SPATIAL VARIATION IN ADOPTION OF RAINWATER HARVESTING TECHNIQUES IN MERU COUNTY, KENYA.

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Degree Requirements for the Award of Master of Arts in Geography of Chuka University

CHUKA UNIVERSITY

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DECLARATION AND RECOMMENDATION

Declaration

This is my original work and that it has not been submitted to this or any other university for the award of degree.

Signature____________________ Date 10/9/2019

Agnes Karwitha Mbogori

AM15/03560/10

Recommendation

This Thesis has been examined, passed and submitted with our approval as University supervisors.

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DEDICATION

To my children; Beatrice Kendi, Victor Mutethia and Stephen Ndumba

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I sincerely thank God, the Almighty who has given me good mental health to undertake and accomplish this task.

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I take any responsibility of any error or omissions in this work.

ABSTRACT

Rainwater harvesting has been used to address water shortage in various regions. The harvested rainwater is used for domestic purposes, irrigation and agricultural processing. Various technologies have been used over time with improvements on the old technologies as well as introduction of new technologies. Rainwater harvesting systems can be constructed with inexpensive locally available materials. People use tanks attached to roofs, caves, earth dams, underground trenches among others. However, despite the economic viability and potential of RWH techniques for improving agriculture and livelihoods, the adoption of RWH techniques by farmers is not adequate. This calls for an examination and evaluation of socio-economic factors that influence the spatial variation in the adoption of rainwater harvesting techniques in the region. A large part of Buuri Sub-County of Meru County is dry and falls in the rain shadow of Mt. Kenya with no permanent rivers and with few community-based water projects, thereby posing a great shortage of water. Like in other hot and dry parts of Kenya, rainwater harvesting has been intensively promoted in Buuri Sub-County to meet domestic needs, irrigation and other purposes. The study was guided by three objectives: (1) To investigate whether the residents of Buuri Sub-County engage in rainwater harvesting, (2) to investigate which rainwater harvesting techniques are used in Buuri Sub-County, and (3) to determine the socio-economic factors that influence the spatial variation in the adoption of rainwater harvesting techniques in the area. The study was an adoption study of descriptive survey design. The target population was 2503 homesteads in Buuri Sub-County, and a sample size of 101 respondents was selected through purposive sampling. Questionnaires were used as the instruments of data collection. Qualitative data obtained was analysed thematically. The quantitative data obtained from the study was analysed using Chi-Square tests, Pearson correlation, t-tests, one way ANOVA, and binary logistical regression. The study revealed that there was inadequate harvested rainwater despite wide adoption of rainwater harvesting (95% of the farmers), with tanks not exceeding 4000 litres highly utilised. This could be attributed to a general lack of awareness on other appropriate rainwater harvesting technologies. Additionally, the findings showed that age, academic qualification, and occupation influenced the respondents' choices of rainwater harvesting technologies. The study revealed that the two regions chosen i.e: Kamutune and Kiirua had a slight difference in adoption of RWHTS, which was 93.5% and 97.8% respectively. Based on these findings, the study recommends the intervention of Rainwater Harvesting Techniques through infrastructural development, financial incentives, and awareness creation to popularise the adoption of alternative techniques of rainwater harvesting for commercial, domestic, and agricultural purposes by the residents of Buuri Sub-County.

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ACRONYMS AND ABBREVIATIONS

ALRMP	Arid Land Resource Management Project
ARCSA	American Rainwater Catchment Systems Association
CBAR	Crop Basin Area Ratio
FARMESA	The Farm Level Applied Research Methods for East and South Africa.
GHARP	Greater Horn of Africa Rainwater Partnership
IRHA	International Rainwater Harvesting Alliance
KNBS/PHC	Kenya National Bureau of Statistics and Population Housing Census
KRHA	Kenya Rainwater Harvesting Association
NCWSC	National City Water and Sewerage Company
NDMA	National Drought Management Authority
OECD	Organisation for Economic Cooperation and Development
RH	Rainwater Harvesting
RHA	Rainwater Harvesting Agriculture
RRWH	Rooftop Rainwater Harvesting
RWHTS	Rainwater Harvesting Techniques
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
TWDB	Texas Water Development Board

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Water is the most important substance on earth. In order to sustain human life, water is a vital necessity for personal consumption, the development of agriculture and manufacturing processes that are essential to the improvement of the quality of human life. The number of people living in river basins is expected to double in the next forty years, reaching 3.9 billion (TWDB, 2007). Additionally, the earth's human population is projected to reach 9.7 billion people by 2050, and its demand for water will increase by 55% (OECD, 2011). Due to competing demands from other sectors and the degradation of the environment, this same number of people will experience severe water stress.

The rapid population growth coupled with the contemporary phenomenon of industrialization, urbanization, agricultural intensification, and lifestyle changes is resulting into a global water crisis (UN-HABITAT, 2006). Due to the stressed nature of secondary sources of water such as lakes and rivers, rainwater-harvesting technology, a technology practised for more than four thousand years, has become a primary alternative to alleviate water scarcity around the world and to help the world meet the challenge of water scarcity.

Various writers and organisations such as Safe Water Network, Charity Life Water Organisation and Water Aid; have provided various definitions of rainwater harvesting. TWDB (2007) describes rainwater harvesting as the capture and storage of rainwater for landscape irrigation, portable and non-portable activities, indoor use and the alleviation of damages caused by storm water. Hatibu and Mahoo (2009) describe rainwater harvesting as a process of concentrating, collecting and storing rainwater for different uses at later times in the same area, where rain falls or in another area during a later time. Tobin, Ediagbonya, Ehidiamen and Asogun (2013) define rainwater harvesting as any human activity that involves the collection and storage of rainwater in some natural or artificial container for immediate use or use before the onset of a different seasonal condition for agricultural, industrial and environmental purposes.

Harvested rainwater can be particularly useful where no other source of water is available or if the available supply is inadequate or of poor quality. Xu (2007) argues that rainwater harvesting is the synergistic integration of rainwater catchment systems and water storage techniques for holding rainwater for a prolonged period of time. Rainwater harvesting is usually employed as an umbrella term describing a range of technologies used in the processes of trapping, collecting, and conserving various forms of runoff water originating from ephemeral water producing during rainy weather conditions. The aim of water harvesting is to conserve rainwater, mitigate the effects of temporal shortages of water and alleviate adverse environmental effects caused by surface run-off water.This can be done by applying the most suitable RWHTS that include::roof water ,surface run-off as well as appropriately storing the harvested water. Water shortages may occur during the dry seasons of the year or during temporal or prolonged periods of rain shortage during expected rainy reasons of the year.

The demand for freshwater on a global basis is becoming an all-encompassing social problem. In several countries people use water, which has been recycled at least three times in their homes. This shows that the demand for usable water is increasing faster than its supply. Therefore, rainwater harvesting is a perfect solution to the water problem. This can be done by harvesting, applying the most suitable technique of rainwater harvesting including roof water and surface runoff, as well as storing it appropriately (KRHA, 2010).

UNEP (1982) identifies three basic stages for any rainwater harvesting technology, namely catchment areas (rooftops and land surfaces), conveyance systems (gutters or drainage pipes) and collection devices (storage tanks or reservoirs). The integration of the basic elements of rainwater harvesting techniques results in the diversion of runoff water from the atmosphere. This occurs using an appropriate catchment area during a given rainfall event and the subsequent storage of portions of the rainwater into a collection vessel. Runoff may be harvested from permanent catchment surfaces or even from intermittent watercourses, resulting in the classification of rainwater harvesting techniques into two broad categories: rainwater harvesting techniques, which harvest runoff from permanent catchment surfaces and rainwater harvesting techniques, which capture runoff from watercourse discharges. Rainwater harvesting technologies can be categorized into several ways based on the runoff generation process, the size of the catchment surface and the type of storage (Julius, Prabhavathy, & Ravikumar, 2013).

Adoption of rainwater harvesting techniques across various regions and during different periods of history is diverse based on the extent and nature of the necessity to harvest rainwater by the local population, the socio-economic disposition of the residents, the geographic characteristics of a region and the distribution of rainfall. During the 3^{rd} century B.C., farming communities such as Baluchistan and Kutal in Pakistan adopted rainwater harvesting techniques for irrigation. Rainwater from Brihadeeswarar Temple was collected in Sivaganga Tanks. At the times of the Indus Valley civilisation, the adoption of this technique of rainwater harvesting was able to cater for domestic purposes, livestock rearing and irrigation. Rainwater harvesting techniques were also used in Israel as early as 2000 B.C. Archaeological discovery of broken cisterns confirms that ancient communities in Israel used to store rainwater. Currently in China and Brazil, the adoption of large rooftop rainwater harvesting techniques is ongoing in the urban areas of Gansu Province (China) and North-East Brazil. In Europe and North America, private enterprises have invested in the production of rainwater harvesting systems such as underground and fibreglass tanks. Filtration and rainwater systems control to harness their rainwater potentials in an effective manner.

According to a UN-HABITAT (2006) report, the quantity of rainwater falling across Africa is equivalent to the needs of a billion people while a third of the continent is deemed suitable for rainwater harvesting. However, the report emphasizes that water crisis is more of a socio-economic problem arising from lack of awareness and investment rather than a matter of physical scarcity. Kumar,*et* al., (2011) stated that people in dry rural areas of African would like to harvest rainwater but are hindered by lack of resources such as storage tanks, appropriate catchment areas, technical know-how among others. Cheserek (2013) confirms the above argument by stating that socio-economic factors influence farmers' decision to adopt rainwater harvesting techniques. He adds that these factors are categorised into household variables (gender, education and age) and economic variables (wealth status, access to credit, social status and household members' perception).

Buuri Sub-County lies on the Eastern Central Highlands of Kenya, one of the nine sub-counties of Meru County. It lies on the leeward side of the Nyambene Ranges and receives inadequate rainfall. A large section of Buuri Sub-County is dry and falls in the rain shadow of Mt. Kenya and hence has unreliable bimodal rainfall averaging 500mm-900mm per annum. These areas are poorly endowed with water sources, and groundwater resources generally lay at a considerable depth of 150m and below. They require drilling of boreholes and mechanised means of lifting the water to the surface for the use by the community. Moreover, most times this underground water is highly saline and unfit for human consumption (Meru County Development Profile, 2013)

In addition, Buuri Sub-County has no large, reliable permanent rivers. In some sections of this region, people trek for long distances to search for water for domestic purposes and watering animals. Small-scale farmers growing crops such as coffee, cotton, wheat, maize, beans and potatoes depend entirely on rainfall, which is unreliable. The region experiences long periods of droughts and acute shortage of water especially in the months of July-September. Due to the terrain of Buuri Sub-County, incidences of flash floods often occur during the rainy season and several months of droughts follow accompanied by an acute shortage of water. A large section of Buuri Sub-County is flat whereas others are sloppy and undulating. Although there are some community-based water projects in the region, water is inadequate for both domestic and airrigation purposes. Some of the community-based water project in the region include; Mutethia, Nkong'u- Nabŭŭ, Ruiri Water Project, Kathita–Kiirua, Kathima and Kirwiro among the others (Meru County Development Profile, 2013).

Rainwater harvesting is one of the strategies applied to solve water shortage in Buuri Sub-County. Various rainwater harvesting technologies have been adopted in Buuri Sub-County. There are efficient techniques with a high potential for rainwater harvesting such as tanks, earth dams, trenches, pans, dugout pits, underground reservoirs among others (KRHA, 2010). Rainwater harvesting techniques are strongly influenced by socio-economic factors. Murgor, Owino, Cheserek and Saina, (2013) confirm that the strong influence of socio-economic factors affects the nature, rate and extent of the adoption of rainwater harvesting techniques.

Incidences of floods experienced in 2011 in Buuri Sub-County during the long rainy season provoked the need to evaluate the nature of the rainwater harvesting techniques and the socio-economic factors influencing the choice of different rainwater harvesting techniques in the area. These floods were followed by acute drought in 2012 and shortage of water.

1.2 Statement of the Problem

One of the biggest challenges of the 21st century is to overcome the growing water shortage. Much of the actual water shortage can be relieved if rainwater harvesting is practised widely and appropriately. People collect and store rainwater in tanks, ponds, barrels and dams. The collected rainwater is a valuable supplement that would otherwise be lost through surface runoffs and evaporation. Rainwater harvesting (RWH) has thus regained its importance as a valuable alternative or supplementary water resource, along with the other conventional water supply technologies.

Like in other dry, arid and semi arid parts of Kenya: in Buuri sub-county household RWH has been promoted intensively to meet their own domestic needs and provide additonal irrigation to their long rain season crops as well as water for domestic animals.Many studies have been done on the rate of adoption on Rain Water Harvesting Techniques(RWHTS). These studies tried to explain why farmers are reluctant in using the technology. However, the findings do not provide adequate reasons as to why the rate of adoption of RWHTS is slow among the farmers.

Despite the economic viability and potential of rainwater harvesting techniques for increasing agricultural productivity and livelihood, the adoption of rainwater harvesting techniques by the residents of Buuri Sub-County is not satisfactory. Water obtained through rainwater harvesting is not adequate for domestic, agricultural and commercial purpose. This study analysed factors that influence spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub-County.

1.3 Purpose of the Study

The purpose of this study was to analyse the socio-economic factors that influence the spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub-County in Meru County.

1.4 Objectives of the Study

The study was guided by the following objectives:

i. To investigate whether the residents of Buuri Sub-County engage in rainwater harvesting.
ii. To investigate which rainwater harvesting techniques are used in Buuri Sub-County.
iii. To determine the factors that influence the spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub-county.

1.5 Research Questions

The research was guided by the following questions:

i. Have the people of Buuri Sub-County adopted rainwater-harvesting techniques?
ii. Which rainwater harvesting techniques do residents of Buuri Sub-County use?
iii. What factors influence the spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub-County?

1.6 Significance of the Study

This study highlighted the socio-economic factors that influence rainwater harvesting in Buuri Sub-County. The information obtained from the study is of great importance to the residents of Buuri sub-County who need to adopt rainwater harvesting techniques. Further, the study is vital for policymakers in the County Government of Meru, who are involved in the development strategies for water and environmental sustainability. Moreover, NGOs will also benefit from this study since it gives them an overview of the capability of the residents of Buuri Sub-County to adopt advanced rainwater harvesting techniques and the extent to which their socio-economic status limits the adoption of these methods.

1.7 Scope of the Study

The study involved the residents of Buuri Sub-County including local administrators and local water projects officials. The study specifically considered the following variables: gender, age, academic qualifications, length of residency, occupation and monthly incomes of the residents (KNBS, 2009). The study covers the nature of the adoption of rainwater harvesting techniques and the influence of socio-economic factors on the adoption of the techniques.

1.8 Limitation of the Study

The study area was vast. Hence, some of the regions could not be accessed on foot and on time. This required arrangement for transport for the research assistants and the researcher before the actual study. The use of chiefs as research assistants required great mobilization and coordination to enable the researcher to reach out to the respondents. Besides, some residents' responses required the researcher to remain alert to discern and to treat appropriately any contradictory data.

1.9 Assumptions of the Study

The study assumed that the residents of Buuri Sub- County were already aware of rainwater harvesting, but they were not fully exposed to advanced rainwater harvesting techniques. Therefore, this limitation hindered them to maximize the potential of rainwater harvesting techniques to obtain adequate RW. Besides, the researcher assumed that the residents' decision and ability to harvest rainwater was predominantly affected by socio-economic factors such as gender, age, education levels and income. The researcher also assumed that the residents of Buuri Sub-County would be cooperative, honest and accurate in giving credible data to enable the collection of adequate and reliable data for the study.

CHAPTER TWO
LITERATURE REVIEW
2.1 Overview of Rainwater Harvesting Techniques in Kenya

Various techniques of rainwater harvesting exist today. Strip catchment tillage method, also known as contour cropping, involves alternating strips of crops with a strip of grass or cover crops. Cultivation is usually restricted to the planted strips and the uncultivated strips release run-off into adjacent crop strips. This system is practised in many dry areas although farmers and extension workers may not recognize it as rainwater harvesting measure (Baugart & Macintosh, 1994).

The basin system, commonly known as 'the negarim' micro-catchment technique, is perhaps the best-known rainwater harvesting system. Water fills the basin and spills around the end of the bud into next basin, sometimes known as 'caag system'. Secondly, the field is divided into a closed basin and water is distributed either through a channel or in a basin to cascade using small spillways. The diversion is achieved using structures such as earth bunds, stones walls or brushwood barriers. Ephemeral streams diversions are subjected to frequent damages and are likely to be washed away by large floods (FAO, 1993). According to Patrick (1997), the approach uses micro-catchment feeds to direct run-off water to a discrete cropped basin. The basins are typically in the range of 40 cm high, and they are suited for free crops but other crops can be grown successfully under a non-mechanized farming system. A related method involves the construction of conservation bench terraces, which are designed to use part of the land surface and catchment to provide run-off onto level terraces on which crops grow. The system works perfectly in gentle slopes of 6% deep soils, in large mechanised farming, and in Crop Basin Area Ratio (CBAR) (Kihara & Ngetho, 1999).

Berhanu, et al., (2002) suggest the use of the streambed system as a strategy to capture rainwater. The systems use barriers such as permeable rocks dams or earth bank to intercept water flowing in an ephemeral stream and spread it across an adjacent valley with terrace to enhance infiltration. The technique is also known as 'Liman system' and is difficult to distinguish from spate irrigation. Diverting water from an ephemeral stream and conveying it to a cropped area, where the distribution is achieved in two ways. It first uses a cascade of open trapezoidal and, later, semi-circular bunds.

According to KRHA (2010) two major forms of rainwater harvesting exist: In-situ or within-field water harvesting and moisture conservation. In the in-situ method, rainwater is collected on the surface upon which it falls so that it can be used more efficiently on the same ground. For instance, the techniques involves rain harvesting where water is collected on roadsides that drain straight to the ground, but this water can be treated before use as it may contain bird faeces, germs and other pollutants. As noted by KRHA, in the same method, rainwater can be collected in dugouts, ponds and underground vessels.

Kihara (2002) argued that the in-situ rainwater harvesting method involves rainwater being collected as direct rainwater or as sheet runoff over a short area field distance, generally about 10 m, and used within the field where it falls. This involves the application of various techniques such as pits, half-moons, dykes and terraces. The water stagnates, then increases the time for infiltration to occur and subsequently the water is available in the plant zone. Ngure (2002) adds that there are several technologies for harvesting sub-surface water, which include dams or shallow structures and use of existing riverbeds or sand reservoirs in riverbeds for water storage. The dams arrest the flow of the surface river in natural shallow sub-surface aquifers, which can then be assessed through wells. A positive effect of this form of water harvesting is limiting of direct evaporative losses since the storage reservoirs are protected from the atmosphere.

The other form of rainwater harvesting is the external rainwater harvesting, which involves rooftop rainwater harvesting. In this method, rainwater is collected on rooftops instead of letting it go down the drain. Such water can be trapped by tanks or any other available containers. Water collected can be used for domestic purposes, irrigation as well as watering the domestic animals in small scale (Ngigi, 2004). According to the author, rainwater can be collected from the gullies and stored in tanks or reservoirs; this is done for longer-term storage or diverted directly to a field for direct infiltration by arresting the flow with the help of bunds, ditches and terraces for short-term storage.

In dry areas, flash floods are common. Thus, the diversion of floodwater into cultivated fields or storage facilities for later use is a very important component of rainwater harvesting. The diversion is achieved by raising the water level through temporary or semi-permanent channels (Hatibu & Mahoo, 2009). The use of cultivated reservoirs involves diverting harvested water into the basin where it is held and stored. The cultivated reservoirs are constructed by digging, and they are then filled to a depth of about 20 m. The scooped soil is then used to build a bund around the perimeter. The system has the same principle with semi-circular loops (Owoade, 2009). The reservoirs help because the rate of rising of water level is very slow due to the relatively large surface; use of reservoirs to control floods becomes more economical if the reservoir is used for other purposes. Ngigi (2009) argued that semi-circular loops (half-moons) involve digging pits having radii of about 2 m, and after the excavated soil has settled, it is used to construct a bound downstream of the pit whose height is about 25 cm. Afterwards, semi-circular loops are applied at a rate of about 300 loops per hectare. The loops are arranged in a line along the contour and staggered down the slope; crops are then grown in the half circle where the water and nutrients accumulate.

The detailed literature reviewed so far, analysed only the various techniques that can be applied to harvest RW. The studies gave no insight on the reasons why those techniques were preferred. The studies provided the researcher with information pertaining various types and methods of harvesting rainwater. However, a literature gap emanates in the line that none of the researchers made an extra effort to evaluate the success or failure of these techniques in curbing water shortage in the regions where they are practised. Nevertheless, the discussed techniques show how rainwater can be collected and used for agricultural purposes. Hence, this literature can be relied upon to find out if the people in Buuri Sub-County are aware of these techniques and the extent to which they apply them.

2.2 Rooftop Rainwater Harvesting Technology

Rooftop rainwater harvesting is another technique through which rainwater is captured from roof catchment and stored in reservoirs. Harvested rainwater can be stored in a sub-surface ground reservoir by adopting an artificial recharge technique to meet the household needs through storage in tanks. Rooftop rainwater harvesting is primarily for household use since the volumes obtained are seldom sufficient to cover agricultural needs beyond kitchen gardening (Pacey & Cullis, 1986). Rooftop water harvesting productions are limited by the amount of roof surface and volume of the tank. The volume harvested will not last throughout the year but should be seen as a seasonal opportunity.

In a study done in Embakasi part of Nairobi's Eastlands area on the quality of rainwater harvesting from rooftops, Gakungu (2013) found out that there is a general community perception that rainwater is safe to drink without having to undergo prior treatment; in contrast, a number of studies have reported the presence of specific pathogens including opportunistic pathogens in rainwater. To compare rainwater contamination in different locations, rainwater samples collected in four sampling sites namely Fetha Estate, Tassia, Nyayo and Baraka Estates were used. The harvested rainwater samples were collected from roof-tops made of three selected roofing sheet materials: corrugated iron sheet, clay tiles, and concrete tiles. Samples were analysed at the NCWSC Kabete laboratories.

A questionnaire survey was also carried in the study area to understand the current water supply situation, the problems the resident face as well as their attitude towards rainwater harvesting. A total of three hundred residents were interviewed. A chemical analysis done by NCWSC reviewed that water collected from iron sheet had a higher average of iron and zinc than the other two roofing materials. Nonetheless, the corrugated iron sheet water sample too had aluminium but no fluoride and manganese. Potassium and sodium levels were lowest in day tiles possible because of its porous nature. Lead and copper were not detected in any of the roof materials. The PH of the samples taken from corrugated iron sheets was lower than those from the concrete tiles roof and clay tiles roof. The turbidity of the water samples from the three roofs exceeded 1mg/l, which is within the World Health Organisation (WHO) guideline. This showed that all harvested rainwater required some form of disinfection by chlorine before use (Gakungu, 2013). The report was quite relevant to the current study in Buuri Sub-County due to the fact that rainwater harvesting in the region is basically for domestic purposes. However, the Embakasi-based study focused only on chlorination as a way of disinfecting the harvested rainwater. Other options to ensure that the rooftop harvested rainwater is safe for domestic purposes could be suggested through further research.

A different study done in India by Pawar-Patil and Mali (2013) to assess the potential of rooftop rainwater harvesting in Pirwadi Village of Kolhapur District, realised that it was very tedious to assess the catchment available for rooftop rainwater harvesting. The research also revealed that rainwater yield varies with the size and texture of catchment and that a smoother and cleaner impervious roofing material contributes to improved capacity of harvested water. It was also confirmed that water collection efficiency varies with roof type, though cement concrete roofs had maximum collection efficiency. However, people of Piwardi in India preferred to construct roofs using baked tiles. The research concluded that the water deficiency situations witnessed during hot seasons could be changed into water adequate situations by adopting roof rainwater harvesting techniques. However, this research focused only on roof-tops as catchment areas whereas there are other catchment areas which have great potential for capturing the rainwater, these include roads, pavements and rock outcrops.

Another study related to rooftop rainwater harvesting was conducted at Sankalchand Patel Sahakar Vidyadham (SPSV) Campus, Gandhinagar, India by Patel, et al., (2014) who realized that approximately 2.35 litres per square foot of collection surface per inch of rainfall could be collected through rooftop technology. However, some rainwater is lost to first flash, evaporation, splash out or overshoot from the gutters during persistent rain periods. It was also determined that rough collection surfaces are less efficient at conveying water as water captured in pore spaces tend to be lost to evaporation. Harvested rainwater can as well be lost through spillage and overflows. The study involved all the major buildings with large rooftops, which included all educational buildings, all hostels, guesthouses and staff quarters. Factors such as the annual rainfall amounts and monthly distribution were considered for sizing the systems.

The measurement of the catchment was done manually with the help of reinforced fibre tape, also known as *tape survey*. Runoff coefficient accounted for losses due to spillage, leakage, infiltration, catchment surface wetting, and evaporation. The rainwater harvesting capacity of different buildings was determined with respect to similar rainfall data. In this study, the rooftop surface area of different buildings including halls of residence and different departmental buildings varied greatly with each other; thus, the amount of discharge produced or rainwater runoff produced also was different. The research concluded that implementation of rainwater harvesting project to the campus of SPSV would be the best approach to fighting water scarcity. The gap in this study is that the research did not reveal factors that hindered or influenced roof-top rainwater harvesting. Patel, *et al.*, (2014) argued that there are other alternative methods of rainwater harvesting that could be used to increase rainwater harvested in the university that were not researched in the study.

2.3 Rainwater Catchment Area

Frazier and Lloyd (1993) argued that any surface or paved areas can be used as a rainwater catchment area. The footpaths and roads can also act as catchment areas since these areas receive the best of the rainwater because of the large amounts of runoff generated from them and there are fewer chances of contaminating the water. Nonetheless, studies done by Ngigi (2009) and Gakungu (2013) indicated that various factor affect determine the quality and quantity of rainwater harvested through various catchment areas. In rooftop harvesting, the roof pent affects how quickly water runoffs during a rain event. A steep roof sheds run-off quickly and more easily and cleans contaminants from the roof whereas a less steep flatter roof causes water to move more slowly raising the potential for the contaminants to remain on the catchment surface. Further, the size of the catchment area determines the quantity of water that can be harvested. The area is based on the 'footprint' of the roof, which can be calculated by finding the area of the building and adding the area of the roof's overhang (Gould & John, 1999).

Lameck (2002) added that conveyance system is equally important; it includes rain gutters and down pipes, which collect the water from the catchment surface to the storage tank. These rain gutters need to be designed appropriately so as to avoid the loss of water during the conveyance process. Storage is the most important part of rainwater harvesting. The storage system is designed according to the amount of water that is to be stored. The design and site location of the storage or the recharge system should be properly chosen. The storage system should be properly sealed to avoid leaking. For domestic purposes, use of chlorine from time to time is necessary to keep the water clean and safe for consumption.

Rock catchment systems are also feasible water catchments in the rocky areas. In Kitui County, for example, some of these rocks are in places that have been subjected to an intensive destruction of vegetation and subsequent soil erosion resulting in bare masses of rocks. The catchments, however, are expensive to construct and maintain, but they provide relatively clean water. Rock catchment systems are also prone to pollution, water stealing, vandalism and destruction by wild animals in search of water; hence, they need to be fenced to keep off intruders and thieves as well as wild animals that may cause pollution and destruction (Ngure, 2002).

According to Ngigi (2004), rock catchments are reservoirs located on the bare surface with sufficient catchment area to capture enough rainwater during the rainy seasons for use during the dry seasons. The reservoirs are constructed using masonry walls. Gutters are constructed on the rocks at a gradient in order to direct the runoff to a reservoir. The most suitable rocks include granite and granitoid gneisses due to their low permeability and resistance to the weathering. The literature review offered by Frazier and Lloyd, Ngure and Lameck accounted how appropriate catchment areas should be. However their findings are important to the current study since it intends to find out the catchment areas used in Buuri Sub-County and whether they appropriately aid RWHTS to solve water shortage.

Nonetheless, for the vast majority of tank-based rainwater harvesting systems, the catchment area is the surface of the roof (Mustafa, 2006). There are some crucial factors about the roof to consider when planning for a rainwater harvesting system. Roof material, one of the main considerations, is not as important as contaminants that maybe on the roof. For landscape purposes, the common asphalt shingle would work fine, but metal is more recommended because it sheds contaminants easily. It is important to avoid wood shingles or metal flashing roofs that contain lead (Pachpute, Tumbo, Sally, & Mul, 2009).

2.4 Factors Influencing the Spatial Variation in Adoption of Rainwater Harvesting Techniques

According to FAO (1986) findings, rainfall in Sub-Saharan Africa is highly erratic and is normally described as intensive storms with very high intensity and spatial, temporal variability; this creates a high risk for annual drought and intra-seasonal dry spells; hence, there is a need for dry spell mitigation by improving water productivity in the region. In fact, various studies have uncovered many promising water-harvesting and soil conservation techniques that can be used by farmers throughout Sub Saharan Africa (Reij, Scoones, & Toulmin, 1998). For instance, Kenya and Ethiopia are said to have the potential to meet the needs of 6-7 times their current population if proper strategies of rainwater harvesting are adopted (Pacey & Cullis, 1986). These findings are justified by a United Nations report, (2000) which established that African countries are suffering or facing water shortages because of climate shortage, but these countries have a massive potential for rainwater harvesting.

The Kenya Law (2002) stated that Kenya is a water scarce country with serious challenges in the protection of resource provision of water supply and sanitation services. Due to the large population of about 40 million as per Population Census Report of 2009, the country has an acute water shortage. The Kenya Water Act responded to these challenges by encouraging the principle of the local users taking responsibility for the guardianship of water resource; one of the ways to solve the problem was to harvest rainwater (Kenya Law, 2002). In the country, rainwater harvesting is practised in various parts of the country; some of the areas where the practice is more pronounced include Lamu, Taita Taveta, Machakos, Kitui, and Laikipia among others (Wanyonyi, 2002).

In West Africa, there is a climate change adaptation programme entitled, “The construction of infrastructure for water storage,” which encourage countries in the region to begin a massive campaign of mobilisation of surface and underground water by the construction of dam and water reserves. For instance, Burkina Faso has built more than 1500 water dams during the last three decades. In Ghana, small reservoirs have been established for water supply and irrigation (Ngigi, 2004). The study showed that annual runoff generated in Africa amounts to 5,195 km^3, which if harnessed, could support the livelihood of many people. Further, Malesu, *et al.,* (2006) observed that surface runoff in Africa countries can be harnessed from a wide range of catchment surfaces such as roads, home compounds, hillsides and open pastureland, which include runoff watercourses and gullies that can be stored in small reservoirs such as ponds or water pans. Through these technologies, areas with the potential surface for runoff provide opportunities to analyse different interventions. The discussion above showed clearly Africa as a continent has a great potential to obtain large volume of RW for both domestic and agricultural purposes. However, their studies showed the rate of adoption of RWHTS but gave no reason for the extent of the adoption and factors influencing the adoption of the technology in the region of study.

According to Kumar, *et al*., (2011) most farmers are not aware of rainwater management techniques for storage and groundwater recharge. The major constraints identified for conservation and management of water and soil include lack of technical knowledge and poor economic status of the farmers. It was reviewed that the most efficient and cheapest way of conserving rainwater at an agricultural farm was the in-situ run off management, which also reduces soil erosion and increases the opportunity time for the ground recharging. The study also found that good results of harvesting and storage of rainwater harvesting and storage are achieved in Ferro-cement water storage structures of a different dimension of 3-5 m deep and 1-3 m in diameter. The research concluded that erratic and even distribution of rainfall both spatially and temporarily necessitates rainwater harvesting to increase and sustain the agricultural productivity.

Further, the study established that excavated dug-out farm ponds tanks are most suitable for storing runoffs in a cultivated land with inverted truncated pyramid shape having 1:1 side slopes with the lining of polyethene sheet of 200 micro-buried under the 20 cm thick soil of bottom and pitched with bricks (Kumar, *et al*., 2011). However, the research never showed the target population, the methods used to arrive at the above conclusion and only focused on farm ponds as a method to trap rainwater. Consequently, other potential techniques of rainwater harvesting were not highlighted.

A study related to the present study was carried by a number of scholars like Murgor *et al*., (2013) in Keiyo Sub-County, which is an arid and semi -arid area just like Buuri Sub-County; hence, the residents face the same challenges as those of Keiyo sub-county. RWH has been promoted intensively in order to harvest water that is required to meet domestic needs and provide additional irrigation to their long rain season crops, but the process was influenced by various socio-economic factors that undermine its success. Combined methods such as field surveys as well as structured and semi-structured interview, were used to solicit data from the residents to determine factors influencing the decision to adopt water harvesting techniques. A descriptive statistical analysis approach for assessing real causes of low adoption rates for rainwater harvesting techniques in the sub-county was used. The researchers concluded that a number of factors were responsible for causing the low adoption of rainwater harvesting in Keiyo sub-county. These included poor capital and human endowment, lack of access to credit, involvement in off-farm activities, negative perception, gender issues, inaccessibility of construction materials, and lack of technical know-how.

The study also revealed that Keiyo sub-county residents' level of education and their involvement in social responsibilities were positively influencing the adoption of the rainwater harvesting techniques. The fundamental recommendations made by the researchers were to create awareness for farmers and the provision of technical and institutional support for facilitation of extension services. The researchers further suggested the provision of technical assistance, training and credit services to the farmers. It was also indicated that available resources needed to be exploited in order to improve livelihoods so as to enable proper rainwater harvesting techniques which can provide enough water for domestic, industrial and irrigation uses (Murgor, *et al*., 2013). A study can be done to evaluate the political factors that influence farmers' decision to adopt rainwater (or "intending to" improve their rainwater harvesting techniques); hence, enabling more rainwater harvesting in Keiyo sub-county.

Ahmed, *et al*., (2013) in their adoption study on RWH in Yatta sub-county used logistic regression model to evaluate a range of factors influencing a variety of RWHTS with roof water 45% and dam 36% being rated high. The Regression Model also showed the education level of households' heads, the experience of water storage, awareness of rainwater harvesting techniques and age of the farmers have a significant and positive influence in the adoption of water harvesting techniques. The research concluded that for an effective implementation and subsequent adoption of rainwater harvesting technologies; farmers require know-how capital, raw materials and organizational support. It was also concluded that there is a need to mobilize and train the residents on the use of rainwater harvesting techniques and sensitization on the potential economic benefits of adopting them.

Gateri, *et al*., 2015) argued that the volume of harvestable water was not sufficient to satisfy the minimum water demand levels of people in Embu during dry seasons. It was also revealed that alternative sources of water such as streams, boreholes or precipitation enhanced through weather modification could be used to supplement available water sources. The study noted that roof methods from rooftops such as surface runoff and groundwater need to be implemented as it is essential for the sustainability of an increasing population. The research has not shown socio-economic factors that influence rooftop RWH strategies in Embu County; however, the study is relevant to the current study in that rooftop RWH technology is also adopted in Buuri Sub-County.

A study conducted in Makueni County in relation to rainwater harvesting technologies by Kimani, et al., (2015) revealed that the adoption of RWHTS in Makueni County is slow irrespective of their potential to improve the residents' livelihoods. A logistic regression analysis was conducted to predict the extent to which socio-economic factors affected the adoption of RWHTS within 160 households in Makueni County. Some of the factors found to have statistically significant positive effects on the adoption of RWHTS are gender, literacy levels, social and economic status and technological know-how on RWHTS. Ways of promoting the adoption of RWHTS such as capacity building and training, poverty alleviation through enhancement of income generation activities, enhanced formation of community groups, and incorporating mechanised technologies in favour of women and children are recommended (Kimani, *et al*., 2015). The findings from this report are quite relevant to the current study in that the researcher intends to analyse the factors that influence the adoption of rainwater technologies in Buuri Sub-County, Meru County

2.5 Benefits of Rainwater Harvesting

According to UN-HABITATS (2000) report, rainwater may be the only available or economical water resource in some regions. This happens because rainwater harvesting systems can be simple to construct from inexpensive local materials that are widely available in most habitable locations. The concept of a water stress index was pioneered based on an approximation of the minimum level of water required per capita to maintain an adequate quality of use in a moderate developing country in an arid zone. Falkenmark (1995) began with the calculation that 100 litres per day (30.3 cubic meters per year) is a rough minimum per capita requirement for basic household needs to maintain good health. The experience of water efficient centres according to Falkenmark shows that roughly five to twenty times this amount tends to be needed to satisfy the requirement of agriculture, industries, and energy production.

The United Nations' Food and Agriculture Organisation (FAO) projected that, by 2025, 1.9 billion people will be living in countries or regions with absolute water scarcity and two thirds of the world's population could be under stress conditions. Therefore, Rainwater Harvesting strategy provides an independent water supply alternative during water restrictions, and in developed countries, it is often used to supplement the main supply. As the world, population grows the average amount of renewable freshwater available to each person declines. Thus, rainwater is inevitably a great breakthrough in both theory and practice. For instance Ethiopia, which is one of the most food insecure countries in the world, has placed great emphasis on household rainwater harvesting as a strategy against rainfall variability and for improving food security of farm households (UN, 2002).

Rainwater harvesting works to improve water security and the quality of groundwater, while increasing the level of water available at the ground level (UNDP, 2003). Rainwater harvesting also reduces the loss of the top layer of the soil; this is by means of controlling the surface runoff through constructions of dams and reservoirs to store the rainwater, which also increase the overall systems on the earth's surface. In addition, the process reduces flooding on roads and further prevents it from contamination.

The World Bank (2009) adds that climate change could profoundly alter future patterns of both water availability and use. This will thereby increase levels of water stress and insecurity both at the global scale and sectors that depend on water in the World. Rainwater harvested is viewed as a strategy to cope with such climate change challenges and also to hinder future water conflicts that may be caused due to sharing the meagre resource on earth.

By harvesting rainwater, homeowners can reduce their utility bills. Rainwater is also said to have zero hardness; hence, money that could be spent on water bills can be used to develop other sectors of economy. Decision-makers, planners, engineers, and builders often overlook the fact that rainwater harvesting is an option for increasing access to water in currently underserved areas (rural or urban). This happens due to lack of information on feasibility, both technical and otherwise; However, in the past decade, the technique has quickly regained popularity as users realise the benefit of a relatively clean, reliable, and affordable water source at home. Rainwater harvesting is flexible and adaptable to a very wide variety of conditions.

Of all the planet's non-renewable resources, freshwater may be the most critically depleted resource. In addition it is difficult to purify, expensive to transport, and impossible to substitute. Fresh water is essential to food production, to economic development, and to life itself. Hence, RWHTS is a strategy that can help to provide additional water that people in the world require. Moon (2012) argues that it is important to human health and well-being, as was underlined in mid-1993 when the United Nations through the Commission on Sustainable Development made the improvement of water quality as one of the first priorities for technology transfers from wealthy countries to poorer ones.

Overall, water is used in the richest and the poorest societies as well as the wettest and the driest regions on our planet (Worn & Hahum, 2006). Organisations such as WHO, FAO, and UN as well as individual researchers such as Falkenmark (1995), Xu (2007), and Worm and Hahum (2006) have shown clearly that water shortage is a global problem despite being an important resource. This is relevant to the current study for the researcher is encouraged to find out more on how rainwater is harvested in the study area. RWH can reduce water stress in Buuri sub-county if not eradicating the problem.

2.6 Limitations of Rainwater Harvesting

Rainwater Harvesting depends on rainfall events, which are highly unpredictable, hence, cannot be relied on as a long-term drought-proof source of water supply. A review of past experiences in water harvesting shows an evidence of a lack of an integrated approach, which led to errors at various levels of the process, the most of which was the neglect of human factors, project operation and management (World Bank,1992). More so, when rainwater harvesting strategies have been initiated by the government or charitable organisations such as NGOs, emphasis is on engineering aspects with no consideration of socio-economic aspect. Hence, the beneficiaries of such projects may not collaborate on its success but work towards its failure. This is because local people are at most times unaware of the improvement in the techniques they apply or the emergence of new methods (FAO, 1993).

Water harvesting projects have rarely been monitored or evaluated to assess the degree of their failure or success. This has prevented the authorities and technicians from assessing past errors and rectifying their methods and policies. As a result, there is a lack of data on previous projects. All subsequent projects were planned the same way with all previous errors and limitations and without any benefit from experiences (Lameck, 2002). However, the expense of harvesting rain water coud be comparable to the cost of drilling and installing a new groundwater well (FDRE, 2002).

Further, Wanyonyi (2002) explained that rainwater harvesting techniques chosen by people in the entire world may be inappropriate. Hence, they might not suit the environmental conditions in one way or another. This can be illustrated by the choice of techniques to be used, the size of catchment surface, and even the selection of construction materials among others. In other cases, appropriate choices may be made to harvest rainwater, but the installation process might be inappropriate. For instance, bad compaction of materials and lack of stabilisation of the system may be evident in the construction of a large rainwater collection system.

Rockstorm (2000) and Mustafa (2006) indicated that rainwater harvesting systems depend on rainfall to recharge; a backup water supply may be required for applications. In case water captured is for domestic purpose it must be treated,More so if it is for drinking, washing and cooking use. This is because as rainwater falls through the atmosphere and onto the catchments surface, it may pick microbial and chemical contamination and percolate matter (TWDB, 2007). Consequently, the costs of rainwater catchment system are typically higher than the cost of obtaining water from the centralised distribution system.

Additionally, rainwater harvesting systems require care and maintenance after installation, which may not be suitable for all homeowners. Proper operation and regular maintenance is a very important factor that is often neglected. Regular inspection, cleaning and occasional repairs are essentials for the success of rainwater harvesting system, all of which are cost effective. Rainwater storage tanks may take up valuable space around the house and it is not subject to state building code. Further, the absence of clear construction guidelines may discourage homeowners and developers from installing these systems (Xu, 2007).

Issues relating to land use have also been found to undermine the success of rainwater harvesting. In particular, the failure to address land tenure issues has often evolved into a hindrance to the success of rainwater harvesting projects. In the case of communal land, where many projects have been implemented, the absence of statutes defining appropriate land use has sometimes caused anarchy (Ward & Butler, 2010). This implies that rainwater harvesting technologies cannot be installed in such areas.

In relation to the preceding challenges, the study was encouraged by Wanyonyi (2002) and FAO (1993) findings on the hindrances of rainwater harvesting; hence, the current study also examines the types of limitation to rainwater harvesting in Buuri Sub-County. However further investigation on technical errors involved in the installation of rainwater harvesting techniques, that may hinder their feasibility can be examined.

2.7 Conceptual Framework of the Study

The conceptual framework that presents the interrelationship of the study variables is shown in Figure 2.1:

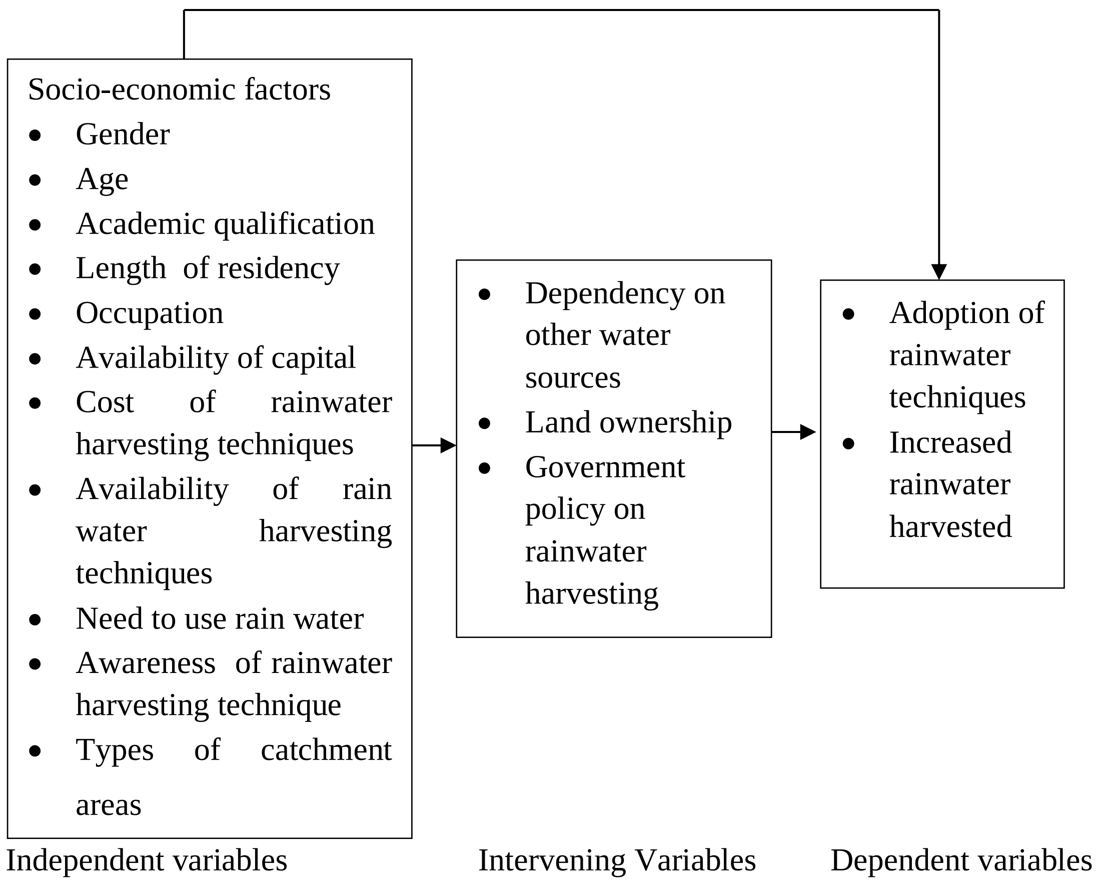

Figure 2.1: Conceptual Framework

Source: Researcher 2018

The conceptual framework shows that the socio-economic factors of gender, age, length of residency, occupation, income and the availability of capital affect the adoption of rainwater harvesting by the residents of Buuri Sub-County and the extent to which they harvest rainwater. Similarly, the cost of rainwater harvesting, the availability of water storage facilities, the need to use rainwater and the awareness of rainwater harvesting techniques are also socio-economic factors that influence RWH. These factors affect the adoption of RWHTS and the extent to which the residents of Buuri Sub-County harvest rainwater.

It was expected that female residents were more likely to adopt rainwater harvesting techniques and harvest rainwater than their male counterparts. Also, older residents of Buuri Sub-County were more open to adopting rainwater harvesting techniques than younger residents. Based on the length of residency, long-term residents are likely to adopt rainwater harvesting techniques and harvest rainwater more than temporary residents of Buuri Sub-County. Residents with a stable occupation and higher incomes are inclined to adopt rainwater harvesting techniques and use advanced harvesting techniques than residents who have unstable occupations and low incomes. Moreover, the adoption of rainwater harvesting and the amount of rainwater harvested was influenced by the academic qualifications of the residents such that those with higher academic qualifications opt to adopt advanced rainwater harvesting techniques and harvest rainwater more frequently than residents with lower academic qualifications.

The availability of capital greatly influences the adoption of RWHTS by the residents of Buuri Sub-County; such that these residents are capable of adopting numerous RWHTS. These techniques are primarily financed through the residents’ incomes. Also, it is expected that based on the cost of rainwater harvesting techniques the residents of Buuri Sub-County are likely to adopt cheap rainwater harvesting techniques as compared to those harvesting methods which are expensive. Nonetheless, the available RWHTS would probably determine the residents’ choice of harvesting methods, since they opt to adopt those techniques that are readily available. Yet, the need to use rainwater is another significant factor that affects the residents’ view on the adoption of rainwater harvesting techniques; residents who view rainwater as a necessity would prefer to adopt rainwater harvesting techniques.

Also, residents who are more aware of the existence of RWHTS probably adopt them from a variety of options, which are readily not known to those unaware of them. It is also expected that the residents' choice to adopt rainwater and the extent to which they harvest rainwater is affected by the type of catchment area used. A permanent and a wide catchment area would make the residents of Buuri sub-county more open to adopting complimentary RWHTS and increase the amount of rainwater harvested unlike temporary and small catchment areas which would discourage the residents from adopting RWH.

All the independent variables should be checked and controlled by the intervening variables which include land ownership, government policy on rainwater harvesting, and the residents' dependency on other sources of water. If adequate water is available from other sources other than rainwater, it would be less likely for the residents of Buuri Sub-County to harvest rainwater. Consequently, a decreased adoption of RWHTS would lead to less rainwater harvested by the residents.

The Government and NGOs policies on RWH would influence the adoption of rainwater harvesting techniques in that taxation on rainwater harvesting systems, for instance, would affect the adoption of a certain technique either positively or negatively. In addition, the nature of both state and county government laws, and perhaps the level of state and/local government financing in a water scarce region such as Buuri sub-county, would increase or decrease rainwater harvested and influence the adoption of RWHTS based on the suitability.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Study Location

The area's total population is approximated at 109,803 within an expansive land area of 961.80 Sq. Km (Kenya Law Reports, 2012). Its wards include (Timau, Kisima, Kiirua/Naari, and Ruira/Rwarera) as indicated in Figure 3.1. This study area was based in Buuri Sub-county particularly Kiirua and Kamutune sub-locations which were selected because a large portion of the area falls on the leeward side of Mt. Kenya and Nyambene Ranges; hence, it receives unreliable rainfall of about 500mm-900mm and is faced with acute shortage of water both for domestic and agriculture purposes (Meru County Profile, 2013).

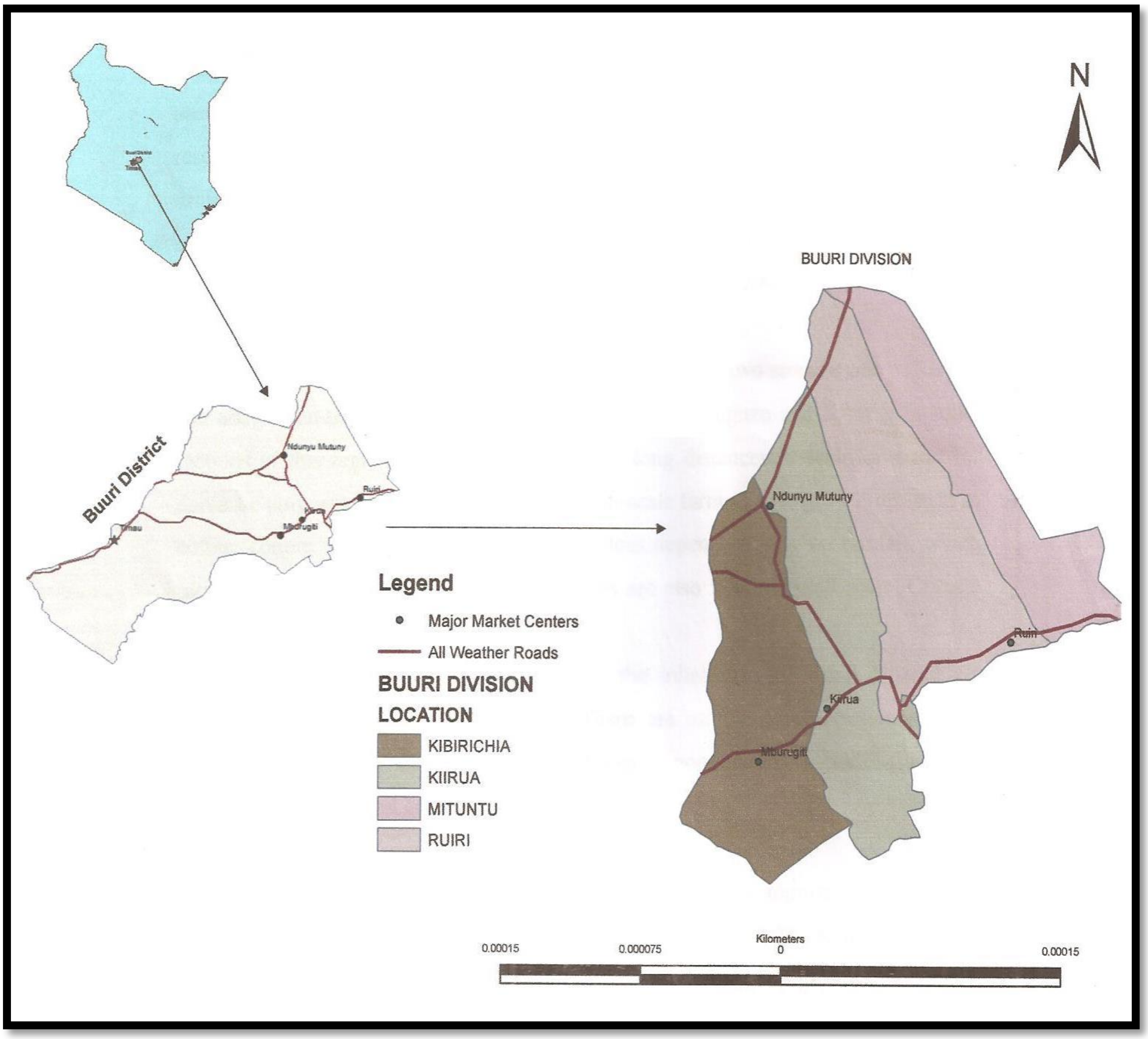

Figure 3.1: A map of the study area Buuri Sub County, Kenya

Source: Meru County Development Profile, 2013

3.2 Research Design

The study was an adoption study which employed a descriptive survey research design. The design was chosen because it allowed the researcher to conduct numerical descriptions of the target population's trends, attitudes, and opinions regarding rainwater harvesting (Cresswel, 2013). Particularly, this design allowed the researcher to obtain results from a sample of respondents drawn from Kamutune and Kiirua sub locations and later generalized the solicited results to the entire Buuri Sub-County population. Advantages emanating from this approach were mainly cost-related, in that it allowed the researcher to incur minimal costs in the data collection process.

3.3 Target Population

The target population for the study were residents of Buuri Sub-County specifically drawn from 2503 households.

3.4 Sampling and Sample Size

Accordingly a multistage sampling approach was utilized to select the participants for the study. Firstly, the study employed the cluster sampling approach to identify viable population within the vast Ruiri (comprising of Mutuma, Ncoroiboro and Kamutune Sub-Locations) and Kiirua (comprising of Kithima, Nkando and Kiirua Sub-Locations) locations. The cluster approach was employed because it was impractical to obtain a list of all population elements from the target study area (Babbie, 1989). Since it was not realistic to involve all residents in the study, the researcher selected the sample size according to various limitations such as distance and available resources. This process culminated in the selection of Kamutune and Kiirua sub locations as the clusters from which the samples were drawn from. Afterwards, the simple random sampling was used to recruit the sample from the two groups using Krejice (2004) table for determining sample size (see Appendix A). Therefore using the total population of 2503 homesteads in Buuri sub-county, the sample size was estimated at 335 homesteads.

According to Mugenda and Mugenda (2005), where the sample size is still large, the researcher can pick a sample size smaller than the former as long as it occupies at least of 30% of the sample size. Therefore, the study used a sample size of 101 homesteads, which was 30% of 335 (0.30 * 335 = 101.50). The respondents were recruited using a purposive sampling approach whereby the area chiefs were used to identify homesteads that were eligible for the study.The households' heads participated in the study. With the help of the research assistants who in this study were chiefs, the respondents were selected through purposive sampling for not all the residents were literate to respond to the questionnaires.

3.5 Instruments

The instruments for data collection were questionnaires. Questionnaires were preferred because they were easier to administer and more convenient in collecting information within a short time and more particularly because the respondents were free to give answers to the sensitive questions.

3.5.1 Questionnaire

The questionnaire (Appendix B) contained three sections namely: Section A which gathered background information of the residents of Buuri Sub-County basically on gender, age, education level and income level. Section B solicited information on the water harvesting techniques used in Buuri Sub-County, the adoption level on water harvesting and factors that influence spatial variation in adoption. Section C contained items that determine the catchment area used by the residents of Buuri Sub-County to trap rainwater.

3.6 Validity

The data collection instruments were evaluated for both construct and content validity. For construct validity of the instrument, it was observed that the obtained measures were in tandem with anticipated patterns: that the residents of Buuri Sub-County engage in rainwater harvesting techniques by using different techniques and at varying levels. Socio-economic factors influencing spatial variation on RWHTS were also evaluated using valid questions. The content validity, relating to the extent to which the instrument covered the content area, was ascertained by the fact that the questionnaire contained questions addressing each research question (Kimbrlin & Winsterstein, 2008). To ensure validity of the research instrument experts in the

Department of Social Sciences of Chuka University evaluated the content and construction validity and advised accordingly.

3.7 Reliability

Consistency of the measurement instrument was ensured by administering a similar questionnaire for all respondents. Further, a test-retest reliability measure was utilized whereby the consistency of the questionnaire results was based on the correlation between the two measures, test and retest surveys. In this study, participants were asked of their willingness to participate in a retest survey. Of the 20 people who agreed to participate in the retest survey, 18 returned completed surveys whose average correlation was .78, which was significant enough to quantify the reliability of the instrument (Kimbrlin & Winsterstein, 2008).

3.8 Procedure for Data Collection

The researcher booked appointments with the area chiefs to whom the Introduction Letter (Appendix C) was presented; thereafter, the questionnaires were distributed to the sampled residents of Buuri Sub-County. The chiefs supervised the administration of these instruments closely. The researcher coordinated and monitored the process. The data for the study was collected within a period of one month.

The research permit (Appendix D) to carry out the research was obtained from National Commission for Science Technology and Innovation to legitimise the research. The permit was presented to the Buuri Sub-County administrative office and the County Director of Education who allowed the study to be carried out in Buuri Sub-County by issuing a research authorization letter (Appendix E).

3.9 Ethical Considerations

Ethical issues in research ensure that the rights and welfare of persons and communities that are subjects of the study are protected and guarded (Nachmias&Nachmias, 2008). The purpose of the research was explained thoroughly to the participants after which, their consent was sought before they were engaged in the study. The residents of Buuri Sub-County were clearly informed about the reason for undertaking the research and the aim of the study in order to obtain full cooperation of the participants. Those who were involved in the study were assured of the confidentiality of the provided information. The respondents were not required to indicate their names or provide any form of personal identification on the questionnaires provided. The research also assured the respondents that the information obtained would not be used for any other purpose other than for academic purposes.

3.10 Data Analysis Procedure

After the data was collected, a codebook was created to facilitate data entry into the Statistical Package for the Social Sciences (SPSS). Afterwards, the field data was cleaned by checking for any missing values or inaccurate data and rectifying it appropriately. After data cleaning, the quantitative data was coded and analysed using SPSS. Descriptive statistical methods i.e. percentage, mean, frequency, range and variance were then used to provide linkages between the findings and the research questions.

3.11 Summary of Data Analysis Methods

Table 3.1 Summary of Data Analysis Methods

Research questions	Independent variables	Dependent variables	Method of analysis
Have the people of Buuri Sub-County adopted rainwater harvesting?	The level of rainwater harvested	Adoption of rainwater harvesting	Descriptive statistics ;Mean,Percentage &Frequency
Which rainwater harvesting techniques do residents of Buuri Sub-County use?	Adopted rainwater harvesting techniques	Adoption of rainwater harvesting techniques	Descriptive statistics and Chi-Square tests
What factors influence the adoption of rainwater harvesting techniques in Buuri Sub-County?	Factors that influence spatial variation in the adoption of rainwater harvesting techniques	Adoption of rainwater harvesting techniques	Chi-square tests, Pearson correlation, T – tests statistics, one way ANOVA and binary logistic regression

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results and discussion of the research findings. The chapter is divided into various sections based on the objectives of the study. The first section presents data on RWH in Buuri sub-county. The subsequent sections in the chapter presents results on RWHTS used by Buuri residents; and factors that influenced spatial variation in RWHTS.

4.2 Prevalence of Rainwater Harvesting

The study investigated the extent to which residents of Buuri Sub County engaged in rainwater harvesting. It was revealed 95.7% of the respondents indicated that they were engaged in harvesting rainwater while the remaining 4.3% reported the contrary. Hence, almost all the respondents interviewed reported to be practicing rainwater harvesting since only 4% specified they were not engaged in rainwater harvesting. These results are presented in Table in 4.1

Table 4.1: Prevalence of Rainwater Harvesting

	Frequency	Percent
No	4	4.3
Yes	88	95.7
Total	92	100

4.2.1 Location and Rainwater Harvesting Techniques

The study further compared RWH in the two sub-locations of the study area. It was established that the prevalence of rainwater harvesting in Kiirua was slightly higher than that of Kamutune Sub- Location. Kiirua Sub- Location recorded a prevalence of 97.8% while Kamutune 93.5% prevalence of rainwater harvesting. The results are presented in Table 4.2.

Table 4.2: Location and Rainwater Harvesting Techniques

		Rainwater harvesting practice		
		No	Yes	Total
Kiirua	F	1	45	46
	%	2.2	97.8	100
Kamutune	F	3	43	46
	%	6.5	93.	100
Total	F	4	88	92
	%	4.3	95.7	100

These results indicate that the residents of Buuri sub-county are aware of RWHTS and the majority have adopted the practice. To investigate the relationship between the location and the RWH; a Chi-square test was conducted which showed no significance, χ^2 (1, N = 92) = 1.045, p =0.307 as presented in the Table 4.3.

Table 4.3: Location and Rainwater Harvesting Techniques

	Value	df	p – Value
Pearson Chi-Square	1.05	1	0.307
Likelihood Ratio	1.09	1	0.296
Linear-by-Linear Association	1.03	1	0.309
N of Valid Cases	92		

4.2.2 Frequency of Rainwater Collection

The study investigated the frequency of RWH by the residents of Buuri sub-county. It was established that half of the respondents (50%) indicated twice a year, 35.9% specified once a year, while 9.8 attested that they always harvested rainwater. This result signifies that though most of the residents practiced rainwater harvesting, the frequency of the practice was very low as only less than a tenth indicated that they always collected rainwater. This is shown in Table 4.4.

Table 4.4: Frequency of Rainwater Collection

	Frequency	Percent
Once a Year	33	35.9
Twice a Year	46	50
Always	9	9.8
Not Applicable	4	4.3
Total	92	100

The varying responses indicate that there are factors that influence different rates of adoption. The study further sought to establish the relationship between location and RWH frequency. A cross tabulation was done to assess the difference in rainwater harvesting frequency among the two geographical locations. The result indicates that 13% of the residents in Kamutune sub - location always harvested rainwater compared to 6.5% of residents in Kiirua sub - location. Hence, the proportion of residents in Kamutune who harvested rainwater always was much higher than their counterparts in Kiirua sub - location as indicated in Table 4.5.

Table 4.5: Location and Rainwater Harvesting Frequency

		Frequency of Rainwater Collection				
		Once a Year	Twice a Year	Always	Not Applicable	Total
Kiirua	F	18	24	3	1	46
	%	39.1	52.2	6.5	2.2	100
Kamutune	F	15	22	6	3	46
	%	32.6	47.8	13	6.5	100.
Total	F	33	46	9	4	92
	%	35.9	50	9.8	4.3	100

The results of the findings depicted Kamutune residents who practice RWH always; being higher could be due to increased need of rainwater as there are few alternative sources as compared to residents of Kiirua who have other sources of water such as boreholes, community water owned projects among the others.

The relationship between frequency of rainwater harvesting and location was examined. The relationship between frequency of rainwater harvesting and location was not significant, χ^2 (3, N = 92) = 2.36, p =0.501. As shown in Table 4.6.

Table 4.6: Location and Rainwater Harvesting Frequency

	Value	*df*	*P* – Value
Pearson Chi-Square	2.36	3	0.501
Likelihood Ratio	2.43	3	0.489
Linear-by-Linear Association	1.79	1	0.181
N of Valid Cases	92		

4.3 Rainwater Harvesting Techniques

The study established the rainwater harvesting techniques employed in Buuri Sub County. It was established that 88% of the respondents utilized tanks while 7.6% had adopted barrels in rainwater harvesting. This results perhaps meant that use of tanks was the most popular technique of harvesting rainwater as 88% of the respondents stated so as indicated in Figure 4.1.

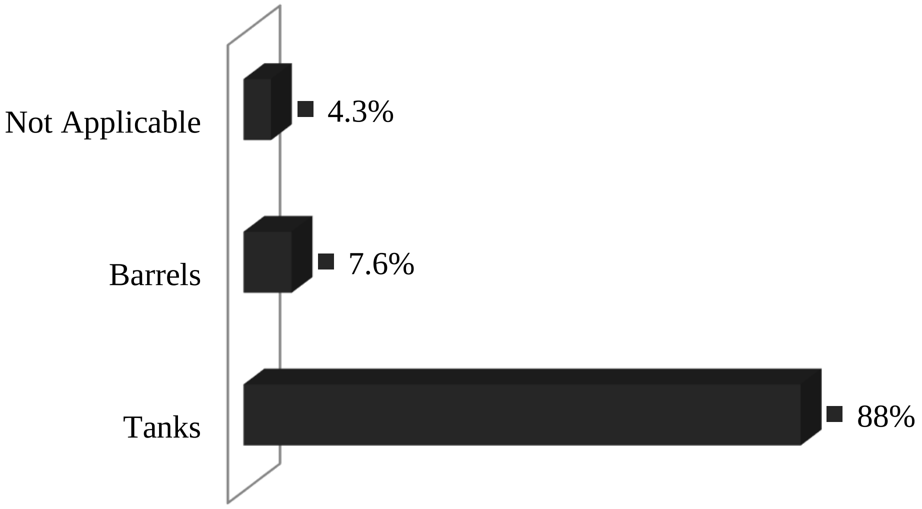

Figure 4.1: Methods used to Collect Rain water

The findings revealed that the use of tanks was a popular technique in rain water harvesting because it was the easiest method to adopt. The residents might have found it easier to obtain tanks of their choices depending on their financial capability. This concurs with Frazier and Lioyd (1982) who argued that a steep roof sheds runoff quickly and, more easily and conveys it into an attached tank. Murgor, *et al.*, (2013) also confirmed these findings, by asserting that tanks are very popular in RWH because they come in varieties and sizes hence giving a wider range of choices for the users. He added that RW tanks come supplied with basket filters, taps and overflow pipes hence increasing their usage. The relationship between rainwater harvesting techniques and location depicted close frequencies at Kiirua and Kamutune sub-locations at 89.1% and 87% respectively. Similarly, use of barrels was established at 8.7% prevalence in Kiirua sub-location compared to 6.5% in Kamutune sub-location as shown in Table 4.7.

Table 4.7: Location and Rainwater Harvesting Techniques

		Method Used to Collect Rainwater			
		Tanks	Barrels	Not Applicable	Total
Kiirua	F	41	4	1	46
	%	89	8.7	2.2	100
Kamutune	F	40	3	3	46
	%	87	6.5	6.5	100
Total	F	81	7	4	92
	%	88	7.6	4.3	100

A chi-square test was also performed to examine the relationship between rainwater harvesting techniques and location. The relationship between rainwater harvesting techniques and location was not significant, χ^2 (2, N = 92) = 1.16, p =0.561. As indicated in Table 4.8.

Table 4.8: Chi-Square Tests

	Value	*df*	*P* – Value
Pearson Chi-Square	1.16	2	0.561
Likelihood Ratio	1.20	2	0.548
Linear-by-Linear Association	0.85	1	0.356
N of Valid Cases	92		

The findings established no significant difference in the engagement of RWH between the two regions of study. This implies that the use of tanks remained the most popular methods used in both localities.

4.3.1 Capacity of Rainwater Collected by Storage Vessel

In regard to capacity of rainwater collected by storage vessel, most respondents utilized storage vessels of up to 4,000 litres.The sizes and frequencies of RW storage vessels are shown in the Figure 4.2

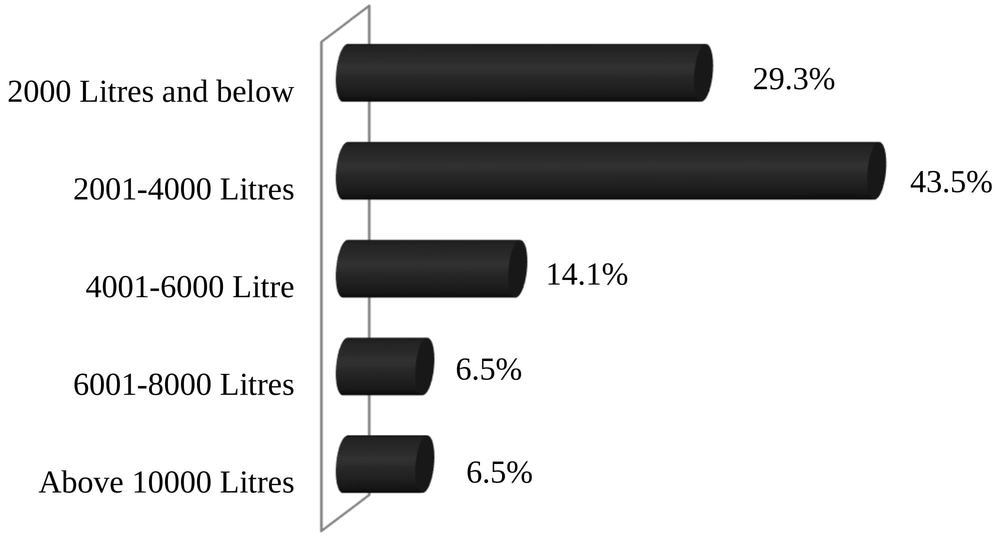

Figure 4.2: Average Capacity of Rain Water Collected by Storage Vessel

A further investigation was done to assess the difference in capacity of rainwater collected by storage vessel among the two geographical locations. It was established that Kiirua sub - location recorded a higher proportion (8.7%) of residents collecting more than 10,000 litres than Kamutune location which posted 4.3% of residents collecting more than 10,000 litres. Kiirua sub - location recorded a higher proportion (32.6%) of residents collecting 2,000 litres and below. This is shown in Table 4.9.

Table 4.9: Location and Capacity of Rainwater Collected by Storage Vessel

		Average Capacity of Rainwater Collected by Storage Vessel					
		2,000 litres and below	2,001-4,000 litres	4,001-6,000 litres	6,001-8,000 litres	Above 10,000 litres	Total
Kiirua	F	15	18	5	4	4	46
	%	32.6	39.1	10.9	8.7	8.7	100
Kamutune	F	12	22	8	2	2	46
	%	26.1	47.8	17.4	4.3	4.3	100
Total	F	27	40	13	6	6	92
	%	29.3	43.5	14.1	6.5	6.5	100

The findings suggested that most residents of Kiirua sub-location were perhaps more settled in their locality and their financial capacity was greater as compared to Kamutune residents. The study revealed that a number of Kamutune residents had leased or hired the land hence probably the reason for lower adoption of RWH. The cost of constructing and buying a RWH storage reservoir is a costly venture. Jothiprakash, *et al.*, (2009) confirmed the findings by stating that the cost of tanks and storage facilities is prohibitive to RWH. The study also revealed that storage capacity played key role in adoption of RWHTS. Availability of storage containers will promote more harvesting of rooftop RW. This study is in line with Kariuki (2014) confirmation that; besides availability of storage containers the capacity is very important for adoption of RWH to succeed.

A further investigation was done to examine the relationship between capacity of rainwater collected and location. The relationship between capacity of rainwater collected by storage vessel and location was not significant, χ^2 (4, N = 92) = 2.76, p =0.599. as presented in Table 4.10

Table 4.10: Location and Capacity of Rainwater Collected by Storage Vessel

	Value	*df*	*P* – Value
Pearson Chi-Square	2.76	4	0.599
Likelihood Ratio	2.79	4	0.593
Linear-by-Linear Association	.23	1	0.631
N of Valid Cases	92		

This implies that same amount of water could be collected in the applied tank of whichever capacity in either location. However, this is dependent on availability of RW in the region.

4.3.2 Rating of Rainwater Collection Vessel

The respondents were asked to rate the performance of rainwater collection vessel. Majority of the respondents (42.4%) opined that the rainwater collection vessels had average performance, 22.8% rated the vessels as below average, 15.2% felt the performance of the vessels was good, and 13% very good while 2.2% rated the performance of the rainwater collection vessels as excellent. This result signifies that, in the opinion of the respondents, the performance of the rainwater collection vessels was not satisfactory since only less than a third of the respondents rated the vessels as good, very good or excellent. This is indicated in Figure 4.3

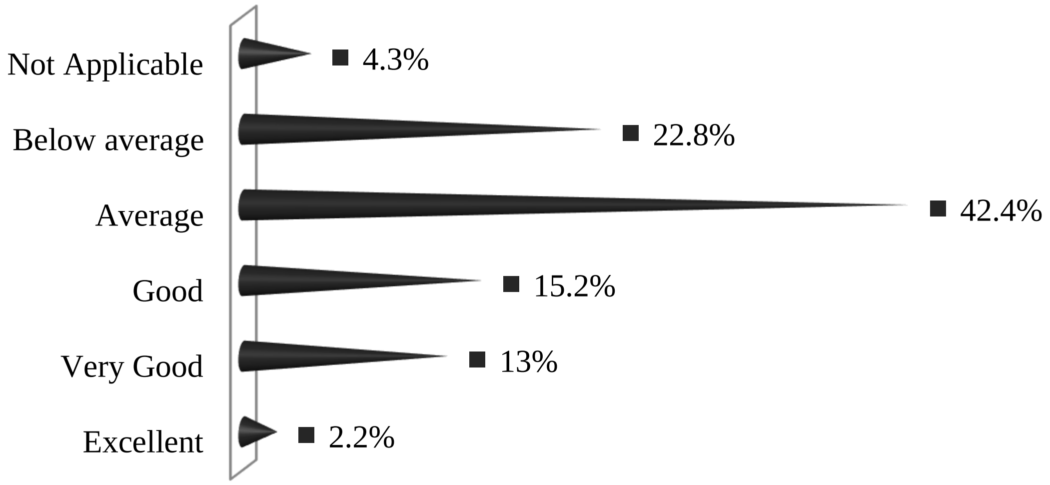

Figure 4.3: Performance of Rainwater Collection Vessel

The study revealed that those who were questioned were not satisfied with the performance of their RW collecting vessels. This probably meant that with improved source of income coupled with appropriate technology they would obtain better RW collecting vessels.

4.3.3 Contentment with Rainwater Collection Techniques

In regard to contentment with rainwater collection methods, slightly more than half of the respondents (53%) attested that they were satisfied with rainwater collection methods while the rest (47%) indicated they were not contented with rainwater collection methods. This result indicates that a substantial proportion of the respondents were not satisfied with the rainwater collection methods since close to half of the respondents opined so as shown in Figure 4.4

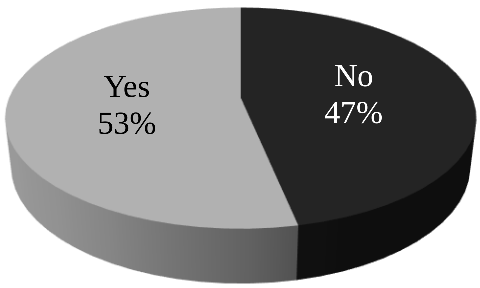

Figure 4.4: Contentment with Rainwater Collection Methods

The study investigated the reason for the contentment of RWH methods and it was established that water harvested was enough for purpose it intended to cater. Those who were not contented argued that they wished to harvest more water for more usage such as growing crops, domestic usage and livestock watering as well as industrial purposes.

To establish the difference in contentment with rainwater collection methods among the two geographical locations; a cross tabulation was done. A higher proportion of the respondents residing in Kamutune sub-location 56.5% were contented with rainwater collection methods compared to their counterparts in Kiirua sub - location where 50% of the respondents affirmed contentment with rainwater collection methods as shown in Table 4.11.

Table 4.11: Location and Contentment with Rainwater Collection Methods

		Contented with Rainwater Collection Methods		
		No	Yes	Total
Kiirua	F	23	23	46
	%	50	50	100
Kamutune	F	20	26	46
	%	43.5	56.5	100
Total	F	43	49	92
	%	46.7	53.3	100

43.50% of the residents of Kamutune felt the basic reason to harvest water was met. On the other hand,s 50% 0f Kiirua residents felt they should harvest more water to satisfy more needs. To determine any relationship between the contentment with rainwater collection methods and location a Chi Square test was performed. The relationship between contentment with RW collection methods and location was not significant, χ^2 (1, N = 92) = .39, p =0.531. The findings are shown in the Table 4.12

Table 4.12: Location and Contented with Rainwater Collection Methods

	Value	*df*	*P* – Value
Pearson Chi-Square	0.39	1	0.531
Likelihood Ratio	0.39	1	0.531
Linear-by-Linear Association	0.39	1	0.533
N of Valid Cases	92		

The findings established that a large proportion of Buuri residents were not satisfied with RWHTS. Then this was depicted by the dissatisfaction displayed by performance of RW collecting water vessels. The study revealed that RW collected by most of the residents lasted for less than a month after collection.

4.3.4 Nature of Rainwater Harvesting Vessel

concerning the nature of water harvesting vessel, 39.1% of the respondents indicated that their vessels were partially covered, 38% stated they were covered while 18.5% specified that their rainwater harvesting vessels were open. These results signified that only a few of the respondents had covered their rainwater harvesting vessels since only around a third of the respondents indicated that their vessels were fully covered as presented in Figure 4.5.

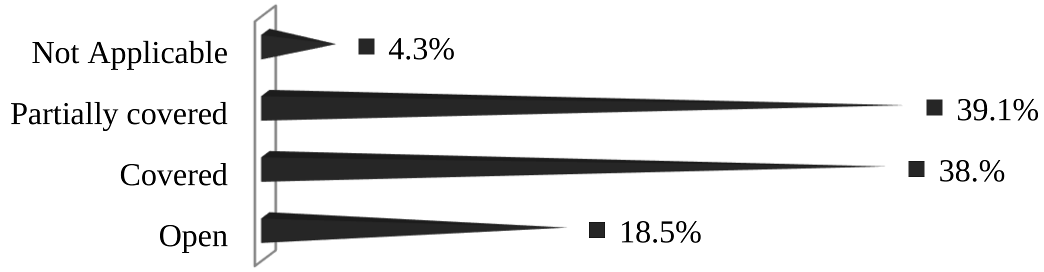

Figure 4.5: Nature of Rainwater Harvesting Vessel

The study found out that much RW was lost through evaporation for the RW collecting vessels were not covered and were placed above the ground. This agrees with findings of Patel, *et al.,* (2014) who argued that much of RW approximately 0.62 gallon per square feet could be collected; but substantial amount lost through evaporation, splash out ,or overshoot from gutters and open water collecting tanks.

4.3.4.1 Location and Status of Rainwater Harvesting Vessel Comparative Analysis

On the relationship between the status of rainwater harvesting vessel and location, a higher proportion of respondents residing in Kamutune sub - location (21.7%) had open vessels than their counterparts in Kiirua sub - location where 15.2% of the vessels were open. Besides, a greater proportion of the respondents in Kiirua sub - location (39.1%) had covered vessels compared to their counterparts in Kamutune sub - location where 37% of the vessels were covered. As shown in Table 4.13

Table 4.13: Location and Status of Rainwater Harvesting Vessel

		Status of Rainwater Harvesting Vessel				Total
		Open	Covered	Partially covered	Not Applicable	
Kiirua	F	7	18	20	1	46
	%	15.2	39.1	43.5	2.2	100
Kamutune	F	10	17	16	3	46
	%	21.7	37	34.8	6.5	100
Total	F	17	35	36	4	92
	%	18	38	39.1	4.3	100

A further investigation was done to examine the relationship between status of rainwater harvesting vessel and location. The relationship between status of rainwater harvesting vessel and location was not significant, χ^2 (3, N = 92) = 2.00, p > =0.572. As presented in Table 4.14

Table 4.14: Location and Status of Rainwater Harvesting Vessel

	Value	*df*	*P* – Value
Pearson Chi-Square	2	3	0.572
Likelihood Ratio	2.05	3	0.562
Linear-by-Linear Association	0.15	1	0.703
N of Valid Cases	92		

4.3.5 Positioning of Rainwater Harvesting Vessel

In regard to positioning of rainwater harvesting vessel, close to two thirds of the respondents (62%) stated that they had placed their rainwater harvesting vessel above the ground, 26.1% indicated they had elevated the vessels on the surface while 7.6% specified that their rainwater harvesting vessels were positioned under the ground. Hence, a high proportion of the respondents had placed their rainwater harvesting vessels above the ground. As indicated in Figure 4.6

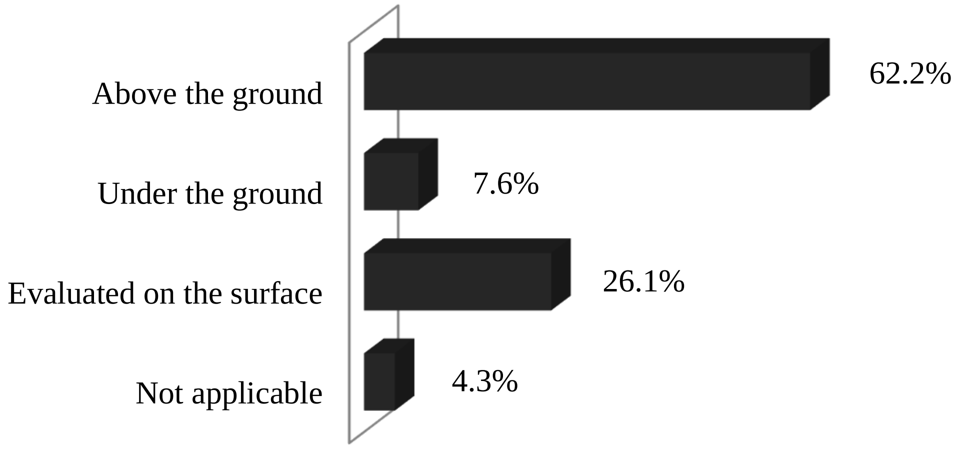

Figure 4.6: Positioning of Rainwater Harvesting Vessel

It was further established that there was a slight difference in the positioning of rainwater harvesting vessels between the two geographical locations considered in the study. Kiirua sub - location had 63% of its residents positioning rainwater harvesting vessels above the ground, slightly higher than their counterparts in Kamutune sub - location where 60% of the rainwater harvesting vessels were positioned above the ground. On the other hand, Kamutune sub - location had 8.7% of its residents positioning rainwater harvesting vessels under the ground, slightly higher than their counterparts in Kiirua where 6.5% of the residents had positioned rainwater harvesting vessels under the ground as shown in Table 4.15.

Table 4.15: Location and Positioning of Rainwater Harvesting Vessel

		Positioning of Rainwater Harvesting Vessel				Total
		Above the ground	Under the ground	Elevated on the surface	Not Applicable	
Kiirua	F	29	3	13	1	46
	%	63	6.5	28.3	2.2	100
Kamutune	F	28	4	11	3	46
	%	60.9	8.7	23.9	6.5	100
Total	F	57	7	24	4	92
	%	62	7.6	26.1	4.3	100

A further investigation was done to examine the relationship between positioning of rainwater harvesting vessel and location. The relationship between positioning of rainwater harvesting vessel and location was not significant, χ^2 (3, N = 92) = 1.33, p =0.723. As indicated in Table 4.16

Table 4.16: Location and Positioning of Rainwater Harvesting Vessel

	Value	*df*	*P* - Value
Pearson Chi-Square	1.33	3	0.723
Likelihood Ratio	1.37	3	0.712
Linear-by-Linear Association	0.22	1	0.639
N of Valid Cases	92		

It was revealed that the two geographical areas chosen and almost the same knowhow on RWHTS and more awareness on positioning and establishment of RW vessels was necessary in both locations.

4.3.6 Period the Harvested Water Lasts

The respondents were asked the period for which the harvested water lasted. Half of the respondents (50%) indicated that the harvested water lasted for less than a month, 38% specified 2 to 3 months and 7.6% stated that the harvested water lasted for 4 to 5 months. Hence, for majority of the respondents, harvested water lasted for less than a month. As shown in Figure 4.7

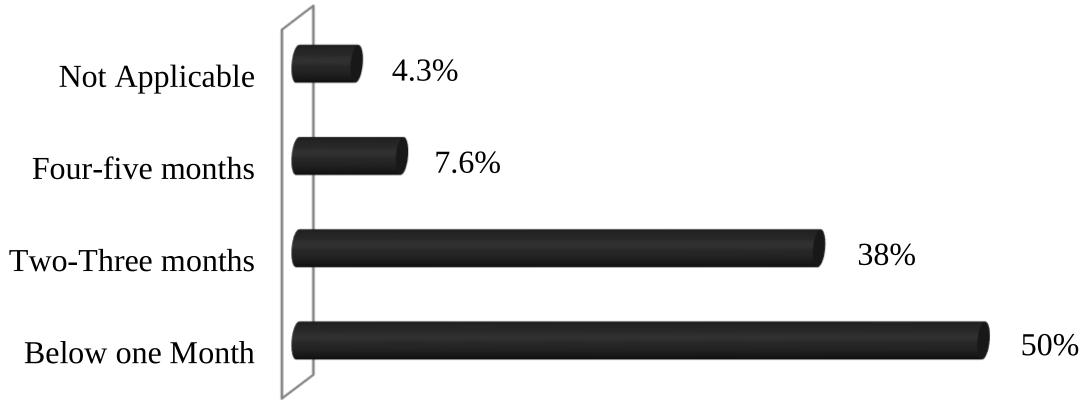

Figure 4.7: Period the Harvested Water Last

The study showed that RW harvested was not enough for various purposes for it lasted for less than a month after collection. This was due to technologies employed. It was further established that harvested water in Kamutune sub - location lasted for a longer period than harvested water in Kiirua sub - location. For instance, 8.7% of the respondents in Kamutune sub - location indicated 4 to 5 months utility of the harvested water, a higher proportion than that of their counterparts in Kiirua sub - location where 6.5% of the respondents registered 4 to 5 utility of harvested water. Similarly, the proportion of respondents who indicated a utility of 2 to 3 months of the harvested rainwater was higher (41.3%) in Kamutune sub - location than in Kiirua sub - location where 34.8% of the respondents recorded 2 to 3 months utility of harvested rainwater. As showned in Table 4.17

Table 4.17: Location and Period the Harvested Water Lasted

		How Long Does the Harvested Rainwater Last				Total
		Below one month	Two-three months	Four-five months	Not Applicable	
Kiirua	F	26	16	3	1	46
	%	56.5	34.8	6.5	2.2	100
Kamutune	F	20	19	4	3	46
	%	43.5	41.3	8.7	6.5	100
Total	F	46	35	7	4	92
	%	50	38	7.6	4.3	100

The study findings showed that the residents of Kamutune used RW harvested more sparingly as compared to those of Kiirua residents who seemed to have other sources of water as compared to the residents of Kamutune. A further investigation was done to determine the relationship between period the rainwater harvested lasted and location. The relationship between period the rainwater harvested lasted and location was not significant, χ^2 (3, N = 92) = 2.18, p =0.535. as shown in Table 4.18

Table 4.18: Location and Period the Harvested Water Lasted

	Value	*Df*	*P* – Value
Pearson Chi-Square	2.18	3	0.535
Likelihood Ratio	2.23	3	0.526
Linear-by-Linear Association	2.06	1	0.151
N of Valid Cases	92		

4.3.7 Uses of Harvested Rainwater

On the uses of harvested rainwater, 88% of the respondents indicated they used it for watering animals, 6.5% cited irrigation and 1.1% stated that they utilized harvested rainwater in fishing.as indicated in Figure 4.8

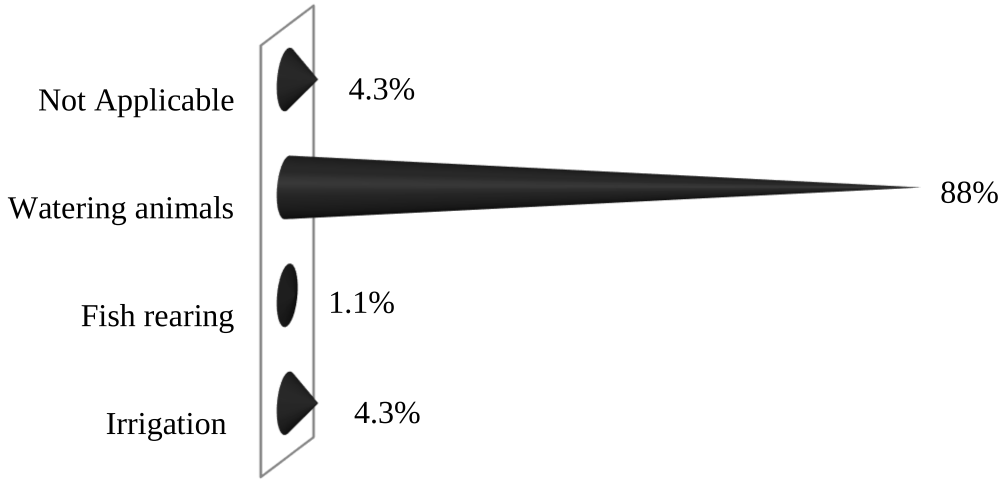

Figure 4.8: Uses of Harvested Rainwater apart from Domestic use

It was established that a higher proportion of residents in Kiirua sub - location (91.3%) utilized harvested rainwater in watering animals than their counterparts in Kamutune sub - location where 84.8% of the respondents indicated utilization of harvested rainwater in watering animals. However, utilization of harvested rainwater in irrigation was on equal proportion for the two locations as each of them enumerated 6.5% utilization of rainwater for irrigation. However, no utilization of rainwater was recorded in Kiirua sub - location for fish rearing as shown in Table 4.19.

Table 4.19: Location and Uses of Harvested Rainwater

		Other Uses of Harvested Rainwater				Total
		Irrigation	Fish rearing	Watering animals	Not Applicable	
Kiirua	F	3	0	42	1	46
	%	6.5	.00	91.3	2.2	100
Kamutune	F	3	1	39	3	46
	%	6.5	2.2	84.8	6.5	100
Total	F	6	1	81	4	92
	%	6.5	1.1	88	4.3	100

The study revealed little water is used in irrigation and fish rearing. Most residents in Buuri sub-county depend on rain fed agriculture with the region being affected by frequent drought and unreliable rainfall. Hence RWH awareness should be created to popularise the practice. The findings agrees with UN(2000) findings which confirms that RW is inevitably a great breakthrough in both theory and practice of rain fed agriculture and a possible solution against rainfall variability and for improving food security of the farm households.

An additional investigation was done to examine the relationship between uses of rainwater harvested and location. The relationship between uses of rainwater harvested and location was not significant, χ^2 (3, N = 92) = 2.11, p =.550. As presented in Table 4.20

Table 4.20: Location and Uses of Harvested Rainwater

	Value	*df*	*P* – Value
Pearson Chi-Square	2.11	3	0.550
Likelihood Ratio	2.54	3	0.467
Linear-by-Linear Association	0.41	1	0.524
N of Valid Cases	92		

4.3.8 Occurrence of Rainwater Collecting Vessels Filled to the Brim
Concerning occurrence of rainwater collecting vessels filling up, three quarters of the respondents (75%) indicated that their rainwater collecting vessels at times get filled up to the brim while 21% stated that their rainwater collecting vessels do not fill to the brim. Hence, most of the respondents had their rainwater collecting vessels filled to the brim at times as less than a quarter of the respondents gave a contrary response. As shown in Figure 4.9

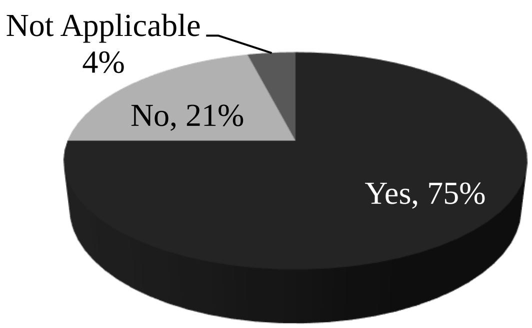

Figure 4.9: Occurrence of Collecting Vessels filled up

A further investigation revealed that the occurrence of colleting water filled up was slightly higher in Kamutune sub-location (76.1%) than in Kiirua sub - location where

73.9% of the respondents indicated that at times their rainwater collecting vessels get filled up. As indicated in Table 4.21.

Table 4.21: Location and Occurrence Collecting Vessels Filled to the Brim

		Are There Times When Collecting Vessel Gets Filled Up?			Total
		No	Yes	Not Applicable	
Kiirua	F	11	34	1	46
	%	23.9	73.9	2.2	100
Kamutune	F	8	35	3	46
	%	17.4	76.1	6.5	100
Total	F	19	69	4	92
	%	20.7	75	4.3	100

The study findings showed that RW collected was insufficient to cater for the minimum demands. These findings are in agreement with Gateri, *et al.*,(2015) whose findings exhibited that; volume of harvestable water was not sufficient to satisfy demands level of people in Embu in dry seasons. Hence other alternative sources of water such as streams and boreholes could be used to supplement available water resources. A test was done to examine the relationship between uses of rainwater harvested and location. The relationship between uses of rainwater harvested and location was not significant, χ^2 (2, N = 92) = 1.49, p =0.475. As presented in Table 4.22

Table 4.22: Location and Occurrence Collecting Vessels Filled to the Brim

	Value	*df*	*P* – Value
Pearson Chi-Square	1.49	2	0.475
Likelihood Ratio	1.54	2	0.464
Linear-by-Linear Association	1.2	1	0.273
N of Valid Cases	92		

4.4 Factors Influencing Spatial Variation in the Adoption of Rainwater Harvesting Techniques

An investigation was done to examine the socio- economic factors that influence spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub County. The gender, age, academic qualification, occupation and income of the respondents were compared against the adoption of rainwater harvesting techniques to assess whether there were any differences between the various sets of the respondents.

4.4.1 Gender and Capacity of Rainwater Collected by Storage Vessel

To establish the relationship between gender and capacity of rainwater collected by storage vessel. The mean capacity of rainwater collected by storage water was slightly higher for females (*M* = 1.32, *SD* = 1.30) than for males (*M* = 1.16, *SD* = 1.31) as shown in Table 4.23.

Table 4.23: Gender and Capacity of Rainwater Collected by Storage Vessel Group Statistics

	Gender	N	Mean	*SD*	Std. Error Mean
Average Capacity of Rainwater Collected by Storage Vessel	Male	45	1.16	1.31	0.20
	Female	47	1.32	1.30	0.19

4.4.1.1 Gender and Capacity of Rainwater Collected by Storage Vessel

An independent-samples t-test indicated that scores were not significantly higher for females (*M* = 1.32, *SD* = 1.30) than for males (*M* = 1.16, *SD* = 1.31), *t* (90) = 0.60, *p* =0.550. Hence, the study did not establish a significant relationship between gender and capacity of rainwater collected by storage vessel as shown on Table 4.24.

Table 4.24: Gender and Capacity of Rainwater Collected by Storage Vessel Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	*t*	*df*	*P* - Value	Mean Difference	Std. Error Difference
Capacity of Rainwater Collected by Vessel	Equal variances assumed	.09	.764	-.60	90	0.550	-.16	0.27
	Equal variances not assumed			-.60	89.76	0.550	-.16	0.27

Although the t-test analysis showed no significance, Table 4.24 indicated more female than male respondents were concerned in matters of RWH issues. This implies that women are engaged in RWH than men. The reason to this might be women groups enhance development activities which include RWHTS to alleviate water shortage. This concurs with the findings of (Kimani, *et al.,* 2015), that recommends for more improved designs of RWH vessels and mechanised technology in favour of women and children.

4.4.2 Age and Capacity of Rainwater Collected by Storage Vessel

The study examined the relationship between age and capacity of rainwater collected by storage vessel**.** A Pearson product-moment correlation was done to examine the relationship between age and capacity of rainwater collected by storage vessel. These results indicate that there was a positive correlation between age and capacity of rainwater collected by storage vessel, Pearson's r (92) = .43, $p < 0.001$
As indicated in Table 4.25.

Table 4.25: Correlations

		Average Capacity of Rainwater Collected by Storage Vessel	Age Bracket
Average Capacity of Rainwater Collected by Storage Vessel	Pearson Correlation	1	0.432
	Sig. (2-tailed)		0.000
	N	92	92
Age Bracket	Pearson Correlation	0.43	1
	Sig. (2-tailed)	0.000	
	N	92	92

The results indicated that more aged people engaged in RWH than the younger ones. This was due to the experience of the aged people. Ibrahim, *et al.,* (2009) pegged this correlation of the older people harvesting more to experience which is very important in adoption of RWH technologies. Ibrahim, *et al.,* (2009) further adds that adoption of various RWHTS and their uniqueness to different age groups is due to their good understanding, experience of the environment and the benefit of different technologies.

4.4.3 Academic Qualification and Capacity of Rainwater Collected by Storage Vessel

The study investigated the relationship between academic qualification and capacity of rainwater collected by storage vessel. One way ANOVA was done to examine the relationship between academic qualification and capacity of rainwater collected by storage vessel. The mean capacity of rainwater collected by storage vessel posted by respondents with graduate qualification was 1.6 (*SD* = 2.07), followed by respondents with post-secondary qualifications who posted a mean of 1.43 (*SD* = 1.63). Respondents with lower primary school qualification recorded a mean of 1.33 (*SD* = 1.12) and those who had completed primary registered a mean of 1.20 (SD = .86) while those with secondary school qualification enumerated a mean of 1.19 (*SD* = 1.44). Respondents with no formal qualification posted a mean of 1.00 (*SD* =.00) while those with diploma qualification registered a mean of 0.90 (*SD* = 0.876) As indicated in Table 4.26.

Table 4.26: Academic Qualification and Capacity of Rainwater Collected by Storage Vessel

	N	Mean	*SD*	Std. Error
No Formal Education	5	1	0.00	0.00
Lower Primary	9	1.33	1.12	0.37
Completed Primary	15	1.2	0.86	0.22
Secondary	27	1.19	1.44	0.28
Post-Secondary Certificate	21	1.43	1.63	0.36
Diploma	10	0.90	0.88	0.28
Graduate	5	1.60	2.07	0.93
Total	92	1.24	1.30	0.14

The result findings are in line with other studies done by (Lioyd 2015), (Florence 2013) and (Ibrahim 2013) which have indicated positive effects of academic qualification on the adoption of RWHTS. Hatibu (2003) noted that farmers with higher level of education were likely to adopt RWH systems more, therefore shortening the period of adoption of the technique and choosing the most appropriate technique for the area.

4.4.3.1 Academic Qualification Level and Capacity of Rainwater Collected

The ANOVA table indicates much difference between the two Mean Squares (1.79 and 0.50). However the difference in the means is not statistically significant since the *p* – value was greater than 0.05. Hence the relationship between academic qualification level and capacity of rainwater collected by storage vessel was not statistically significant. As shown in Table 4.27

Table 4.27: Academic Qualification and Capacity of Rainwater Collected ANOVA

	Sum of Squares	*df*	Mean Square	*f*	Sig.
Between Groups	3.02	6	0.50	0.28	0.944
Within Groups	151.72	85	1.79		
Total	154.74	91			

Although the relationship between the academic qualification and the capacity of RW collected was not statistically significant; education qualification is vital in adoption of RWH for the farmers that have higher education are likely to adopt or practice RWHTS more compared to the less educated farmers.

4.4.4 Occupation and Capacity of Rainwater Collected by Storage Vessel

The study investigated the relationship between occupation and capacity of rainwater collected by storage vessel. The mean capacity of rainwater collected by storage vessel for salaried respondents was 2.41 (*SD* = 1.48) followed by respondents on casual work who posted a mean of 1.06 (*SD* = 0.43). Respondents engaged in business activities posted a mean capacity rainwater collected by storage vessel of 0.57 (*SD* = 0.51) while those engaged in farming enumerated a mean of 0.32 (*SD* = 0.57) as indicated in Table 4.28.

Table 4.28: Occupation and Capacity of Rainwater Collected by Storage Vessel

Salaried Job	32	2.41	1.48	0.26
Business	21	0.57	0.51	0.11
Casual Work	17	1.06	0.43	0.10
Farming	22	0.32	0.57	0.12
Total	92	1.24	1.30	0.14

4.4.4.1 Analysis of Variance

The p – value of the Levene statistic is less than 0.001 indicating that the variances are statistically different as indicated in Table 4.29. Though Bonferroni procedure assumes equal variances, our sample size is large, which reduces the problem, hence the ANOVA can be interpreted. As shown in Table 4.29

Table 4.29: Occupation and Capacity of Rainwater Collected Test of Homogeneity of Variances

Levene Statistic	*df*1	*df*2	*P* - Value
15.49	3	88	0.000

There is much difference between the two Mean Squares (24.06 and 0.94), resulting in a significant difference F (3, 88) = 25.64, $p < 0.001$ as shown in Table 4.30. Hence the means of the four occupation categories are not all equal. As shown in Table 4.30

Table 4.30: ANOVA

	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups	72.16	3	24.06	25.64	0
Within Groups	82.58	88	0.94		
Total	154.74	91			

4.4.4.2 Occupation and Capacity of Rainwater Collected Multiple Comparisons

Multiple comparison procedure was performed to examine all possible pairs of means and determine if each individual pairing is the same or statistically different. The multiple comparison, (Table 4.31), show that four out of six pairs vary: 1) Salaried job versus business $p < 0.001$ which is lower than the Sig. level of 0.05, these groups vary. 2) Salaried job versus casual work $p <.001$ which is lower than the Sig. level of 0.05, these groups vary. 3) Salaried job versus farming $p < 0.001$ which is lower than the Sig. level of 0.05, these groups vary and 4) Casual work versus farming $p = .20$ which is lower than the Sig. level of 0.005. As depicted in Table 4.31

Table 4.31: Occupation and Capacity of Rainwater Collected Multiple Comparisons

(I) Occupation	(J) Occupation	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Salaried Job	Business	1.84*	0.27	0	1.29	2.38
	Casual Work	1.35*	0.29	0	0.77	1.93
	Farming	2.09*	0.27	0	1.55	2.62
Business	Salaried Job	-1.84*	0.27	0	-2.38	-1.29
	Casual Work	-0.49	0.32	0.127	-1.12	0.14
	Farming	0.25	0.30	0.394	-0.33	0.84
Casual Work	Salaried Job	-1.35*	0.29	0	-1.93	-.77
	Business	0.49	0.32	0.127	-0.14	1.12
	Farming	0.74*	0.31	0.02	0.12	1.36
Farming	Salaried Job	-2.09*	0.27	0	-2.62	-1.55
	Business	-0.25	0.30	0.394	-0.84	0.33
	Casual Work	-0.74*	0.31	0.02	-1.36	-0.12

The study findings exhibited that there was great correlation between various occupations and RW harvested by the residents of Buuri sub-county. The association between occupation and spatial variation in adoption of rainwater harvesting techniques was sought. This variable was found to be significant at 0.05 level of significance and [Exp (B) .51] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques. This result corresponds well with the finding of Kimani, *et al*., (2015) who established that economic status is significantly associated with adoption of rainwater harvesting techniques. It also supports the finding of Kumar, *et al*., (2011) who asserted that poor economic status is a constraint in conservation and management of water. A person's occupation is commonly associated with his/her economic status. A person in a favourable economic status is likely to engage in rainwater harvesting than one in unfavourable economic status as some of the techniques in harvesting rainwater could require a considerable fortune.

4.4.5 Income Level and Capacity of Rainwater Collected by Storage Vessel

An investigation was done to establish the relationship between income level and capacity of rainwater collected by storage vessel. A Pearson product-moment correlation was done to examine the relationship between income level and capacity of rainwater collected by storage vessel. These results indicate that there was a positive correlation between income level and capacity of rainwater collected by storage vessel, Pearson's *r* (92) = 0.36, *p* < 0.001 as indicated in Table 4.32

Table 4.32: Income Level and Capacity of Rainwater Collected Correlations

		Monthly Income(Kshs)	Capacity of Rainwater Collected by Vessel
Monthly Income(Kshs)	Pearson Correlation	1	0.36
	Sig. (2-tailed)		0
	N	92	92
Capacity of Rainwater Collected by Vessel	Pearson Correlation	0.36	1
	Sig. (2-tailed)	0	
	N	92	92

The study revealed that the residents with low income adopted RWHTS less as compared to those with higher income levels. These findings are in agreement with Ahmed, *et al*., (2013) who stated that farmers income level was an important factor affecting adoption of RWHTS. He also argued that farmers who relied on farm produce as a source of income are likely to adopt RWHTS less for they have little income.

4.4.6 Gender and Contentment with Rainwater Collection Methods Comparative Analysis

The study further established the relationship between gender and contentment with rainwater collection methods. A cross tabulation was performed to examine the relationship between gender and contentment with rainwater collection methods. The proportion of females who were content with rainwater collection methods was higher (57.40%) than their male counterparts who were content with the methods utilized to harvest rainwater as they recorded a contentment prevalence of 48.90%. as shown in Table 4.33

Table 4.33: Gender and Contentment with Rainwater Collection Methods

			Contented with Rainwater Collection Methods		
Gender	Male	F	23	22	45
		%	51.1	48.9	100
	Female	F	20	27	47
		%	42.6	57.4	100
Total		F	43	49	92
		%	46.7	53.3	100

The results of the study findings revealed that women are more concerned with water issues as it was depicted by their higher participation in the study. This was confirmed by a study done by Kimani, *et al.*, (2015) who confirmed that gender positively influenced the adoption of RWHTS within the ASALS.

A chi square test was performed to examine the relationship between gender and contentment with rainwater collection methods. The relationship between gender and contentment with rainwater collection methods was not significant, χ^2 (1, N = 92) = 0.68, p =.411 as shown in Table 4.34.

Table 4.34: Gender and Contentment with Rainwater Collection Methods

	Value	*df*	*P* – Value
Pearson Chi-Square	0.678	1	0.411
Likelihood Ratio	0.68	1	0.411
Linear-by-Linear Association	0.67	1	0.413
N of Valid Cases	92		

4.4.7 Age and Contentment with Rainwater Collection Methods Comparative Analysis

The study examined the relationship between age and contentment with rainwater collection methods. The mean age for those contented with rainwater harvesting methods was higher (M = 3.18, SD = 1.36) than for their counterparts who were not content with rainwater collection methods (M = 2.12, SD = 1.18) as shown in Table 4.35.

Table 4.35: Group Statistics on Age

	Contentment with Rainwater Collection Methods	N	Mean	*SD*	Std. Error Mean
Age Bracket	Yes	49	3.18	1.36	0.20
	No	43	2.12	1.18	0.18

4.4.7.1 Age and Contentment with Rainwater Collection Methods

An independent-samples t-test indicated that age scores were significantly higher for those content with rainwater collection methods (*M* = 3.18, *SD* = 1.36) than for their counterparts who were not content with rainwater collection methods (*M* = 2.12, *SD* = 1.18), *t* (90) = 3.99, *p* <.001. Hence, the study established a significant relationship between age and contentment with rainwater collection methods. As presented in Table 4.36

Table 4.36: Age and Contentment with Rainwater Collection Methods Independent Samples Test

		No	Yes	Total
Age Bracket	Below 20 years	4	2	6
	20-30 years	26	13	39
	40-50 years	27	10	37
	60-70 years	2	3	5
	Over 70 years	1	0	1
Total		60	28	88

Mean = 35.57 years
Mode = 34.44 years
Median = 34.74 years

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.736	4	0.603	0.672	
Likelihood Ratio	2.889	4	0.577	0.672	
Fisher's Exact Test	2.861			0.629	
Linear-by-Linear Association	0	1	1	1	0.562
No. of Valid Cases	88				

The study reviewed that the older residents adopted RWHTS more than the younger residents. This probably was due to their greater experience and understanding of the study region as compared to the younger persons. A greater percentage of the younger persons in Buuri sub-county hold no lands or homesteads of their own; hence could not make major decisions on RWHTS. Kimani, *et al*., (2015) argued that marital status affect the adoption of RWH technologies positively.

4.4.8 Academic Qualification and Contentment with Rainwater Collection Methods Comparison Analysis

The study sought to establish the relationship between academic qualification and contentment with rainwater collection methods. The respondents with lower primary school qualification posted the highest contentment prevalence of 77.8% followed by the respondents with primary school qualifications who registered a contentment prevalence of 73.3%. On the other hand, respondents with graduate and diploma qualification recorded the lowest contentment prevalence of 40% each. As indicated in Table 4.37

Table 4.37: Academic Qualification and Contentment with Rainwater Collection Methods

		Contentment with Rainwater Collection Methods		
		No	Yes	Total
No Formal Education	F	2	3	5
	%	40	60	100
Lower Primary	F	2	7	9
	%	22.2	77.8	100
Completed Primary	F	4	11	15
	%	26.7	73.3	100
Secondary	F	14	13	27
	%	51.9	48.1	100
Post-Secondary Certificate	F	12	9	21
	%	57.1	42.9	100
Diploma	F	6	4	10
	%	60	40	100
Graduate	F	3	2	5
	%	60	40	100
Total	F	43	49	92
	%	46.7	53.3	100

The study findings showed that residents that had less literacy levels were satisfied with the techniques used in RWH. Probably this was due to less exposure and awareness to more advanced RWHTS. The exposure and awareness in RWH creates significance impact on adoption of the technologies as it is argued by Kimani, *et al.,* (2015) and Ibrahim (2009). A further investigation between academic qualification and contentment using a chi-square showed no statistical significance. The relationship between academic qualification and contentment with rainwater collection methods indicated that χ^2 (6, N = 92) = 6.95, p =0.326. As shown in Table 4.38

Table 4.38: Academic Qualification and Contentment with Rainwater Collection Methods Chi-Square Tests

	Value	*df*	*P* – Value
Pearson Chi-Square	6.95	6	0.326
Likelihood Ratio	7.22	6	0.301
Linear-by-Linear Association	4.6	1	0.032
N of Valid Cases	92		

4.4.9 Occupation and Contentment with Rainwater Collection Methods Comparative Analysis

The study evaluated the relationship between occupation and contentment with rainwater collection methods. Respondents engaged in salaried jobs posted the highest contentment prevalence of 96.9% followed by respondents engaged in farming who enumerated contentment prevalence of 54.5%. On the other hand, respondents engaged in business registered a contentment prevalence of 19% while those engaged in casual work recorded a contentment prevalence of 11.8% as indicated in Table 4.39.

Table 4.39: Occupation and Contentment with Rainwater Collection Methods

		Contentment with Rainwater Collection Methods		
		No	Yes	Total
Salaried Job	F	1	31	32
	%	3.1%	96.9%	100%
Business	F	17	4	21
	%	81.0%	19.0%	100%
Casual Work	F	15	2	17
	%	88.2%	11.8%	100%
Farming	F	10	12	22
	%	45.5%	54.5%	100%
Total	F	43	49	92
	%	46.7%	53.3%	100%

The study findings depicted that the residents of Buuri sub-county who had a stable and a reliable job were perhaps occupied by their jobs; hence no much time to search for other means of water thus engaged more in RWH technologies. With stable income they could afford to construct water tanks or buy ready -made tanks. The above findings are supported by Lloyd (2015) who argued that higher income implies a greater incentive for investment in RWHTS and their ability to bear the risk of associated adoption.

A chi square test was performed to examine the relationship between occupation and contentment with rainwater collection methods. The relationship between type of occupation and contentment with rainwater collection methods was significant, χ^2 (3, N = 92) = 46.10, $p < 0.001$. As shown in Table 4.40

Table 4.40: Occupation and Contentment with Rainwater Collection Methods

	Value	*df*	*P*–Value
Pearson Chi-Square	46.1	3	0
Likelihood Ratio	55.17	3	0
Linear-by-Linear Association	12.99	1	0
N of Valid Cases	92		

4.4.10 Income Level and Contentment with Rainwater Collection Methods

The study investigated the relationship between income level and contentment with rainwater collection methods. The mean income level for those content with rainwater harvesting methods was higher (M = 3.63, SD = 1.83) than for their counterparts who were not content with rainwater collection methods (*M* = 2.47, *SD* = 1.80) as presented in Table 4.41

Table 4.41: Income Level and Contentment with Rainwater Collection Methods Group Statistics

	Contentment with Rainwater Collection Methods	*N*	Mean	*SD*	Std. Error Mean
Monthly Income	Yes	49	3.63	1.83	0.26
	No	43	2.47	1.80	0.28

4.4.10.1 Income and Contentment with Rainwater Collection Methods t–test Statistics

An independent-samples t-test indicated that income scores were significantly higher for those content with rainwater collection methods (*M* = 3.63, *SD* = 1.83) than for their counterparts who were not content with rainwater collection methods (*M* = 2.47, *SD* = 1.80), *t* (90) = 3.07, *p* =0.003. Hence, there was a significant relationship between income level and contentment with rainwater collection methods**.** As indicated in Table 4.42

Table 4.42: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	*Sig.*	*t*	*df*	*P* - Value	Mean Difference	Std. Error Difference
Monthly Income	Equal variances assumed	0.08	0.783	3.07	90	0.003	1.17	0.38
	Equal variances not assumed			3.07	88.81	0.003	1.17	0.38

The study found out that residents of Buuri sub-county with higher income adopted RWHTS due to their ability to purchase RWH structures and obtain upgraded roofs and tanks that aid in the practice. Residents with limited income adopted RWHTS less. A similar finding was done by Kariuki (2014) who established that limited sources of income and land reduce the ability of farmers to adopt RWHTS.

4.4.11 The Logistic Regression Analysis of Socio-Economic Factors

To determine the socio-economic factors significantly associated with spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub-County, logistic regression was utilized since the dependent variable was dichotomous. The model summary, classification table and Omnibus test of model coefficient were used to test the goodness of the logistic model.

The Nagelkerke R Square shows that about 58% of the variation in the outcome variable is explained by this logistic model, hence this is a good model fit. Nagelkerke's measure gives us a higher value than does Cox and Snell's since Nagelkerke's measure is a modification of Cox and Snell's, allowing the measure to use the full 0-1 range. As indicated in Table 4.43

Table 4.43: Model Summary

Step	Cox & Snell *R* Square	Nagelkerke *R* Square
1	0.43	0.058

4.4.11.1 Null Model.

The null model presents the results with only the constant included before any coefficients are entered into the equation. Logistic regression compares this model with a model including all the predictors to determine whether the latter model is more appropriate. As shown in Table 4.44

Table 4.44: Null Model

	Observed		Predicted: Contentment with Rainwater Collection Methods		Predicted: Percentage Correct
			No	Yes	
Step 0	Contentment with Rainwater Collection Methods	No	0	43	0
		Yes	0	49	100
	Overall Percentage				53.3

The classification table shows how well our full model correctly classifies cases. The overall percentage shows the model is 75% accurate. This is a good model fit since the overall percentage of the null model is 53.3%.   as presented in Table 4.45

Table 4.45: Classification Table

	Observed		Predicted Contentment with Rainwater Collection Methods		Percentage Correct
			No	Yes	
Step 1	Contentment with Rainwater Collection Methods	No	29	14	67.4
		Yes	9	40	81.6
	Overall Percentage				75

4.4.11.2 Omnibus Tests of Model Coefficients

Model chi-square tests whether the model as a whole predicts occurrence better than chance. In binary logistic regression, it is interpreted as a test of the capability of all predictors (independent variables) in the model jointly to predict the response (dependent) variable. The model is statistically significant because the *p* - value is less than 0.05 as depicted in Table 4.46

Table 4.46: Omnibus Tests of Model Coefficients

		Chi-square	*df*	*P* – Value
Step 1	Step	29.89	5	0
	Block	29.89	5	0
	Model	29.89	5	0

4.4.11.3 Factors Associated with Spatial Variation in Adoption of Rainwater Harvesting Techniques.

The socio–economic factors considered in the study were; gender, age, academic qualification, occupation and monthly income. The output of the logistic regression indicating the significance of each of the predictor variable is shown in Table 4.47.

Table 4.47: Factors Associated with Spatial Variation in Adoption of Rainwater Harvesting Techniques

	B	*S.E.*	Wald	*df*	*P* - Value	Exp(B)
Gender	0.03	0.51	0	1	0.949	1.03
Age Bracket	0.51	0.2	6.45	1	0.011	1.66
Academic Qualification	-0.48	0.19	6.53	1	0.011	0.62
Occupation	-0.68	0.27	6.22	1	0.013	0.51
Monthly Income	0.03	0.17	0.02	1	0.877	1.03

4.4.11.3.1 Gender

The study found no association between gender and spatial variation in adoption of rainwater harvesting techniques. This study did not establish any significant relationship between gender and spatial variation in adoption of rainwater harvesting techniques. The *p*-value of this predictor was more than 0.05.

4.4.11.3.2 Age

This study established the association between age and spatial variation in adoption of rainwater harvesting techniques. This variable was found to be significant at .05 level of significance and [Exp (B) 1.66] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques. The study established a positive relation between age and spatial variation in adoption of rainwater harvesting techniques since the Exp (B) is greater than one. This result corresponds well with the finding of Ahmed, *et al*., (2013) who found out that age is significantly associated with adoption of rainwater harvesting techniques. It is likely that as a person ages, he/she perceive surrounding the opportunities and threats more clearly. Hence, the older respondents were able to appreciate that their land is in semi-arid zone, a threat to some of their developmental projects, and that harvesting rainwater could mitigate the effect of such threat since their land is arable and consequently engage in harvesting rainwater more than their younger counterparts.

4.4.11.3.3 Academic Qualification

The study established the association between academic qualification and spatial variation in adoption of rainwater harvesting techniques. This variable was found to be significant at .05 level of significance and [Exp (B) .62] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques. This finding is in agreement with the findings of Murgor, et al., (2013) who established that level of education is significantly associated with adoption of rainwater harvesting techniques. It also supports the assertion by Ahmed, et al., (2013) that level of education of households' heads has a significant influence in the adoption of rainwater harvesting techniques. The result is also in harmony with the finding of Kimani, et al., (2015) who found out that literacy levels had significant effect on adoption of rain water harvesting techniques.

The explanation of this finding could be the fact that persons with some basic form of formal education could be more likely to comprehend the significance of rainwater adoption than their counterparts with minimal or no formal education and hence take rain water harvesting as a priority. It is also possible that educated people could have travelled wider than their counterparts with minimal formal education and encountered various techniques of harvesting rainwater or at least have read more than their counterparts on the benefits of rainwater harvesting and hence are more likely to appreciate and embrace rainwater harvesting.

4.4.11.3.4 Occupation

The association between occupation and spatial variation in adoption of rainwater harvesting techniques was sought. This variable was found to be significant at .05 level of significance and [Exp (B) .51] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques. This result corresponds well with the finding of Kimani, *et al*., (2015) who established that economic status is significantly associated with adoption of rainwater harvesting techniques. It also supports the finding of Kumar, *et al*., (2011) who asserted that poor economic status is a constraint in conservation and management of water. A person's occupation is commonly associated with his/her economic status. A person in a favourable economic status is likely to engage in rainwater harvesting than one in unfavourable economic status as some of the techniques in harvesting rainwater could require a considerable fortune.

4.4.11.3.5 Income

The study examined the association between income and spatial variation in adoption of rainwater harvesting techniques. This study did not establish any significant relationship between income and spatial variation in adoption of rainwater harvesting techniques. The *p*-value of this predictor was more than .05. This implies that the respondents who participated in the study never differed much in their financial capability. Hence spatial aspect of the study region had no influence on the income of the residents.

4.4.11.4 Correlation Matrix of Socio-Economic Factors

The variables were examined using a correlation matrix to assess multiple correlation problems. The possibility of multiple correlations was ruled out since there was no significant correlation between any two predictor variables as indicated in Table 4.48.

Table 4.48: Correlation Matrix

	Gender	Age Bracket	Academic Qualification	Occupation	Monthly Income
Gender	1	0	0.22	0.09	0.1
Age Bracket	0	1	-.08	0.01	-0.17
Academic Qualification	0.22	-0.08	1	0.33	0.1
Occupation	0.09	0.01	0.33	1.00	0.54
Monthly Income	0.1	-0.17	0.1	0.54	1

The study showed no statistical relationship between the spatial variation and various factors that were being investigated i.e. gender, age, academic qualification and monthly income. However it was established that age, academic qualification and occupation of the residents of Buuri sub-county greatly influenced the spatial variation in adoption of RWHTS.

CHAPTER FIVE
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The main objective of the study was to examine the socio economic factors that influence the spatial variation in the adoption of rain water harvesting techniques in Buuri Sub County. This chapter discusses summary of the findings, makes conclusions of the findings, and gives relevant recommendations.

5.2 Summary of the Findings

The study sought to establish the extent to which residents of Buuri Sub County engaged in rainwater harvesting, the rainwater harvesting techniques employed in Buuri Sub County, and the socio-economic factors that influence spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub County.

5.2.1 Engagement in Rainwater Harvesting

It was revealed that almost all the respondents were practicing rainwater harvesting. However, the frequency of rainwater harvesting was very low with only less than a tenth indicating that they always collected rainwater. It was further established that there was no significance difference in engagement of rainwater harvesting between the two locations included in the study; Kiirua sub – location and Kamutune sub – location.

5.2.2 Rainwater Harvesting Techniques

The study established that use of tanks was the most popular technique of harvesting rainwater adopted by the respondents and that most utilized storage vessels of up to 4000 litres. It was further established that the performance of the rainwater collection vessels was not satisfactory, a substantial proportion of the respondents were not satisfied with the rainwater collection methods and that a low proportion of the respondents had covered their rainwater harvesting vessels. It was also revealed that a high proportion of the respondents had placed their rainwater harvesting vessels above the ground. Harvested rainwater lasted for less than a month for majority of the respondents, whereby it is used for domestic purpose and watering animals. Most of the respondents had their rainwater collecting vessels filled to the brim from time to time. The study did not establish any significance difference in the rainwater harvesting techniques employed in the two geographical locations of concern.

5.2.3 Factors that Influence Spatial Variation in the Adoption of Rainwater Harvesting Techniques

The study established that age, academic qualification and occupation were significantly associated with spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub- County.

5.2.3.1 Age

The study established relationship between age and spatial variation in adoption of rainwater harvesting techniques. This variable was found to be significant at 0.05 level of significance and [Exp (B) 1.66] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques. The study established a positive relation between age and spatial variation in adoption of rainwater harvesting techniques since the Exp (B) is greater than one.

5.2.3.2 Academic Qualification

The study revealed the association between academic qualification and spatial variation in adoption of rainwater harvesting techniques. This variable was found to be significant at 0.05 level of significance and [Exp (B) 0.62] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques.

5.2.3.3 Occupation

The association between occupation and spatial variation in adoption of rainwater harvesting techniques was sought. This variable was found to be significant at 0.05 level of significance and [Exp (B) 0.51] indicating that it was significantly associated with spatial variation in adoption of rainwater harvesting techniques.

5.3 Conclusions

The study concluded that age, academic qualification and occupation are significantly associated with spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub-County.To ensure successful adoption of RWH, supporting organisations should take into account the above-highlighted factors and concerted efforts should be put to enhance building the capacity of Buuri sub-county farmers on RWHTS. .Farm income should be as well be diversified and other support mechanism put with a view to increasing income which will in turn increase the level of adoption of RWHTS; for majority of the residents were small scale farmers.

The study concluded that age was significantly associated with spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub County. Older persons are able to appreciate that residing in semi-arid zone is a threat to some of their developmental projects, and that harvesting rainwater could mitigate the effect of such threat since their land is arable, and consequently engage in harvesting rainwater more than their younger counterparts.

The study concluded that academic qualification was significantly associated with spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub County. Persons with some basic form of formal education could be more likely to comprehend the significance of rainwater adoption than their counterparts with minimal or no formal education and hence take rainwater harvesting as a priority.

The study concluded that occupation was significantly associated with spatial variation in the adoption of rainwater harvesting techniques in Buuri Sub County. A person's occupation is commonly associated with his/her economic status. A person in a favourable economic status is likely to engage in rainwater harvesting than one in unfavourable economic status as some of the techniques in harvesting rainwater could require a considerable fortune.

5.4 Recommendations

Based on the findings the following were the recommendation for the study:

i. Creation of Rain Water Harvesting Techniques awareness campaign targeting the younger population in semi-arid and dry zones. This can be enhanced by providing trainings on different methods of RWHTS to enhance the diversity of their knowledge of RWH technologies.
ii. Coming up with strategies of grouping persons in semi-arid and dry areas, where persons could share their experiences in rainwater harvesting techniques; moderated by a technical officer familiar in the field.
iii. Initiating grant schemes on rainwater harvesting techniques targeting the less endowed in the semi-arid and dry zones. This can be in form of provision of extension services, technical assistance and credit services availed to the residents of Buuri sub-county.

5.5 Suggestion for Further Research

The following areas are suggested for further studies:

i. A similar study in analysis of socio-economic factors that influence spatial variation in adoption of RWHTS to be done in another county.
ii. The influence of the government RWH policies on adoption on RWHTS in Buuri-sub-county.
iii. Investigate levels of livelihood change among RWH adopters as compared to those not harvesting rainwater.

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APPENDICES

Appendix A: Table for Determining Sample Size

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	241	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	960	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

N = Population;   S = Sample Size

Adapted from Krejcie and Morgan (2004)

Appendix B: Questionnaire for the Residents

My name is Agnes Karwitha a student at Chuka University, pursuing a Master's Degree in Geography. I am carrying a study to analyse the factors that influence spatial variation in adoption of rainwater harvesting techniques in Buuri Sub County in Meru County, Kenya. I kindly request you to provide me with the necessary information, which will be treated with confidentiality and used for academic purposes only.

SECTION A: BACKGROUND INFORMATION

(Tick where appropriate)

1. Indicate the Gender

Male ☐ Female ☐

2. Indicate your appropriate age bracket

Below 20 years ☐ 20 – 30 years ☐ 40 – 50 years ☐

60 – 70 years ☐ Over 70 years ☐

3. What are your academic qualifications?

Degree ☐ Diploma ☐ Certificates ☐ Others ☐

4. (a) Are you a resident of Buuri Sub-County? Yes ☐ No ☐

(b) If yes for how long have you lived in Buuri Sub-County? ....

☐ Below 1 year ☐ 1 – 10 years ☐ 11 – 20 years

☐ 21 – 40 years ☐ 41 – 50 years

☐ Over 50 years

5. As a resident of Buuri Sub-County, what is your occupation?

☐ Salaried job

☐ Business

☐ Casual Work

☐ Farming

☐ Others

6. On average what is your monthly income?

☐ Below Kshs. 1000 ☐ Ksh. 9001 and over

☐ Kshs. 1001-3000

☐ Kshs. 3001-5000

☐ Kshs. 5001-7000

☐ Kshs. 7001-9000

7. For the period/time, you have lived in Buuri Sub-County what problems related to water do you experience? Explain appropriately…...………………………………
……………………………………………………………………………………..
……………………………………………………………………………………..

SECTION B: WATER-HARVESTING TECHNIQUES AND FACTORS INFLUENCING SPATIAL VARIATION IN ADOPTION OF RAINWATER HARVESTING TECHNIQUES

1a) Do you harvest rainwater. (Tick where appropriate)

Yes ☐ No ☐

If not explain the reason for not doing it……………………..……………..………
………………………………………………………………………….…….…....

2. How often do you collect the rainwater in a year?

Once a year ☐ Twice a Year ☐ Always ☐

3. (i) What method/technique do you use to collect and store rainwater (Tick where applicable)

a) Tanks ☐ b) Barrels ☐ c) Earth dams ☐

d) Pits ☐ e) Trenches ☐ f) Others ☐

ii) If you use other methods, explain briefly how the rainwater is captured and stored……………………………………………………………………………………
………………………………………………………………………………………

iii) Briefly, explain why you choose the method/technique of rainwater harvesting in 3(i) above…………………………………………………………………….………………

5i) Are you contented with the method/technique of rainwater harvesting you use in your residence?

Yes ☐ No ☐

ii) Give reason for your answer____

f) How do you rate your collecting /storage /vessels you used in rainwater harvesting?

- Excellent ☐
- Very good ☐
- Good ☐
- Average ☐
- Below average ☐

7i) On average what is the capacity/volume of the rainwater collecting, storage container/vessel you use in your resident (tick where appropriate)

a) 200 litres and below ☐

b) 2001 -4000 litres ☐

c) 4001-6000litres ☐

d) 6001-8000 litres ☐

e) 8001-10,000 litres ☐

f) Above 10,000 litres ☐

8i) What is the nature of your rainwater harvesting collecting/storage container /vessel

a) Open ☐ b) Covered ☐ c) Partially covered ☐

ii) Do you experience any difficulties due to the nature of your rainwater harvesting container /vessel chosen above? Explain and specify…………………………………..

……………………………………………………………………………………….….

9ia) Where is your rainwater collecting container /vessel situated.

Above the ground ☐ Under the ground ☐ Elevated on the surface ☐

None of the above ☐

b) If none of the above explains where your container/vessel for collecting and storing rainwater is situated ………………………………………………………………….

……………………………………………………………………………………..…….

……………………………………………………………………………………..…….

10) Approximately how long does the harvested rainwater last, after the rainy season is over?

- Below one month ☐
- Two-three months ☐
- Four- five months ☐
- More than five months ☐

11) Is the rainwater collected enough for all domestic purposes for at least 4 months in a year? Yes ☐ No ☐

If No, where else do you get water from. Explain ……………………..………………

12a) Apart from the domestic purpose how else do you use collected rainwater?

Irrigation ☐

Fish rearing ☐

Watering animals ☐

Factory processing. ☐

b) Do you find the rainwater adequate for the purposes above? Give your personal view. Yes ☐ No ☐

13a) In your view what do you suggest should be done to enhance the collection of more rainwater in Buuri Sub-County.

Explain…………………………………………..………………………………

……………………………………………………………………………….………

bi) According to your experience are there times during the rainy season when all rainwater collecting container/vessels get filled up? ("Tick where appropriate")

Yes ☐ No ☐

ii) If yes, explain where does uncollected rainwater go to

………………………………………………………………………………..………

14. Do you use rainwater and surface runoff overflow for another purpose?

Yes ☐ No ☐

If yes, highlight the purpose for which rainwater overflows and surface run–off is used for.

i)………………………………………………………………………………….…..

ii)…………………………………………………………………………………….

iii)…………………………………………………………………………...…..

15a) In your view are there times when the surface` run-off and overflows cause any problem in Buuri Sub-County.

Yes ☐ No ☐

If yes, specify the problem…………………………………………………….…

b) As a resident of this region, what would you suggest needs to be done by the county government, well-wishers or non-governmental organisation to help trap the overflows and surfaces runoff that occur during the rainy seasons.

………………………………………………………………………………………..………

…………………………………………………………………………………………

16. Do you experience any environmental problems/constraints in the process of rainwater harvesting process?

Yes ☐ No ☐ Not aware ☐

If the answer is yes, explain how it affects.

………………………………………………………………………………………..……

………………………………………………………………………………………..…..

SECTION C: RAINWATER CATCHMENT AREA

(Tick where applicable)

a) (i) What kind of catchment area/surface for capturing rainwater do you use to harvest rainwater?

Roads ☐ Footpaths ☐ Roofs ☐

Rocky area ☐ None of the above ☐

ii) If the methods/choices given are not applicable, which catchment area is used specify……………………………..…………………………………….…………....

………………………………………………………………………..…………....

iii) Give a reason for the choice of catchment area selected in (a)(i) above….………

…………………………………………………………………………………………

…………………………………………………………………………………………

b) If roof catchments system is used, approximately what is the average area of your roof? Tick where appropriate)

$20m^2$ and below ☐

$21\text{-}50m^2$ ☐

$51\text{-}70m^2$ ☐

$71\text{-}100m^2$ ☐

Above $100m^2$ ☐

c) In your view, what can be done to improve the roof catchment area to enable more rainwater harvesting.

……………………………………………………………………………………

……………………………………………………………………………………

d) Apart from rainwater, where else do you get water? (Tick the appropriate answer)

a) Borehole ☐ c) Project water ☐

b) Well ☐ d) Lake ☐

e) River ☐

e) Is the water from the source selected in (No. d) above available throughout the year? (Tick the appropriate answer)

Very adequate ☐

Adequate ☐

Not adequate ☐

Little ☐

Very little ☐

f) As a resident of this area, what is your occupation?

Business ☐ Salaried Job ☐ Casual Farming ☐ Others ☐

If others specify …………………………………………………………………………….

g) How does water shortage affect your financial status /income level as a resident of BuuriSub-County.

Explain………………………………………………………….…………………

…………………………………………………………………………..........................

Appendix C: Letter of Introduction

Agnes Karwitha Mbogori
P.O. Box 1594-60200
MERU
CELL No: 0725 801 684

Dear Respondent,

RE: REQUEST FOR DATA COLLECTION

I am a postgraduate student at Chuka University, pursuing a Master degree in Geography**.** I will be conducting research on an analysis of factors that influence spatial variation in adoption of rainwater techniques in Buuri Sub-County in Meru County.

I kindly request your assistance in filling in the questionnaire and responding to the interview schedule attached to enable me complete my research.

The questionnaire and the interview schedule are strictly for academic purpose and any information offered will be treated with absolute confidentiality.

It will be my pleasure if you give accurate and honest information.

Thank you in advance.

Yours Faithfully,

Agnes K. Mbogori

Appendix D: NACOSTI Research Permit

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 14999

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MS. AGNES KARWITHA MBOGORI
of CHUKA UNIVERSITY , 0-1594 MERU,has been permitted to conduct research in *Meru County*

on the topic: *AN ANALYSIS OF SOCIO-ECONOMIC FACTORS THAT INFLUENCE SPATIAL VARIATION IN ADOPTION OF RAINWATER HARVESTING TECHNIQUES IN MERU COUNTY, KENYA*

for the period ending:
18th July,2018

Permit No : NACOSTI/P/17/87940/18027
Date Of Issue : 18th July,2017
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

Appendix E: NACOSTI Research Authorization

NATIONAL COMMISSION FORSCIENCE, TECHNOLOGY ANDINNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/87940/18027**

Date: **18th July, 2017**

Agnes Karwitha Mbogori
Chuka University
P.O. Box 109-60400
CHUKA.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"An analysis of socio-economic factors that influence spatial variation in adoption of rainwater harvesting techniques in Meru County, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Meru County** for the period ending **18th July, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Meru County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Meru County.

The County Director of Education
Meru County.