The researcher confirmed from the twenty four schools visited, only six had put in place the requisite infrastructure for harvesting water from the rooftops. The infrastructure in place included gutters and pipes to direct water to the tanks and only three schools from the six with infrastructure for water harvesting had filters in place to check contamination of the harvested water. In two of the schools, the tanks were plastic with a capacity of fifteen thousand liters while in one school, there was a built stone walled tank with a capacity of one hundred thousand liters.

4.6.2 Respondents Opinion on Climate Change Information Dissemination

The respondents believed that climate change should be disseminated by way of having a more proactive approach with regard to interaction with the media especially vernacular radios to raise awareness with 82 of the respondents alluding to it. Use of barazas and social gatherings was thought as the best approach by 10 respondents, engagement of the church and religious bodies were the approach that 72 respondents vouched for integration of the climate change awareness education in the school curriculum was the mode suggested by 7 respondents while the use of opinion leaders as agents of change was considered as the most viable option by 60 of the respondents.

4.6.3 Respondents Consideration of the Climate Change Dissemination Approach

The respondents were of the consideration that the current approaches as regards climate change dissemination were not appropriate with 190 of them attesting to it. The response showed that 100 respondents believed that it was fairly appropriate while 94 believed that it was appropriate. The response was thus an indication of misgivings about the approaches employed to disseminate climate change information.

4.7 Hypotheses testing

The two hypotheses to be tested were;

H_1: Majority of decision makers in public primary schools in Murang'a East District are not aware of climate change issues.

H_{1A}: Majority of decision makers in public primary schools in Murang'a East District are aware of climate change issues.

Ho: $\sum\sum (O-E)^2 = 0$

H_1: $\sum\sum (O-E)^2 \neq 0$

Ho: states that the variables are independent of each other.

The significance level: $\alpha = 0.05$.

H_2: There is no relationship between climate change awareness and adoption of RRwH by decision makers in public primary schools in Murang'a East District.
H_{2A}: There is relationship between climate change awareness and adoption of RRwH by decision makers in public primary schools in Murang'a East District.

Cross tabulation was done between leadership positions in schools and climate change awareness which gave a Chi-square value of $\chi^2 = 7.890$ at a significance level of 0.019. The calculated statistic $\chi^2 = 7.890$ was found to be less than the tabled critical value of $\chi^2 = 8.132$. The response showed a situation whereby the leadership position was insignificant to climate change awareness at α 0.080. The hypothesis that majority of the decision makers in public primary schools in Murang'a East district are not aware of climate change issues was thus confirmed.

Cross tabulation was done between rainwater harvesting awareness among decision makers in schools and climate change awareness which gave a Chi-square value of $\chi^2 = 12.826$ at a significance level of 0.012. The calculated statistic $\chi^2 = 12.826$ was found to be less than the tabled critical value of $\chi^2 = 13.411$. The response confirmed that climate change awareness was insignificant to rooftop rainwater harvesting awareness at α 1.96. The hypothesis that there is no relationship between climate change awareness and the adoption of rooftop rainwater harvesting by decision makers was thus confirmed by the study.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study sought to explore rooftop rainwater harvesting as an adaptation of climate change a case of Murang'a East district primary schools. The study sought to answer the following research questions as set out in Chapter One Section 1.3.

The response shows that parents in all education zones were involved in decision-making activities by virtue of being involved in leadership positions. The exposure to leadership helps the parents' access information as regards to current trends and prevailing best practices and requisite exposure which allows for climate change awareness information.

The most prevalent source of water for the primary schools in the district was rivers and piped water. Some schools had boreholes, wells and few relied on purchases from water vendors and the children carrying the resource from home. Instances of drying up of rivers and having lower levels in terms of volumes in the springs and wells occasioned by climate change has exposed most of the schools to the risk of disruption of water supply.

The responses show that most of the parents were fully aware of the rooftop rainwater harvesting. They were fully aware of the initiative provider who helped the schools access facilities for rooftop rainwater harvesting. They appreciated the roles played by the various initiative providers.

The response showed that the major constraint to the adoption of rooftop rainwater harvesting was lack of funds, lack of awareness, ignorance and the perception that water scarcity was a temporal problem. The issue of insecurity and the perception that harvested water was not safe were equally found out to be constraints to the adoption of rooftop rainwater harvesting.

5.3 Conclusions of the Study

The study can thus conclude that the respondents were fully aware of climate change. Respondents confirmed weather observations with noticeable changes in reduced rainfall levels. The media came out strongly as the leading medium of

climate change effect information dissemination. Climate change effect has been felt on the ground with the respondents confirming that the schools in which their children study had been greatly affected.

Climate change affected water supply to schools leading to disruption of supply. This led to increased waterborne diseases, lower standards of hygiene and reduced learning time. The dwindling and reduction of volumes of springs, wells and rivers was confirmed and bridged by way of fetching from rivers, pupils carrying from home and the use of water browsers.

The respondents were highly aware of the rooftop rainwater harvesting as a climate change adaptation initiative and regular rains were confirmed by a fair number of respondents. Presence of rooftop rainwater harvesting infrastructure was confirmed with parents leading in infrastructure provision.

The respondents believed that a multi-prolonged approach which entailed incorporation of climate change awareness into the education curriculum, greater sensitization, exploitation of church and the involvement of community leaders would serve the purpose.

5.4 Recommendations of the Study

The study made the following recommendations:-

Climate change is real and the consequences are great and with far reaching ramifications on the populace, greater efforts should be made to sensitize the masses on climate change with the urgency that it deserves. Every other stakeholder should be given their due consideration and value as key resource persons in the climate change awareness creation campaigns. This will naturally enable the populace to own the initiatives and do all that it takes to help salvage the situation in their own little way.

Water is life and its importance with regard to the anchorage and provision of life to flora and fauna cannot be overemphasized. Climate change on the other hand has had the debilitating effects of compromising the water supply situation at the advent of dwindling water sources driven by the effects of drought, reduced

rainfall and the depletion of water towers. There is need to sensitize the masses on the essence of the conservation of the available water and the water catchment areas. The approach will inevitably instill a sense of duty to the citizens with regard to the responsibility of conservation and ownership of programmes.

Our country Kenya is on the tropics. We have the benefit and great privilege of two rainy seasons in a year. Most of the citizens of the republic going by the response generated by the study are fully aware of the importance of rooftop rainwater harvesting but have failed to adopt it due to lack of funds, ignorance and the caused approve of assuring that water scarcity is a temporal problem. There is need to develop and legislate a framework that ensures that all buildings have provisions for the rooftop rainwater harvesting infrastructure. This will have the impact of ensuring the presence of rooftop rainwater harvesting infrastructure and the enactment of the same by way of statute.

The study established that the local community was fully aware of the rooftop rainwater harvesting. Efforts should be made to identify financiers to provide resources for the acquisition of rooftop rainwater harvesting infrastructure. This is with the rationale that the savings accrued to the households and institutions in the time expended to seek water in the disruption of supply and connection to the mainstream water and sewerage supply may be much compared to the capital expenditure of the initial installation. Availing of technology to treat the harvested water will help demystify the myth that rooftop rainwater may not be safe. It will ultimately help the masses appreciate the need to harvest water from their rooftops and the savings accrued will be channeled to other spheres of national growth and development.

The researcher suggests that a similar study with a bigger geographical spread to the county level should be conducted with a view of finding out if similar factors that apply to Murang'a East district apply to the other areas. The researcher equally suggests that a study should be carried out to determine the factors affecting surface runoff water harvesting in Murang'a East district.

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APPENDICES

Appendix 1: Introduction letter

Purity Mumbi Wahogo
P. O. Box 10200 - 381
Murang'a

Dear Respondents

I am a post graduate student at Kenyatta University, School of Environmental Studies. I am undertaking a research on "Rooftop Rainwater Harvesting as adaptation to climate change in schools in Murang'a East district Kenya".
Kindly assist by filling in questionnaires to the best of your ability. Your cooperation will be highly appreciated and your identity will be treated with utmost confidentiality.

Thanks in advance

Yours faithfully,

Purity Mumbi Wahogo

Appendix 2: Questionnaire for parents with children in primary schools

Kindly fill in the required information in the spaces provided and tick in the boxes. Your contribution by way of filing in the questionnaire will make the study a success and your participation is highly appreciated.

General Information

1. Name of school .....

2. Location of the school .....

Please tick where applicable

3. Respondent's gender Male ☐ Female ☐

4. Respondent's age

   20-29 ☐

   30-39 ☐

   40-49 ☐

   50 and above ☐

5. Highest level of education attained

   Primary ☐

   Secondary ☐

   Tertiary ☐

   University ☐

6. Kindly indicate the economic activity that you undertake

   Subsistence farming ☐

   Commercial farming ☐

   Business ☐

   Formal employment ☐

   Other .....

7. What is the average household income per month?

   Less than 5000 ☐

   6000 – 10000 ☐

   11000 – 15000 ☐

   16000 – 20000 ☐

   20000 and above ☐

8. Kindly indicate your religion

   Christian ☐

   Muslim ☐

   Hindu ☐

   African traditions ☐

   Any other .....

9. Kindly indicate if you have any leadership position in the school

   Yes ☐

   No ☐

10. Kindly indicate which position you hold in the school's leadership

    .....

11. Kindly indicate if you hold any other leadership position in the community and state which one

    .....

12. How long have you been a resident of this location? Please indicate

    0 – 5 yrs ☐

    6 – 10 yrs ☐

    11 – 15 yrs ☐

    16 – 20 yrs ☐

    20 and above ☐

Climate Change Awareness

14. Have you keenly observed the weather in the recent past?

To a great extent ☐

To a fair extent ☐

To a very fair extent ☐

15. For how long have you observed the weather changes?

0 -5 yrs ☐

6 – 10 yrs ☐

11 – 15 yrs ☐

16 – 20 yrs ☐

16. What particular change have you observed in the time you have indicated?

(Tick if those you have observed)

a) Higher temperatures ☐

Lower temperatures ☐

b) Reduced rainfall ☐

Prolonged drought ☐

17. Have you heard climate change being mentioned?

Very much ☐

Fairly ☐

Very fairly ☐

18. Please indicate the forum that it is you heard climate change mentioned

(Tick the forums that you have heard climate change mentioned)

Media ☐

Church ☐

Chief's baraza ☐

Agricultural field day ☐

Political rally ☐

Any other .....

19. Do you agree that climate change is real?

Very much ☐

Fairly ☐

Very fairly ☐

20. Has climate change affected the school that your child attends?

To a great extent ☐

To a fair extent ☐

To a very fair extent ☐

21. In which specific ways has climate change affected the school your child goes to?

Flooding ☐

Loss of infrastructure ☐

Increased whirlwind and dust ☐

Irregular water supply ☐

Any other .....

22. Has the school put in place any measures to take care of these effects?

To a great extent ☐

To a fair extent ☐

To a very fair extent ☐

23. Have you observed the following:-

Please tick as appropriate

A – Agree **SA – Strongly Agree** **U – Undecided**

D - Disagree **SD - Strongly Disagree**

i). Rainfall has been increasing in the last 10 years	SA	A	U	D	SD
ii). Temperatures have increased for the last 10 year	SA	A	U	D	SD
iii). Dust from whirlwind have become more frequent	SA	A	U	D	SD
iv). Climate change has disrupted economic activities	SA	A	U	D	SD
v). The school my child attends has been reached in climate change awareness	SA	A	U	D	SD
vi). Climate change has affected the learning process in the school my child attends	SA	A	U	D	SD
vii). There has been disruption of water supply in the school my child attends	SA	A	U	D	SD
viii). The disruptions in water supply in the school my child attends are attributable to climate change	SA	A	U	D	SD

Climate Change in Relation to Water Supply

25. What is the source of water supply to the school your child attends?

River ☐

Borehole ☐

Well ☐

Piped water ☐

Any other .....

26. Is the system of water supply assured at all times?

Very much ☐

Fairly ☐

Very fairly ☐

27. In case of disruption of water supply how does the school cope?

Fetching from river ☐

Pupils carrying from home ☐

Use of water browsers ☐

Any other .....

28. Kindly confirm the following:-

Please tick as appropriate

A – Agree **SA – Strongly Agree** **U – Undecided**

D - Disagree **SD - Strongly Disagree**

i). I have not witnessed the following occurrences and I fell they are related to climate change:

River flooding	**SA**	**A**	**U**	**D**	**SD**
Drying up of rivers	**SA**	**A**	**U**	**D**	**SD**
Drying up of wells	**SA**	**A**	**U**	**D**	**SD**
Low volumes from springs	**SA**	**A**	**U**	**D**	**SD**

ii). The school has put in place any measures to respond to the situation above in (11) through:

Constructing a dam	**SA**	**A**	**U**	**D**	**SD**
Harvesting water from roofs	**SA**	**A**	**U**	**D**	**SD**
Pumping water from the river	**SA**	**A**	**U**	**D**	**SD**
Drilling of bore hole	**SA**	**A**	**U**	**D**	**SD**

Awareness of Rooftop Rainwater Harvesting

29. Are you aware that rain can be harvested from the roofs to cater for periods of shortage?

Very much ☐

Fairly ☐

Very fairly ☐

30. Who provided the initiative?

Parents ☐

Provincial administration ☐

Local leaders ☐

Any other .....

31. Kindly confirm the following:-

Please tick as appropriate

A – Agree **SA – Strongly Agree** **U – Undecided**

D - Disagree **SD - Strongly Disagree**

i. Water harvested from the roof top is safe for drinking and usage	**SA**	**A**	**U**	**D**	**SD**
ii. Water harvesting is cost effective	**SA**	**A**	**U**	**D**	**SD**
iii. The community has embraced rooftop rain water harvesting	**SA**	**A**	**U**	**D**	**SD**

Rooftop Rain Water Harvesting Constraints in Relation to Climate Change

Awareness Level

32. Kindly confirm the following attributes:-

Please tick as appropriate

A – Agree **SA – Strongly Agree** **U – Undecided**

D - Disagree **SD - Strongly Disagree**

i. The disruption of water supply has affected the school in the following ways:					
Increased water borne diseases	**SA**	**A**	**U**	**D**	**SD**
Low standards of hygiene	**SA**	**A**	**U**	**D**	**SD**
Reduced learning time	**SA**	**A**	**U**	**D**	**SD**

33. How do you think information on climate change should be disseminated?

.....

.....

34. Do you consider the current approaches in climate change information dissemination as appropriate?

.....

35. Is the local community aware of rooftop rainwater harvesting?

.....

36. Are there constraint against the adoption of roof top rainwater harvesting?
Please tick any factor listed below that you feel could be a hindrance to the adoption of roof water harvesting practice in the school your child attends

Lack of funds ☐

Lack of awareness ☐

Ignorance ☐

Insecurity ☐

Harvested water is not safe ☐

Water scarcity is a temporary problem ☐

Any other.....

.....

Appendix 3: Interview schedule for County Director of Environment

1. How long have you worked in the district as the environment officer?

.....

2. Kindly describe your experience in the work station with regard to your interaction with the community?

.....

3. How would you rate the local community concerning awareness of climate change?

.....

4. Has your office made efforts towards educating the community on climate change issues? .....

5. Has it been your own initiative or there is a government programme in place?

.....

6. How has the community responded to the initiative?

.....

7. What is the situation of water supply to households, learning institutions and social centers in the district? .....

8. Have there been instances of water scarcity or disruption of water supply?

.....

9. In the event of scarcity how does the community cope? .....

10. How are the rainfall patterns in the district? .....

11. Would you consider the rainfall adequate for viable agricultural activities?

.....

12. Have there been efforts to harvest rainwater from the rooftops in the public primary schools in the district during the rainy season?

.....

13. Are there any plans to sensitize the community on the need to harvest rainwater?

.....

14. How would you perceive the situation of water supply and distribution in the learning institutions?

.....

15. How can it be improved and what would be the best initiative for the situation?

.....

.....

Appendix 4: Checklist

1. Check and ascertain if the institution has a source of water supply.

2. Confirm if the water supply is regular.

3. If the source is piped water confirm if it is from a communal project or from a commercial water service provider.

4. If the source of water is a river confirm whether the water is seasonal or permanent.

5. Find out the distance from the institution to the river

6. Find out the distance from the institution to the nearest river

7. Find out the depth of the bore hole if source of water is from a borehole.

8. Confirm where the other nearest borehole is located.

9. Confirm if water supply from the bore hole is reliable

10. Check the topography of the area around the school.

11. Confirm whether it is hilly or flat

12. Find out if there is occurrence of runoff during rainy season.

13. Confirm whether the runoff is harvested or not.

14. Confirm the surface area of catchments.

15 Confirm the number of classes and all the roofed structures.

16. Confirm the type of roofing.

17. Confirm the condition of the roof

18. Find out if there is any infrastructure for harvesting rainwater from the roofs.

19. Confirm the presence of pipes and other plumbing accessories to harvest rainwater.

20. Check for the presence of tanks to store rainwater.

21. Confirm if the tank has rain water.

22. Find out if the tank has a filter to check contamination.

23. Check the condition of the tank i.e. If it is operational.

24. Find out the capacity of the tank.

25. Confirm if the tank is cleaned and how regularly this is done

26. Find out clean the roofs and gutters are.

27. Confirm whether there has rain in the last one month

28. Apart from tanks check for other storages 'jars', 'drum'or'cistern'

29. Check if the storage contains water

30. Check how clean the tank is i.e. for any objects, vegetation etc that are likely to cause contamination.

Appendix 5: How rooftop rainwater harvesting infrastructure works

Rainwater can be collected from most forms of roof. Tiled roofs, or roofs sheeted with corrugated mild steel etc are preferable, since they are the easiest to use and give the cleanest water. Thatched or palm leafed surfaces are also feasible; although they are difficult to clean and can often taint the run-off. Asbestos sheeting or lead-painted surfaces should be avoided (WaterAid n. d.). This study revealed that most schools in Murang'a East District are roofed with corrugated iron sheets hence they can harvest save cooking, washing and even drinking water if treated.

In Rooftop Rainwater Harvesting Systems rainwater from the roof is collected in a storage vessel or tank for use during the periods of scarcity. Usually these systems can be designed to support the drinking, cleaning and cooking needs in schools. Such a system usually comprises a roof, a storage tank and guttering to transport the water from the roof to the storage tank. In addition, a first flush system to divert the dirty water which contains roof debris collected on the roof during non-rainy periods and a filter unit to remove debris and contaminants before water enters the storage tank are also provided.

Roof catchment

The roof of the house is used as the catchment for collecting the rainwater. Roofs made of corrugated iron sheet, tiles or concrete can be utilized for harvesting the rainwater. Thatched roofs are not suitable as it gives some colour to water and also the water carries pieces of roof material (such as palm leaves).

Gutters

Gutters are channels fixed to the edges of roof all around to collect and transport the rainwater from the roof to the storage tank. Gutters can be prepared in semi-circular and rectangular shapes. Locally available material such as plain galvanized iron sheet can be easily folded to required shapes to prepare semi-circular and rectangular gutters. Semi-circular gutters of PVC material can be readily prepared by cutting the PVC pipes into two equal semi-circular channels. Bamboo poles can also be used.

Downpipe

Down pipe is the pipe, which carries the rainwater from the gutters to the storage tank. Down pipe is joined with the gutters at one end, and the other end is connected to the filter unit of the storage tank.

First flush pipe

Debris, dirt and dust collect on the roofs during non-rainy periods. When the first rains arrive, this unwanted material will be washed into the storage tank. This causes contamination of water collected in the storage tank thereby rendering it unfit for drinking and cooking purposes. Therefore, a first flush system is incorporated to dispose off the water from 'first rain' so that it does not enter the tank. A simple system that may be recommended for schools is based on a simple manually operated arrangement, whereby, the down pipe is moved away from the tank inlet and replaced again once the first flush water has been disposed.

Filter unit

The filter unit is a container or chamber filled with filter media such as coarse sand, charcoal, coconut fiber, pebbles and gravels to remove the debris and dirt from water that enters the tank. The container is provided with a perforated bottom to allow the passage of water. The filter unit is placed over the storage tank.

Storage tank

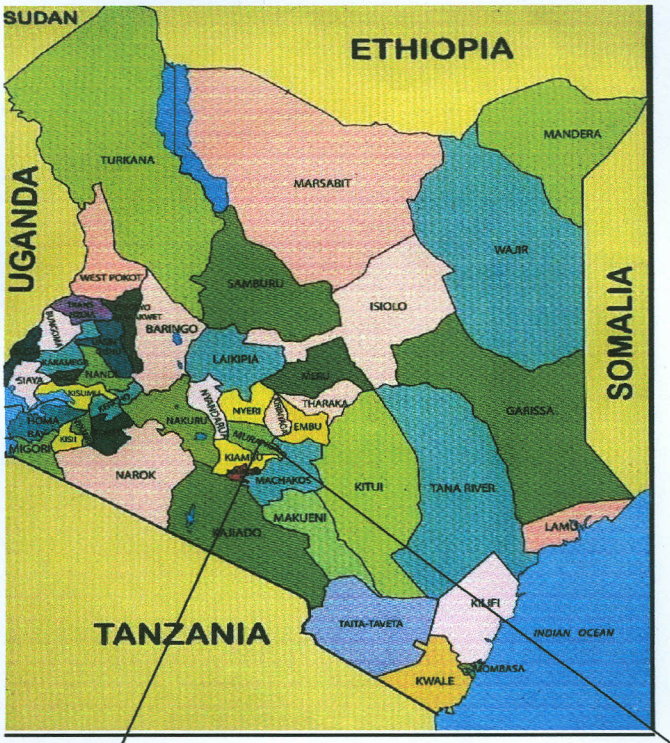
Storage tank is used to store the water that is collected from the Rooftops. Common vessels used for small scale water storage are plastic bowls, buckets, jerry cans, clay or ceramic jars, cement jars, old oil drums etc. For storing larger quantities of water the system will usually require a bigger tank with sufficient strength and durability.

Collection pit

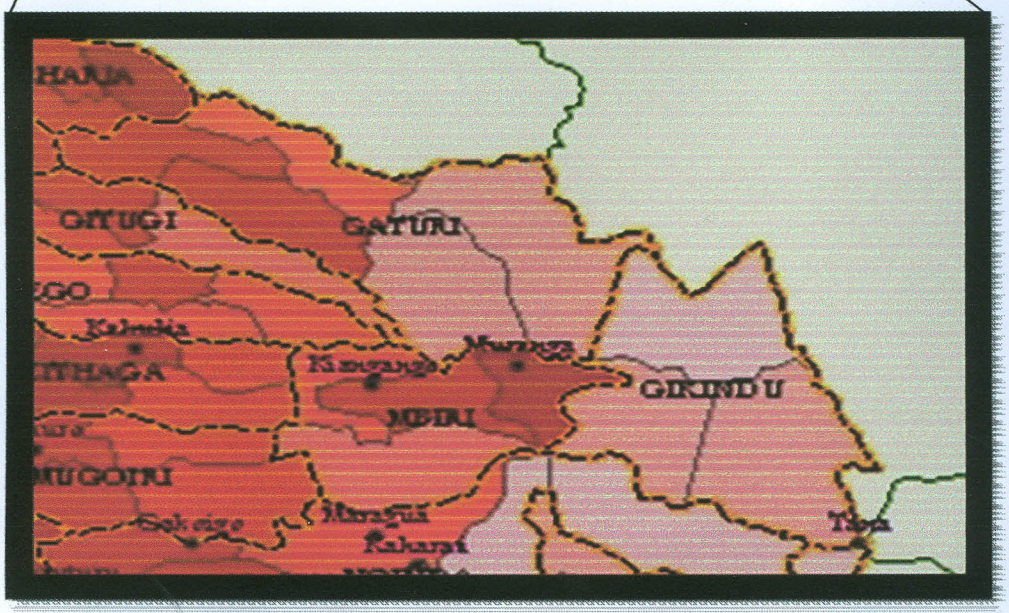
A small pit is dug in the ground, beneath the tap of the storage tank and constructed in brick masonry to make a chamber, so that a vessel could be conveniently placed beneath the tap for collecting water from the storage tank. A small hole is left at the bottom of the chamber, to allow the excess water to drain-out without stagnation.

Appendix 6: Study area

Kenya Counties Map



Murang'a East



Source: Adopted from District Environmental Action Plan 2006-2011 Murang'a District