

**WATER AVAILABILITY CHANGES IN YATTA CANAL AND ITS IMPACTS ON
LIVELIHOODS IN YATTA SUB-COUNTY, MACHAKOS COUNTY**

BY

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A Project submitted in partial fulfillment of requirements for the award of Degree of Master of Arts in Water Resource Management in the Department of Geography and Environmental Studies, University of Nairobi

OCTOBER, 2018

DECLARATION

I hereby declare that this research project is my own original work and that it has never been presented for the award of a degree either in this or any other institution.

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DEDICATION

To my beloved family members and my colleagues, friends and spiritual brothers and sisters for their support.

ACKNOWLEDGEMENT

First, I wish to thank God for enabling me to have good health and allowing me to complete this research project. I am very grateful to my able supervisors for their continuous guidance and supervision of my research project. I also thank and appreciate my beloved sister for her continuous moral support. I wish to thank all study participants who were involved in activities of this study and those who assisted in making the study a success. I pray that God will remember you in times of need.

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LIST OF ACRONYMS

FAO	Food and Agriculture Organization
ILO	International Labour Organization
IFAD	international Fund for Agricultural Development
ISRIC	World Soil Information
KNBS	Kenya National Bureau of Statistic
LPCD	Litres Per Capita per Day
NEMA	National Environmental Management Authority
OECD	Organization for Economic Cooperation and Development
PPP	Private Public Partnership
UNEP	United Nations Environmental Programme
UNICEF	United Nations Children's Fund
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization
WUA	Water Users Association
WRMA	Water Resources Management Authority
KFSSG	Kenya Food Security Steering Group
YAWASCO	Yatta Water and Sewarage Company

ABSTRACT

Out of every 10 people in Africa, 2 do not have access to safe water supply, while 4 in every 10 people do not have access to basic sanitary services. With only 0.3% of the world's waters accessible as fresh water, rise in population has led to increased demand for this precious resource. This study sort to investigate how this demand among other factors, also investigated and discussed, led to change in water availability in the Yatta Canal. The research also sought to determine how changes in water availability in Yatta Canal do affect the livelihoods of communities of Yatta Sub County. The specific area of study is Kithimani Ward, within Yatta Sub County where Yatta Canal is located. Yatta Canal get its water from Thika River and drains into Mwitasyano River. The researcher relied on both primary and secondary data collected from the field and desktop research respectively. Methods of primary data collection included questionnaires administration, photography, interview and observation. A sample of 90 respondents obtained using Nasuirma model (2000) was interrogated using questionnaires. Secondary data was collected through internet searches, interactions with books on the subject matter and demographic data was obtained from existing census reports. Collected data was analyzed using one-away ANOVA, Duncan New Multiple Range Test and Correlation analysis. The results of data analysis and projections were presented in graphs, charts and tables. The study results showed average water consumption per household of 600 litres a day. The study results further showed that seasonal variations on water availability from Yatta Canal (and other different sources) were recorded in Yatta Canal basin with 95.6% of the households in Yatta having poor access to water. The burden of fetching water relied disproportionately more on female child and female adult compared to their male counterparts. The study also established that 76.67% of the community residents along Yatta Canal belong to the poor socio-economic status. A positive correlation ($r=0.811$ for human factors, $r=0.774$ for natural factors and $r=0.638$ for stakeholder involvement) was established between these water changes contributors and livelihoods of the rural households along Yatta Canal. Lastly, there is poor participation of various stakeholders (residents, CBOs, NGOs, and Donor Agencies) apart from the government in water management decisions among the rural communities along Yatta Canal. However, the t-test statistic showed no significant difference existing between mean values of both male and female respondents ($p=.186$). The study concluded that the livelihoods of the rural communities living along the Yatta canal was adversely affected by extreme variability in water availability in the canal and that interventions by the government in water management and poverty reduction in Yatta canal had not been effective. The study recommends that the people living in Yatta Ward should find alternative sources of water since relying on the Yatta canal is not sustainable as the canal is not sufficient to satisfy their demand of water for both domestic and agricultural purposes.

CHAPTER ONE:

INTRODUCTION

This chapter discusses how the demand of water has changed over the decades with rise in populations. The chapter includes a background of study followed by the statement of the research question. Research objectives are then outlined followed by a justification of the study.

1.0 The Background of study

Food security is challenged greatly by how resources of land and water are used as they are the main sources of how food security is distributed in the world. Demographic pressures and climate change have increased the demand for water and water infrastructure, thereby negatively affecting the livability of societies, particularly in Africa and Asia by also increasing their vulnerability to food insecurities and poor sanitation (UNESCO, 2011).

According to UN DESA (2011), the world's current population is at 7.0 billion and is expected to grow with a 33% to 9.3 billion by the year 2050, that will lead to a high demand in food by about 60% (Alexandratos and Bruinsma, 2012). Moreover the population living in the urban is also expected to rise from 3.6 billion to 6.3 billion in the 2050s (UN DESA, 2011). Worldwide 70% of available water is used for agriculture, while 20% and 10% for industrial and domestic use respectively. The demand for fresh water is increasing by 64 billion cubic meters a year (UNESCO, 2011).

Water is an integral part to any society's growth and development. With enough water a population can easily support itself with constant food supply through farming (Ngigi, 2009). The Kenya population continues to grow hence the need to improve the national food basket irrespective of the ecological area as other countries have done. Many countries have embraced irrigation and successfully done away with rain fed agriculture. Other countries have been successful to the extent that they export food apart from feeding its own population. Building of dams and canals has proven to be successful as they have transformed millions of lives (FAO, 2011).

About half of the world's workforce which is approximated at 1.5 billion people works in water-related sectors. (UN Water, 2016).

Water is highly depended upon by industries such as the agriculture sector which approximately uses water in its 95% of its jobs, the industry sector which consumes about 30% of water and the services sector which consumes about 10% of water in its jobs. It is also evident that the agriculture sector, the industrial and services sectors dependency on water is estimated at 5%, 60% and 30% respectively in their jobs (UN Water, 2016). It is estimated that the highest populations in the world work with crop and animal production or fisheries which makes about 40% of the global population. World Bank (2005) argues that 20% of the world's populations consist of waged workers, and the remaining population is self-employed or is into family businesses which are about 570 million farms (UN Water, 2016).

There is need for county government to come up with sound policies regarding rural development policies touching on land mainly due to rapid increase in population. With the new constitution now in place county governments should now be able to prioritize the needs of their locals in the rural areas, special case now being Yatta Sub County. Such projects will not be successful unless the county government in this case Machakos County comes up with elaborate sound policy measures on land keeping in mind that land issues are now more complicated than in the recent past. There is also need to have more elaborate interventions in matters to do with water. Factors dealing with success on water investments should be well articulated (Osman-Elasha, 2010).

Yatta Canal was constructed by the British colonists as an earth canal between 1953 and 1959 by using colonial detainees with the purpose of conveying water from Thika River to serve the Yatta area of Matuu and the south Yatta area of Kitui. It is a source of livelihood for the people of Yatta Sub County (Ndunda E and Gathuru G, 2017).

The canal supports over 74,836 people and 35,000 livestock. It generates 662 million shillings from sale of farm produce and other commercial activities annually. The Canal is 58.8 km long from the intake in Thika River to terminal point (border of Machakos and Kitui counties), and the overflow flows to mwita syano river. It conveys water to Kithimani, Ndalani and Matuu towns and

there environs where it is used for domestic, irrigation and livestock water purposes. The canal commands more than 180km² (18000 Ha) of irrigable land (Ndunda E and Gathuru G, 2017).

This study took into consideration the relationship between water availability changes in Yatta Canal and the livelihoods of the residents of Yatta Sub County. It looked at how water supply affects people's livelihoods, assets, capabilities to generate incomes and other activities that are required to secure the necessities of life.

1.1 Statement of Research Problem

Access to safe water has been faced by different kinds of challenges related to unrelenting environmental and social challenges which most of the populations are aware about. In every 10 people in Africa, 2 do not have access to safe drinking water supply, while 4 in every 10 people do not have access to basic sanitary services. 90% of 5,000 individuals who pass away of diarrhea disease on a day to day basis in Africa, are under 51 years of age. A lot of women and girls spend about 4-6 hours fetching and carrying water on a daily basis, which eventually prevents girls from going to school (Aroka, 2010). It is estimated by the WHO/UNICEF that deals with water supply and sanitation that about 1.8 billion people globally consume feacally contaminated water or water that is delivered through a system that is prone to contamination.

Compared to all other continents in the world, Africa is the poorest continent when food securities is concerned, deterioration in how the people live is evident with the highest population of poor people living in rural areas who rely heavily on subsistence agriculture with their main concern being survival. One of the high risk factors faced by the rural people is water availability. There is very minimal literature on the impact of water availability changes on livelihoods asset of the rural people especially as far as Yatta-Sub County is concerned, (Todaro and Smith, 2009).

Water borne diseases such as round worms, whip worms, guinea worms and schistosomiasis are caused by lack of good sanitation facilities and poor hygiene. Schistosomiasis for example is common among poor school-aged children according to (UNICEF, 2010). The same report by UNICEF (2010) indicated that lack of access to safe drinking water and inadequate sanitation causes death from preventable diseases of about 2.2 million people in developing countries

annually. There is therefore a need to establish a correlation between access to clean water and effects on resources used to achieve good health. The lack of access to clean water often leads to families using available resources to look for water or treat illness arising from poor access to water. This is the main objective of the present study in Yatta Sub County.

Yatta Constituency is considered as an erratic precipitation area meaning it is a semi-arid area covering an area of 1,057 Km²; its population is estimated to be at 147,579 people. The area experiences frequent droughts which makes it a low agricultural productive area. It is estimated that 70 % of Yatta residents depends on agriculture as their main source of livelihood, with a poverty level of about 67.5 %, it is almost impossible to invest irrigation schemes for agricultural purposes. Most of the farmers practice small scale farming which mostly takes place during the short rain period (Manohar S, Mang'oka JM, 2017).

The additional water needed to eradicate hunger and malnutrition across all Africa's population by 2030, corresponds to all the water reserved and used currently for industrial, domestic and agricultural purposes (FAO, 2012) Deprivation of freshwater ecosystems and land impairs the rate and impact of droughts, famine and other natural catastrophes, especially in ecologically fragile regions like Yatta sub county where the deprived often live, this can often result into increased competition and the likelihood for conflict over access to communal water resources.

However, despite such commitments and the strong call for improvements on all populations and communities, access to water supply, water resource management and sanitation services remains low. The main aim of this project is to make a contribution to provision of improved water availability in Yatta-Sub County through suitable strategies such as water storage/management of water catchment for irrigation and domestic uses.

The Yatta area is drained by one perennial river and two seasonal rivers namely Athi, Tiva and Mwitasyano respectively. Athi River is fed by tributaries emanating from the Aberdare ranges in Central Kenya. Tiva River is fed by Mwitasyano among other small tributaries generated accumulation of water surpluses in the upland regions. Mwitasyano River originates from the overflow of the Yatta canal (GOK, 2002).

1.2 Research objectives

1.2.1 Main research objective

The main objective of the research is to assess the impacts of water availability changes on Yatta resident's livelihoods along the Yatta canal in the Yatta-Sub County.

1.2.2 Specific objectives included:

- Ascertaining factors leading to the change in water availability in Yatta canal.
- Determining the correlation between change in water availability in Yatta Canal and the livelihoods of the rural residents.
- To assess the levels of stakeholder participation, organization and management in rural water schemes.

1.3 Research question

The study aimed at investigating the following questions:

- To ascertain the factor that lead to change in water availability in the Yatta canal.
 - i. What are the human activities that lead to such changes?
 - ii. What are the natural factors that lead to such changes?
 - iii. What measures are in place to mitigate effects of human and natural activities in Yatta Canal?
- To determine the correlation between changes in water availability in Yatta Canal and the livelihoods of the rural residents.
 - i. How does water availability affect the livelihoods of the rural people?

- ii. How affordable is water from the available sources?
 - iii. Is there a relationship between water availability and food security in Yatta Sub County?
- To assess the levels of stakeholder participation in organization and management of rural water schemes.
 - i. Do rural communities participate equally on the operation and management of water schemes?
 - ii. Are Government, NGOs and Donor Agencies doing enough to meet both water and sanitation challenges faced by rural communities?
 - iii. Are concessions given to the poor and disabled in access to water and sanitation?

1.4 Research Hypothesis

1. There is a no relationship between water availability changes and improved livelihoods in the Yatta sub-county
2. There is no stakeholder participation involvement in operation and management of water schemes in Yatta Sub County.

1.5 The Justification of study

This study aimed to ascertain the reasons for changes in water availability in Yatta Canal and how it affects agricultural production, general health, and other aspect of livelihoods. In addition, the challenges faced by rural communities in meeting the water and sanitation needs were investigated. The role of water as one of the most important variables in engendering sustainable rural development and poverty alleviation was established through linkage between water access and rural livelihood capital. Furthermore, the study aimed establish the measures undertaken so as to ensure gender, generational, intergenerational equity in water resource management in Yatta-Sub County.

The research provides information on environmental factors that have contributed to water shortage which would be a suitable indicator hence need for intervention towards reduction of the identified causes.

1.6 The Scope of study

The study limited itself to investigating the impact of water availability changes to improved livelihoods in randomly selected population of Yatta Sub County in Kithimani sub-ward. The study focused on the challenges related to water accessibility changes, availability and the urgency to resolve them. The scope of the study was limited within the research objectives, questions and the hypotheses.

1.6.1 Limitations of the study

In carrying out the research, the researcher foresees some limitations; top on the list is lack of funds in the form of research grant. The research requires an elaborate coverage of the communities in Kithimani and Yatta as a whole as well as at least four Research Assistants, thereby putting much pressure on them with the accompanying stress.

Another challenge of the study was the reluctance of some respondents to give some information they deem personal as well as those they might be ashamed such as educational and income levels. As such, determining the demographic characteristics of the community was a challenge.

One more limitation of the study was the dearth of information i.e. secondary data about study area especially photographic information and demographic data about Yatta canal.

1.6.2 Overcoming the limitations

The researcher overcame the above limitations by hiring at least three research assistant and negotiated a reasonable fee with them as well as work out a formula for extensive coverage of the study area.

To address the challenge of reluctance of respondents giving out information, the researcher ensured that the research assistants speak the local dialect, preferably from and familiar with the local community.

Finally the researcher generated necessary information from satellite imagery, ArcGIS as well as any photographic data taken recently.

1.7 Definitions of operational study concepts

Livability is the sum of factors which add up to a community's quality of life. They include; the built and natural environments, economic prosperity, social equity and stability, education and learning opportunities, entertainment and recreational facilities.

Subsistence farming: This is a form of agriculture where much of the production is consumed by the household. It is often characterized by low-input use provided by the farm.

Water access: This is the degree to which a household obtains its water from a reliable source be it for drinking or agricultural purposes.

Rain-fed agriculture: This is agricultural practice which relies exclusively on rainfall as its source of water.

Rural community: These are people usually living in rural farmlands. Most rural people will spend much of their working time on the farm.

Drought is a prolonged period of abnormally low rainfall and a subsequent shortage of water. It also often leads to famine, minimal to zero supply of food.

Multiple use of water: This is where water is used for several activities such as domestic and agricultural use.

Household is a unit of measurement, usually in research, which usually regards a house and its occupants as a unit. It's a social unit composed of those living together under the same dwelling.

Livelihood assets (capitals): These are a key component of the sustainable livelihoods approach. They are thus the assets on which livelihoods are built. They are usually divided into five categories (types of capital): human capital, natural capital, financial capital, social capital, and physical capital.

Livelihood: This comprises of people, their capabilities and the means of living which include food income and assets.

Water availability: This is the ability of a water source (surface water body, groundwater, and municipal water) to sustain any additional water demands put on it (GEMI, 2012).

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter is a situational analysis of water availability - globally, in African and in Kenyan rural areas shall be discussed. The chapter also looks at demand for water and the relationship between water availability and community livelihoods according to existing literature. The literature review also seeks to meet the objective of the study by seeking to review the existing information on the subject matter and identify gaps and help in the formulation of the conceptual framework to move the research forward.

2.1 Livelihood index

Livelihood index is developed based on sub-indices which are agricultural status, nutritional status, health and sanitation status, food availability status and infrastructure status. People experience community – subjected to a variety of interrelated aspects that affect them as community - as a whole, so multiple aspects - most of which are anchored to the environment - of livability are considered to get the whole picture. Good communities create livable environment by maintaining and improving their environment that is; water, air and land (Chambers, 1989).

2.1.1 Sustainable livelihoods

According to Chambers & Conway (1992), “Sustainable livelihood is one that is able to cope with the challenges and is also able to maintain and enhance its capabilities and resources both currently and in the future thus ensuring the maintenance of a natural resource base.”

Livelihood is access to the necessities of life which include food, water, clothing, shelter, and education. (Chambers and Conway, 1992)

2.1.2 Rural livelihoods

Livelihood makes the household a centre of analysis. This takes into consideration all assets, that is, physical, financial, human, natural and social assets.

The physical approach emphasizes more on ensuring that methods of decision making are improved in the families and ensuring good management standards are observed instead of just improving the households' irrigations systems. Social capital on the other hand emphasizes on provision of safe water to the poor and also ensuring that the households are also involved in decisions made in the society. The natural capital approach involves training of households on how to build new water resources that are safe and how to protect the catchments. small-scale credit programs development is emphasized by financial capital while importance of community self-assessment of needs are emphasized by human capital together with monitoring of participation and mainstreaming of gender balancing (Pender *et al.*, 2004).

Physical and financial capitals are very limited in households in the rural areas. The rural areas main assets are labour and the lands they possess. Community relationships in the rural areas and their kinships make up the social capital. Measurement of social capital, its role and importance are difficult due to their elusiveness. This has led to most of the studies focusing on physical, natural and human forms of capital as they are much easier to measure and report. The productivity of land and labor are improved by improving agricultural water. Rural livelihoods can be improved by building new schemes in irrigation and improving water harvesting methods that are safe and cheap for the rural areas to adopt therefore investing in physical capital (Deller *et al.*, 2001).

2.1.3 Sustainable Development Goals

In 2015 there has been noted progress towards the sustainable development goal, whereby 4.9 billion people globally had their sanitation improved. However 2.4 billion people did not use improved sanitation and among those 946 million continued to practice open defecation, most of who are in developing countries (SDG Report, 2016).

2.1.4 Rural poverty.

A rural area is an area surrounded by fields and pastures; dominated by woods, forest, water, mountain and desert. These are areas where human settlement and infrastructure are not very common and thus occupy only small portions of the land. The majority of people living in rural areas spend most of their time in the farms, as land here is cheaper and abundant, political issues

here are much harder compared to the urban areas and the transaction costs too are higher. Heterogeneous features are high in these areas. The rural areas also have less potential. Due to low social services and infrastructure, the poverty level in the rural areas is high and leads to a report of about 80% of people living beyond the poverty level (IFAD, 2009).

The main sources of income of people in the rural areas are from subsistence production of which they are small holders of. They also rely on small wages from seasonal jobs and informal non-farm income sources as they are mostly landless (IFAD, 2009).

Negligence in infrastructure has been experienced from most rural areas in Kenya. Focus has been put upon urban areas in the improvement of health, education and water supply. This has led to rural areas being left out in the provision of these services and therefore leading the population to live under the poverty line. Also limited access to reliable water sources or over reliance on rain-fed agriculture has subjected rural communities particularly in Yatta Sub-County to perennial food shortage as agriculture is affected (The World Bank, 2009).

2.2 Factor that lead to change in water availability

2.2.1 Human factors that lead to changes in water availability

Water resources all over the globe are greatly threatened by human activity such as sedimentation, pollution, climate change, deforestation, landscape changes, and urban growth. (Figueras *et al.*, 2003; Bergkamp *et al.*, 2003)

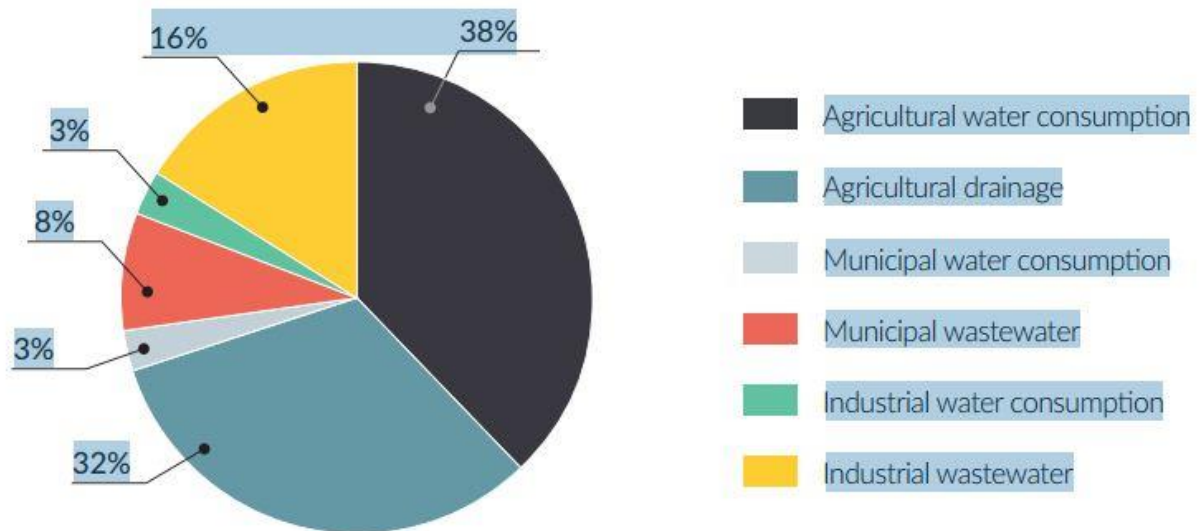


Figure 1: Water consumption by major water use sector (circa 2010)

Source: Based on data from AQUASTAT (n.d.a.); Mateo-Sagasta et al. (2015); and Shiklomanov (1999).

Degradation of ecosystems is the greatest threat to water resources. This is because degradation of ecosystems involves landscape changes; cutting down of trees thus clearing forests, farming which destroys the natural landscapes, building of cities, roads and mining of surfaces. These changes cause threats to the water sources in one way or another; some affect the sources directly on natural resources while other affect directly or indirectly on the water sources (Figueraset al., 2003; Bergkampet al., 2003).

Rise in population also has increased the demand for water as different uses compete for this resource. Water usage has increased 6 times globally and will double in the year 2050. The usage of world's water resources are in irrigation and increased agricultural activities as follows; 70% for irrigation, 20% by industries, while 10% is for domestic use (WWDR, 2017).

Operations up-stream

Another factor that leads to changes in water availability in Yatta canal is extensive use of water by users upstream. Farm owners upstream engage in large scale, commercial farming (both cash and food crops) and as a result require large amounts of water to meet this need. The farm owners downstream are forced to cope with a lesser amount of water, which at times is completely lacking.

2.2.2 Natural factors that lead to changes in water availability

Factors that lead to decreasing water availability are discussed in the following sub-sections; these are natural factors and some such as decreased rainfall are as a result of sustained environmental degradation. Location and siltation however have minimal human input but still lead to decreased water availability.

Location

The availability of water is affected by whether the environment has high levels of rainfall, high ground water supplies, presence of lakes and rivers and the areas' general arid condition. An example of one of the areas with little fresh water due to arid and semi-arid conditions is the Yatta Sub County (Woodhead, T. 1968).

Decreased Rainfall

Decrease rainfall has a great effect on water availability. The unreliable rain patterns experienced in 2016 are largely the cause of water shortage. The average expected rainfall which is 1000mm was contrary to what was received as only a quarter of this was received. Low amounts of rainfall mean that water getting to households is greatly reduced as dams and canal water levels go low. This often leads to rationing of water so as to reduce the risk of drying out (Gatheru M. & Gichangi E M, 2013).

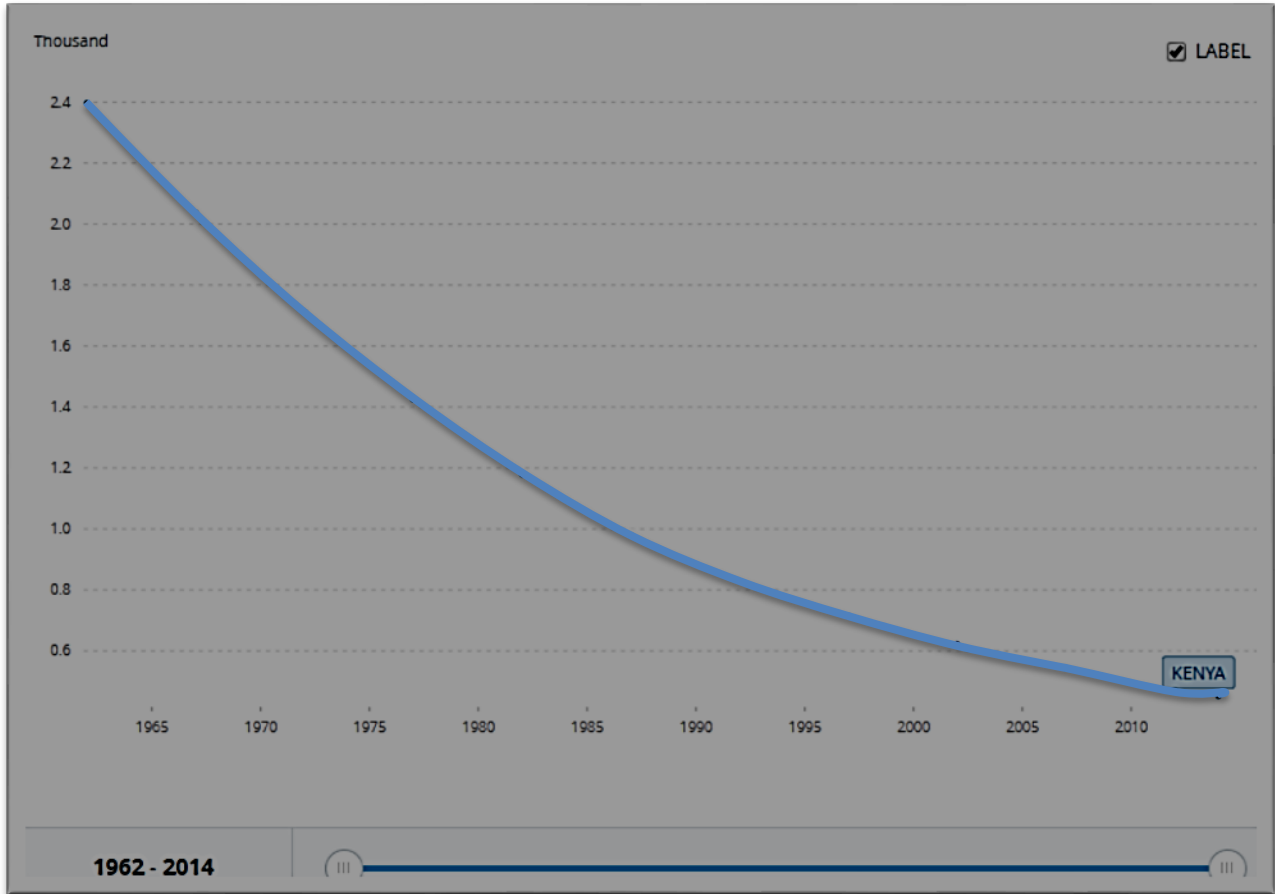


Figure 2: Renewable internal freshwater resources per capita (cubic meters)

Source: The World Bank Group (2017)

Siltation.

Lack of sufficient vegetative cover often leaves soil cover exposed to erosion. In case of flash floods, soil is often carried into water dams and canals. Soil exposed along river banks is also often carried downstream in case of surface runoff finding their way into rivers. This normally leads to siltation in canals and dams thereby reducing the amounts of water in there as observed in Yatta Canal during the research.

2.3 Water availability and livelihood

The competing demand for both food and water, has been worsened by an increasing population, which brings with it food insecurity, poverty and environmental degradation (S.E. Cook, 2009)

2.3.1 Water availability and sustainable livelihood.

The importance of water in livability of a community can never be overemphasized. Water is crucial for the survival of all terrestrial lives. To humans, water is a critical component to ensuring effective and efficient functioning of economic activities, food production and functioning of cities. Population increases have led to increased demand and competition for water. As a result, uninterrupted access to this crucial resource is no longer guaranteed. This puts all water dependent sectors at the risk of being negatively affected in case of water shortages (FAO, 2016).

Water and the global economy are inter-linked. The daily water requirement for a person is approximately 20-50 liters of clean water a day, for the purposes of drinking, cooking and hygiene (UN-Water, 2013). However the amount of fresh water available per person has reduced by 60% between 1950 and 2010.

Kenya is classified as one of the countries with lowest levels of water as it has the lowest water replenishment rates compared to other countries as it has a 647 meters cubed per capita per annum compared to the required level of 1,000 meters cubed per capita per annum a (UN-WATER/WWAP, 2016). It estimated that only about 56% of the Kenyan population is able to access safe water. This has caused a high number of hospital attendances due to high number of preventable diseases caused by lack of water, good sanitation and proper hygiene. Compared to the previous years, the level of sanitation has dropped from 49% to 43%. Most of the diseases caused by poor sanitation are common in the rural areas as about 50% of the Kenyan population do not have proper sanitation (UNICEF, 2016).

Kenya is considered a water scarce country with future projections of water available per capita dropping from 650m³/year to about 359m³/year by 2020 (UN-WATER/WWAP, 2016). This will

be mainly as a result of population increase, competition in water uses, increased water demands and climate change. However, the globally accepted value of water availability is 1000m³/ year. (Kithia, S.M 2010).

2.3.2 Water and jobs

Three out of every four jobs worldwide are water-dependent. This is so such that water shortages and lack of access could limit economic growth in the years to come. This is according to the 2016 United Nations World Water Development Report titled; “Water and Jobs”, launched on 22 March on the World Water Day, in Geneva (UNESCO 2016).

About 40% of the economically active population globally works either in crop, animal production or fisheries. 20% are employed as waged workers or are involved in family labor which is estimated to be 570 million farms (UN Water, 2017). The industries that make use of most water are food and drinks industries that employ about 22 million people of which 40% are women; the chemical, pharmaceutical, rubber and tires employs about 20 million while electronics employ about 18 million people (UN Water, 2017).

Jobs in the water sector usually fall under one of the following three categories: i) water resources management, including integrated water resources management (IWRM) and ecosystem restoration and remediation; ii) building, operating and maintaining water infrastructure; and iii) the provision of water-related services including water supply, sanitation and wastewater management.

2.3.3 Water affordability.

The level of water connectivity to households in Africa still remains low which in-turn serves to limit households from accessing clean water both for drinking and domestic use. This may result to the use of untreated water by households. Alternatively, households could result to buying water from vendors who tend to overprice the commodity (UNDP, 2006).

2.3.4 Water and food security

The main causes of hunger in most of the countries are as a result of water scarcity as this is a main impact on food production. Enough food would be produced if water management was improved and thus about 3000 million more people would have access to adequate food by 2030 (FAO, 2007).

The world population is rapidly increased from 7 billion in 2011 towards over billion by 2050, increasing the use of fresh water for human consumption, agriculture, industry and other uses six fold. To feed an increasing number, food production will have to increase, double the current amount, but the amount of water and arable land available remains the same. In addition, climate change and extreme weather events increasingly pose a threat agricultural production. Consequently new adaptive measures of water management in agriculture include rain fed and irrigated agriculture, watershed management and livestock rearing (FAO, 2007).

2.4 Stakeholder involvement in water management schemes

The existing water-related problems are expected to increase with conventional water resource management systems not being able to overcome future challenges. There is need for an integrated water resource management system. This should be both participatory and scientifically informed and be based on the bottom-up approach. The Involvement of key stakeholders helps to ensure that any catchment management plans take into consideration local needs and interests.

2.4.1 Stakeholder involvement in water supply and management.

According to WRA rules (republic of Kenya, 2007), a stakeholder is a person or an entity which has influence or is affected by development process on a resource. World Bank (2007) notes that when user groups, private sector and the government have clear roles, objective and expectations, sustainable water management becomes attainable. Stakeholders' main role in water supply is to

ensure the design and management of water resources. When this is effectively done, efficiency, equity, cost recovery and easy access of services to the poor is increased. This increases the level of participation and delivery of institutional arrangements to the poor thus success of the projects. Prior to referendum and promulgation of Kenya's new constitution in 2010, water and sanitation utilities consumers were never involved in decision making and management (World Bank, 2007).

Participation plays a key role in addressing the challenge of water supply by providing a means of revealing the demand and preference and of ensuring that the services match the people's needs. It also reveals the cost the community is willing to pay for and maintain the services provided (World Bank, 2007).

2.4.2 Water use Efficiency

Efficiency in water management ensures that production and distribution of water is a success, the costs of services are minimized and this therefore ensures that the resource is preserved for future generations to come and the continuity of the community. Affordability is also another vital aspect in ensuring that water resource is effectively provided. Improvements in infrastructure are encouraged by reuse and conservation of water due to high rates but this can also cause prohibition in costs.

Water systems can be maintained by ensuring that leakages are repaired in time and accountability in water usage making water systems to run effectively. Pipe leakages have been a threat to the infrastructure as they cause service interruptions in the developed economies. In the developing economies where metering has not been well established, this thus results to cases of non-revenue water, and service interruptions (Rukunga, G. Kioko, T. *et al.*, 2006).

Efficiency in water schemes is achieved when different water users are involved in management of the water resources. A sense of ownership is established thus minimal amount of water is wasted while in supply and the canal and other water infrastructure are well taken care of.

2.5 Theoretical framework

The underpinning theory this study is founded upon the notion that interventions must be based upon an appreciation of what underpins livelihoods, in this case availability of water for various uses. The new 'sustainable livelihoods' approach to rural poverty alleviation provides a useful framework for analyzing the resilience of rural livelihoods by incorporating social resources along with the material and physical resources of traditional studies. The primary purpose of the effective management of water resources is to increase the productivity or efficiency of water within river basins as a means to simultaneously achieve improved environmental and social outcomes; the latter inclusively defined as wellbeing to capture multidimensional gains in, for example, health, food security and poverty alleviation, M. Geran, Jean (2018).

The Universal Declaration of Human Rights” by the UN (1948) did not manifest water despite it being an essential for life. The human rights declaration did not also acknowledge air and that would have been a reason for not manifesting water. Despite the Universal Declaration of Human Rights not acknowledging water, many international agreements and conventions have acknowledged water as a fundamental need for every human being together with food and health care. The main objective of the projects could only be realised through access to clean water (Gleick 1998). Many organizations in past years have played a significant role in ensuring that water is acknowledged as a human right. According to the 1995 UN “Declaration on the Right to Development, they indicated that denying a person access to clean water is like violating their human rights (Gleick 1998).

A human daily consumption of water is distributed as follows by the World Health Organisation (WHO); to fulfil ones needs for consumption and assurance to proper hygiene requires 50 litres per capita per day (Howard and Bartram 2003); drinking water needed per person per day is about 5L; food preparation requires about 10L and bathing and sanitation services require about 35 L (Gleick, 2007).

Every country in the world that is not able to provide 100 LPCD to every human being means that there is shortage and thus should ensure that the needs of every individual concerning access to clean water are met (Howard and Bartram 2003). In areas where there is scarcity of water for

example the arid or semiarid in the world, water is limited to ensure equal supply to everybody and thus little quantity is observed. The UN (2010)'s main goal is to ensure that clean water is adequately supplied to all parts of the world and access to it is effective.

Water privatisation is supported by the Indian government. However, it ensures that only the supply is privatised. Projects of PPP decreased in the 1990s due to the failed first projects witnessed in the same year. Other projects founded in the year 2005, have showed significant success. The projects established from 2005, involved generation of water in bulk and distribution of network rehabilitation (Department of Economic Affairs 2009, Indian Government).

The problems and risks associated with the PPP projects that had been established before led to less establishment of the projects due to failure. These risks and problems were; resistance from internal parties, resistance of labour and governments instability. More risks were experienced from changes that came up with laws and regulations and risks in transactions due to the program of privatisation that were caused by project designs, administrative bodies that are incapable and reluctance in proceeding with the projects (Nallathiga, 2007).

2.5.1 Origin of livelihood thinking.

Early interdisciplinary research on livelihood focused on household studies, villages and farming systems which came to impact development studies and livelihood thinking in modern society (Lipton & Moore, 1972). According to chambers and Conway (1992), research in livelihoods was derived from the Institute of Development Studies in 1992 that aimed at locating sustainable livelihood that lead to development of actor-oriented approaches, environmental framework, social sustainability and poverty reduction.

2.5.2 Determinants of livelihoods

There are numerous determinants of livelihood strategy. Many livelihoods are predetermined by accident of birth. These are referred as categorization, for example in India children may be born on a caste with an assigned role as potters, shepherds or washer people. Predetermination and less singular determines most livelihoods. The social, economic and ecological environments are the

main factors that most people determine their livelihoods due to desperation. Other people use migration and education as their determinants of their livelihood (Chambers *et al.*, 1991).

2.5.3 Components and Flows in a Livelihood

Chambers and Conway, (1991) established with four components of Sustainable Livelihoods namely; tangible and intangible assets, people and livelihood capabilities. Tangible assets are such as; food stocks, stores of value such as gold, jewelry and woven textiles while intangible assets include; cash savings in banks and other credit schemes (Chambers *et al.*, 1991).

2.6 Conceptual framework

Water availability and livelihoods are inseparably interconnected. The overall development strategy of a country and any other policies – such as economic, trade and monetary policies – have a direct and indirect impact on both demand and investment in water activities (Aroka, 2010).

In past years, most of the African communities were satisfied with subsiding in small acres of land of about 0.5 hectares per person which they mostly used for cultivation. But in the present years, great changes have been witnessed that have resulted from multiplication of populations thus provision of commercial outlets and more agricultural innovations that have given people the capacity to farm on more lands. Stock numbers have grown in high rates due to high number of people thus higher demand. This has increased pressure on the semi-arid areas which has resulted to scarcity of local products (GWP, 2000).

Many dangers have resulted to both land and population due to their changing relationships thus being a threat to each other. This has come up due to overworking of the land leading to it losing its productivity and people sharing land resources inappropriately thus depriving others and thus risks security (GWP, 2000).

Pastoralism is mostly common in areas where the land is dry in the African setting. These areas are mostly surrounded by thorn shrub, grasslands, and savannah that extend from one end of the desert to the other. The arid areas are occupied by the hardier animals whereas the less arid areas

are occupied by cattle and cultivation (Aroka 2010). Where pastoralism is common, the land tends to be owned by the whole family although land improvements such as boreholes may be owned individually. On the other hand, areas where cash crop farming and other form of settled cultivation is practiced, individual property rights tend to appear (Aroka 2010).

The study examined water availability changes in Yatta Canal and its impact on livelihoods in Yatta Sub-county. The conceptual framework is adapted from Portier *et al.*, (2010) which is a tool to help better understand interactions between sustainable livelihoods and water availability. The study identified independent variables such as water availability which included; water access, water affordability, water quality and distance and time spent on getting the water (J. K. Cherutich 2012).

Another independent variable is water resources management under which there is training of water technicians, decision making on water uses, gender representation and challenges facing water resources. One more independent variable is socio-economic factors such coping strategies (J. K. Cherutich 2012).

The study also looked at dependent variable which is the sustainable livelihood, under which there is improved health, increased rate of education, enhanced food security and increased income levels. The moderating variables included water laws and policies and cultural factors such as attitude of water drawers (J. K. Cherutich 2012).

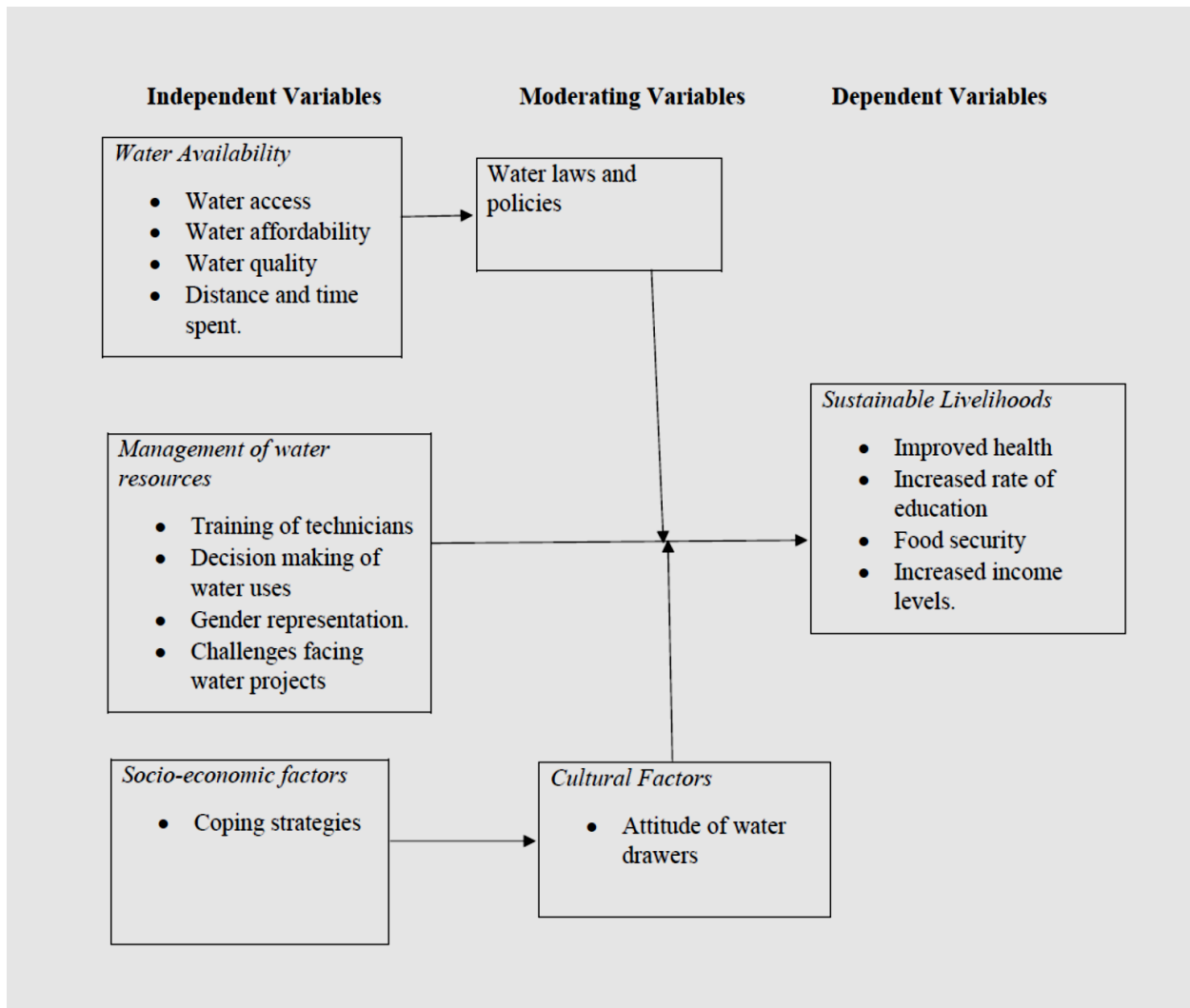


Figure 3: Conceptual framework

Source: J. K. Cherutich (2012).

2.7 Gaps in literature review

There is enough comprehensive literature on the study area, Yatta Canal, especially concerning water availability and its effect on liveability of the residents. Available literature fails to capture the issue of water scarcity and how to address the problem from the locals' perspective. There is minimal information showing factors that could lead to changes in the availability of water in Yatta

canal. The most recent documented literature on water availability on Yatta Canal dates back to January 2017, by *construction review online*, which is still not sufficient enough for decision making. The review states that the canal currently provides 1600 cubic meters of water per day, supplying to about 1070 farmers who use the water to irrigate about 4000 hectares of land.

The researcher aimed to address gaps by providing comprehensive literature derived from the research study. This was achieved by involving the locals during the study by way of interviews and questionnaires. The study also obtained up-to-date information on water demand and uses in Kithimani Ward and provided comprehensive maps of the study area, having the relevant information pertaining to water availability and liveability in Yatta Sub County.

2.7.1 Current and future opportunities of Yatta canal

Yatta canal offers numerous opportunities for locals, mainly in socio-economic sector. Water from the canal is used for irrigation and (apart from food crops) can be used to grow cash crops thus enhancing the economic standard of the locals. Food security can also be improved in future with proper management of the canal, which will ensure that water availability is improved. Yatta canal also presents opportunities in the fisheries sector where locals can rear fish in the canal and on their private lands. This will consequently improve their economic standards and livelihoods as well as ensuring food security.

2.7.2 Current and future threats of Yatta canal

One of the major threats facing Yatta Canal is siltation. This is brought about by erosion of loose soils especially on and near the canal banks. This is caused by over cultivation and encroachment on canal banks. Another threat facing the canal is loss of water through seepage and reshaping of the canal to reach more household farms. The Canal water is also at risk of pollution from surface runoff, carrying farm chemicals, which end up in the canal. Evaporation of canal water is also an issue of concern especially during dry seasons.

2.7.3 Strengths of the Yatta canal

Yatta sub county has three permanent rivers flowing through it i.e. Rivers Athi, Tana and Thika. Water management activities are effectively practiced by the help of the Green Water Credit which is a mechanism created for the farmers upstream. They help farmers with finances to establish programs that help farmers to perform scenarios and cost-benefit analyses by the help of ISRIC World Soil Information as the leading agency. The team is working in Kenya, China, Morocco and Algeria (IFAD, 2012).

2.7.4 Weakness

One major weakness of Yatta canal is poor management of the canal that that has left the canal in a deplorable state where some parts of the Canal banks have fallen off. Poor management has also left the canal to siltation.

Another weakness of the canal is the lack of stakeholder involvement in decision making. When key stakeholder are not involved particularly the users of the water resource, they end up lacking a sense of ownership of the project.

2.8. STUDY AREA

2.8.1 The Study area

The Study area is in Kithimani Ward Yatta sub-county, Machakos County. The county has an estimated population of 1,098,584 (KNBS, 2009). It lies between 01°14'S 37°23'E with an elevation of 1,138 m (3,734 ft) covering area in total of 5,952.9 km². Machakos County borders Nairobi, Kiambu, Embu, Kitui, Makueni, Kajiado, Muranga and Kirinyaga counties. It has a total of 264,500 Households covering an area of 6,208 SQ. KM. Population density is 177 persons per square kilometers (IEBC, 2010) as indicated in figure 6.

Yatta sub-county covers an area of 1,057.30km², with a population of 147,579 and has five wards namely; Ndalani, Matuu, Ikombe, Katangi and *kithimani*. Kithimani has a population of 33,714 people (IEBC, 2010).

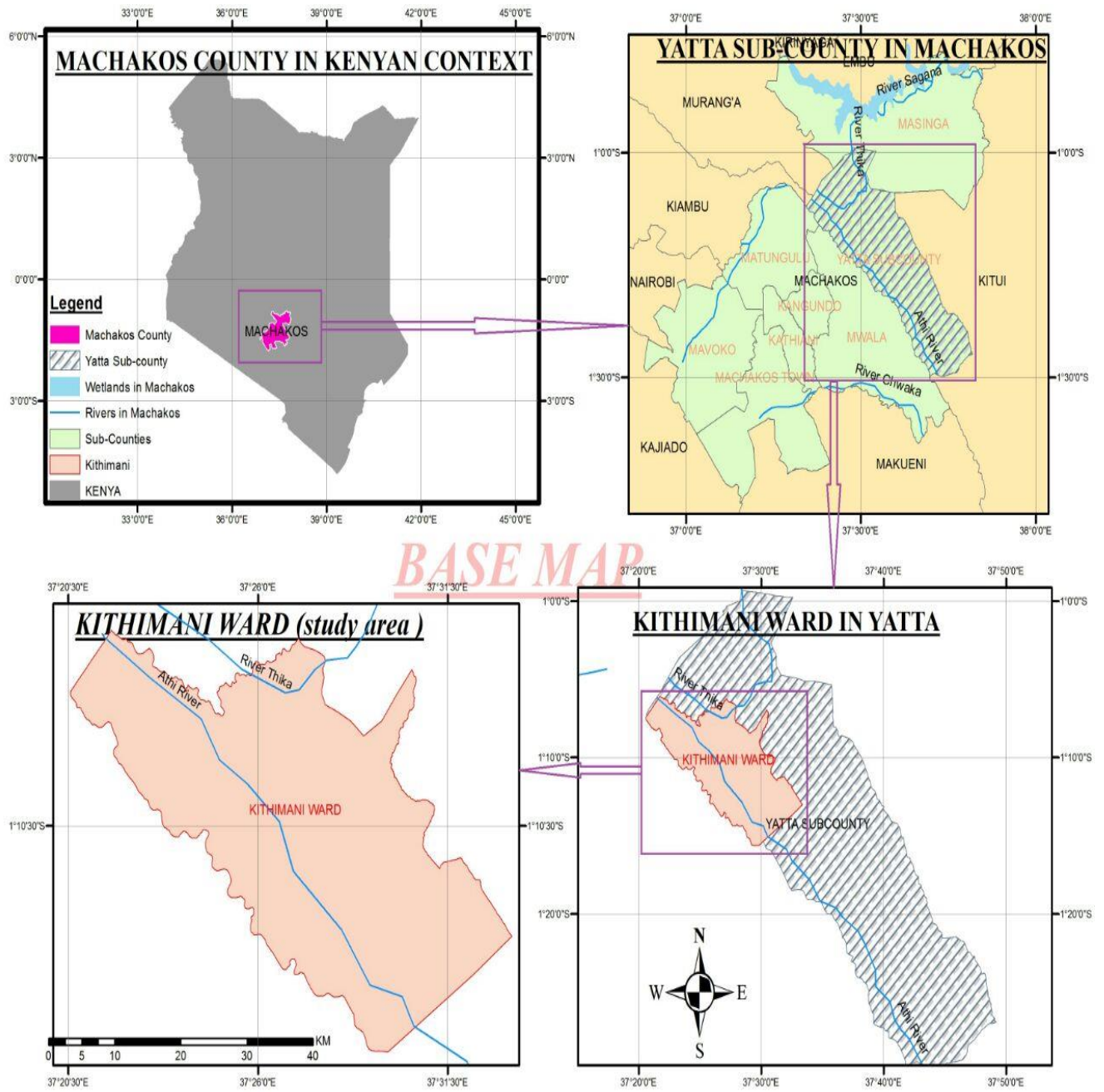


Figure 4: Map of Kithimani Ward – study area

Source: Researcher (2017)

2.8.2 Yatta canal basin

Yatta Canal is 60 km long located between longitudes (0.80 W, 1.270 E) and latitudes (36.660 N, 37.100 S) at an altitude of about 1525 m above sea level in Yatta Sub-county of Machakos County and it covers land area of 1,057 Km² with 147,579 people.

Yatta Canal is situated in Kithimani sub-ward, Yatta Sub County about 100 km from Nairobi along Thika- Garissa road. It supplies water for domestic, livestock and irrigation use. At the border of Kitui and Machakos counties is where the Yatta plateau cuts across to river MwitaSyano of the canal which was a project established in the pre-independence period. This canal is an important and main source of domestic and small-scale irrigation used by the locals (Kioko, T. & Kanyangi, L., 2006). The Yatta farrow whose source is the Thika River is an artificial canal and the only source of surface water for irrigation and domestic use in Yatta. Currently, only 800 ha are supplied with irrigation water against a potential acreage of 2512 ha. (Kioko, T. & Kanyangi L, 2006).

2.8.3 Canal Technical Data

The canal is unlined except for the first 80m up to the washout gate and another 130 m at Mathauta river Bifurcation point. Its length is divided into sections of one kilometer each and named by these distances (the intake is termed kilometer zero- Km 0, canal length at kilometer ten is termed Km 10 while the canal end is termed Km 60) (MWD, 1984). It has auxiliary structures that ensure continuous flow and protect it from excessive siltation. These include 53 No. storm water overpasses, 7 No. road/bridges, 27 No. flumes, 53 km long cut off drains, 1,300 acres of protective terracing on uphill side of the canal and 59 km long access road.

The canal's initial slope from intake to Mathauta River (km49) is 1:2,500 while that from Mathauta River to the end (a distance of 10.5km) is 1:1,000 (MWD, 1989). It was designed to have a flow of 1.13m³/s between the intake and Mathauta River section and 0.283m³/s between Mathauta River and canal end section. Average bottom width is 2m, side slopes are two vertical to one horizontal and mean velocity is 0.45m/s. A controlling device has been constructed to guarantee a flow of 143 l/s into Mwita Syano River (MWD, 1984).

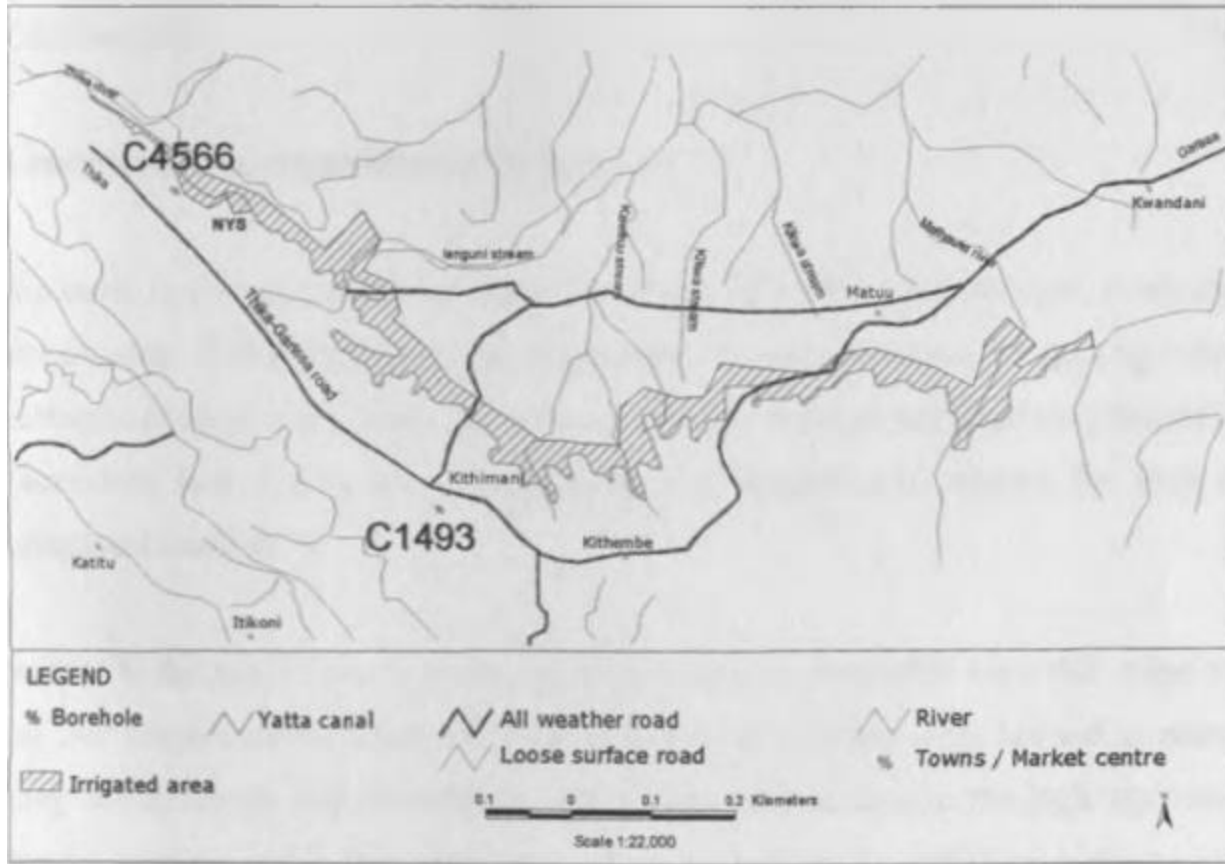


Figure 5 Yatta Canal Basin

Source: Simitu (2007)

2.8.4 Yatta canal climatic and geological characteristics

The climate can be defined as semi-arid with average temperature ranging from 12°C to 25°C. the hottest months being March -October and the coldest being July-August (MWI et al. 2005). There are two distinct rainy seasons. The long rains fall between March and May and the short rains fall between October and December (MPND, 2002) with mean annual rainfall being 650mm (MWI et al, 2005).

2.8.4.1 Regional Geology

The study area is located within the Mozambique belt which lies east of the rift valley in Kenya. This is a broad belt that defines the southern part of the East African Orogen and essentially consists of medium-to-high-grade gneisses and voluminous granitoids. The belt is also composed

of igneous rocks consisting of phonolites and tuff. Paleosands and current sands are also a common feature. It extends south from the Arabian-Nubian shield into southern Ethiopia, Kenya, Somalia, via Tanzania to Malawi and Mozambique and also includes Madagascar (Fairburn W.A, 2006).

2.8.4.2 Local Geology

Locally, the geology of the area can be said to comprise only two of the three major types of rocks (metamorphic, Igneous and sedimentary). The dominant rock type is the metamorphic, which comprises of the mica schist, gneisses and granitoids.

The igneous system is composed of phonolites and tuffs. The tuffs are further classified as lapilli, trachytic or welded tuff. Paleosands, recent sands and kunker limestone are also present as tertiary deposits though limited in occurrence Madagascar (Fairburn W.A, 2006).

2.8.4 Yatta Canal Soils

The main soil types in Yatta are; Acrisols, Luvisols, Ferralsols, Alfisols, Ultisols, Oxisols and Lithisols. Acrisols, classified by FAO is clay rich, have low plant nutrient, excess aluminum and is highly erodible. The soil has fair water retention due to the clay component which leaves most of water closer to surface and prone to evaporation. Luvisols have mixed mineralogy, high plant nutrient and good drainage. Luvisols form on flat or gently sloping landscapes and are nearly devoid of clay and iron bearing minerals. Ferralsols are characterized by yellow and red colors formed as a result of accumulation of oxides, that is, iron and aluminum. Ferralsols have low fertility due to high residual metal oxides and leaching of mineral nutrients. This shows that this soil also has poor water retention which leads to leaching of mineral nutrients. It is also prone to erosion and water evaporation (FAO, 2007).

The study investigated the soil properties to determine their properties with respect to erodability and water retention as these also affect water availability in Yatta Canal. Erodible soils normally results to siltation in the canal thereby reducing water availability in Yatta Canal.

2.8.5 Yatta canal hydrology

Yatta Canal is in Athi River Basin and is fed by one perennial river, Thika River, which a tributary of Tana River. In case of overflow, Yatta Canal flows into River Mwitasyano.

Thika River flows through Kiambu County in central Kenya. The River forms a psychological boundary between the counties of Murang'a and Kiambu. (Simitu, Lawrence Nguniko, 2007).

2.8.6 Yatta canal water quality

Due to agricultural practices, surface runoff that contains agricultural chemicals, normally finds its way into the canal causing eutrophication of the Canal Waters. This affects water quality and thereby causes plants to grow in the canal consequently reducing water in the canal (Manohar *et al.*, 2017).

2.8.7 Yatta canal land use

Most of the land use activities contributing to economic well-being include livestock rearing, bee keeping, poultry and agriculture. Most significant is the use of the canal for horticultural crop production especially the vegetables for sale in the local markets and in Nairobi city. Some vegetables transported to Nairobi for commercial purpose include Kales, Onions, Cabbages, fruits such as avocados, watermelons bananas and oranges. Lands adjacent to the canal have sugarcane grown on them, which is later harvested and sold in local market and at major bus stops along Thika-Garissa highway.

2.8.8 Yatta canal population

The population of Yatta sub-county is approximately 147,579 comprising of an average of 36,895 households distributed within the study area. The population as at the 1999 census was 79,749 people (KFSSG, 2006). The study population was the residents that live along Yatta Canal basin in Yatta Sub-County. High populations with a myriad of uses for water depending on Yatta Canal, the levels of water have reduced, reducing the amounts of water available for Yatta residents. The population on the study area provides market for agricultural products, it also participates in Catchment conservation such as bush clearing and desilting of the canal.

2.8.8.1 Current population, water trends and availability on Yatta Canal.

Before the rehabilitation of the canal the maximum abstraction was 1.13m³/s which increased after rehabilitation up to 3m³/s, discharging up to 3000m³/day and irrigating up to 80% of arable land along the canal.

Below are the Yatta Canal populations according to 2009 Census and 2017 population according to geometric population growth.

i.e. $P_t = P_o(1+r)^t$ Equation 1

Where P_t is population after time t and P_o is the current population. Population growth rate is 2.6% according to World Bank (2016), and the data used is for 8 years from i.e. from 2009 to 2017.

Table 1: 2.1 populations along Yatta Canal

<i>Location</i>	<i>2009 population P_o</i>	<i>Current population (2017) P_t</i>
Mavoloni	16,272	19,990
Ndalani	21,648	26,583
Kithimani	33,714	41,399

Matuu	27,145	33,333
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Assuming that other factors such as deaths, births and migration remain constant, Kithimani alone has experienced an increase in population of approximately 8,685 people. This is an additional demand on water from the canal that eventually reduces the water from the canal.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter sought to meet the objectives laid out in the study by formulating working strategies. This section thus outlines the various methods used in data gathering, data sources and the analysis methods. Data selected for this study was dictated by the research problem at hand and the analysis of the data was meant to address the research problem and meet the study objectives. ANOVA was to provide a statistical test as to whether the population mean scores of various groups are equal and to generalize the *t*-test of the study groups. One-way ANOVA was used to compare the mean score between groups. The study was basically used to test the null hypothesis. ANOVA was to test the assumptions of the research and determine whether the data collected and cleaned meets or violates the assumptions.

3.1 Research design and data collection

The study aimed to focus on the issues affecting water availability changes in the Yatta Canal, taking into consideration current management of available water resources in relation to the living standards of the Yatta community. The study thus aimed at answering the research question, confirm or disapprove research hypothesis and more importantly to meet the objectives of the study, which is to understand water availability changes in Yatta Canal and its impacts on livelihoods. The study therefore employed various methods of data collection that aimed at understanding the preferences of the study population, collecting qualitative and quantitative data which was analyzed and interpreted to achieve the study objectives.

3.2 Target population

In this study, target population refers to the collection of individuals, within Yatta Sub County geographical boundary, and is bound by the same problem of poor access to reliable and safe drinking water.

The study was done in Kithimani sub-ward (an area of 196.90km²) that has a population of about 33,714 people according to 2009 censuses and an average of 36,895 households. The study sought also to interrogate sub county administrators and officials in charge of agriculture, water and sanitation in the sub county. Other key informants are NEMA and WRMA officials at the regional level. These were interrogated in order to ascertain the populations served by these organizations and how water availability changes affect their livelihood.

3.3 Sampling strategy

According to William M.K, (2006) the technique of sampling used usually depends on the type of analysis being done.

The study used the stratified sampling method whereby the researcher divided the study population into two strata (groups). Each stratum i.e. the males and females, was then interrogated separately to get their individual perspectives with respect to water use and how they are affected by changes in water availability in Yatta canal. Each stratum responded to 50% of the questionnaires.

The study then used random sampling on each of the stratum, where a sample is obtained by selecting one unit on a random basis and choosing additional units at evenly spaced intervals until the desired number of units is obtained within each of the stratum. The reason for using this sampling method was to avoid bias and achieve accurate representation of the study population.

Using equation 1 indicating Nasuirma model a sample size of 100 was obtained. The sample was divided into two, where each stratum responded to 50 questionnaires as discussed above.

The sample size is obtained using *Nasuirma model*;

$$n = \{NC_v^2\} / \{C_v^2 + (N-1)0.05\}^2 \dots \dots \dots \text{Equation 2}$$

Where N is the target population, which is 33714 (Census 2009)

C_v is the coefficient of variation, which is 0.5

e is tolerance at desired level of confidence, which is 0.05

Therefore $n = \{33714(0.5)^2/0.5^2 + (33714 - 1)0.05\}^2$

$n = 99.70$ approx. 90

3.4 Nature and sources of data collection

Both primary and secondary data was relied on while conducting this study. Primary data was collected from the source, area of study, while secondary data was from available published material on the subject matter.

The quantitative data was collected using structured data collection instruments that can fit diverse experiences into predetermined response categories, for testing of the study hypotheses. This data was collected using observation for instance the number of females fetching water and the quantity they carry. The researcher collected this data via in-depth interviews, document review, and observation methods.

3.4.1 Primary data

Primary data for this research was collected through household survey. The surveys took face-to-face questionnaire interviews supplemented by focus group discussions in line with the participatory methodology. The participatory approach aimed to change externally imposed standards and get rural people themselves to participate in decisions and procedure that affect their lives, as well as to determine aspects of poverty and livelihood from their perspective.

The questionnaires were administered randomly to males and females, specifically to the male household head and another for their spouses of the household heads. The reason for administering the questionnaires to the two groups was to eliminate male bias in responses, and also provide gender-specific perspectives on issues related to domestic water use in rural communities.

The questionnaire had six parts:

1. Household characteristics, such as household size, educational levels
2. Socioeconomic factors such as income, household asset domestic time budgets, intra-household expenditures.
3. Information on water availability, water use pattern and water quality.
4. Sanitary information, availability of sanitary facilities, the nature of the sanitary facilities, and the feminine and other vulnerable group access to sanitary facilities.
5. Agricultural water use, farming pattern, livestock keeping and fisheries.
6. Non-agricultural livelihood practices.

The questionnaires given to women are similar to that for men. This helped in providing a gender perspective to the survey. Where there were inconsistencies or other issues that needed clarification, the structured questionnaire were supplemented with informal discussion to clarify such issues.

Qualitative data such as family sizes which informed the demand of water on Yatta Canal. Data on household income was also collected in connection to water availability, that is, how water availability affects family incomes. Quantitative data such as water quality and sanitation conditions along the canal was also collected in a bid understand how quality of livelihood is affected by water availability changes.

3.4.2 Secondary Data

Secondary data was sourced from regional official agencies such as NEMA and WRMA on rural water supply and state of available water resources. The health conditions in terms of, morbidity and mortality was collected from health posts and health centers in the concerned rural communities, where possible. The study was interested in water-mortality relationship and thus sought specific information as to the cause of deaths. Moreover, information on school attendance

was obtained by interrogating parents at household level. Demographic data was collected from KNBS.

There are also special national policy documents available on the subject matter such as National Spatial Plan, Kenya Vision 2030, National Environmental Action Plan Framework (2009), Kenya National Environmental Policy (2013) and National Land use Policy.

3.5 Data Collection techniques

These are the various methods that were employed to collect data for purposes of study. They included all methods used for both primary and secondary data. The choice of method is influenced by the data collection strategy, the type of variable, the accuracy required, the collection point and the skill of the enumerator. Links between a variable, its source and practical methods for its collection can help in choosing appropriate methods. The main data collection methods used were:

3.5.1 Questionnaire

Qualitative and quantitative data water availability, usage, affordability and quality. Also information on how different genders are affected by change in water availability in Yatta Canal. In this case the enumerators posed questions directly in form of forms filled in by respondents alone. Questionnaires were handed out later collected. In some cases, the enumerators assisted the respondents in answering the questions and the left with the filled questionnaires.

3.5.2 Direct Observation

This included observing activities, people and situations so as to gauge the general trend in the study area as far as water management, supply and usage is concerned. In this case the researcher observed several aspects including the conditions of the canal.

3.5.3 Interviews

In interviews information is obtained through inquiry and recorded by enumerators. In open interviews notes were taken while talking with respondents. The notes were subsequently structured (interpreted) for further analysis. In the open-ended interviews, which needed to be

interpreted and analysed even during the interview, the interview were conducted by competent enumerators. These were used to collect data on water availability, usage, affordability and quality.

3.5.4 Photography

This technique helped to capture visual data on the activities around Yatta Canal. Information collected by photography also helped understand some aspect about the study like the people fetching water, water usage and water management among others.

3.5.5. Ethical considerations

Approval to conduct the study was sought from the University of Nairobi, the National Commission for Science technology and Innovation and authorities at Yatta Canal. Individual consent was sought from each respondent before participating in the research.

3.6 Data presentation and analysis

In this subsection, various methods of data analysis and presentation used in the research are discussed. Data scientifically collected are subjected to scientific analysis in a bid to achieve the objectives of the study and to test study hypotheses.

3.6.1 Methods of presentation and data analysis.

The data obtained from the survey was subjected to both descriptive and analytical statistics. Bar and pie charts were used to present the results, whereas t-test was used to test if significant difference exists between mean values of the males and female respondents. The purpose of using ANOVA was to test the assumptions of the research, that is the null and alternative hypotheses, and determine whether the data collected and cleaned meets or violates the assumptions. One-way ANOVA compares the mean scores between the groups under study and helps determine whether any of those mean scores are significantly different from each other. Specifically, it tests the null hypothesis:

$$H_0: \mu_1 = \mu_2 = \mu_3 = \dots = \mu_k \dots\dots\dots\text{Equation 3}$$

Where μ = group mean and k = number of groups. If, however, the one-way ANOVA returns a statistically significant result, we accept the alternative hypothesis (H_A), which is that there are at least two group means that are statistically significantly different from each other.

The Regression equation was modeled as follows;

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where

Y = Livelihood

X_1 = Farm size

X_2 = Proximity to canal

X_3 = Farming type

X_4 = Irrigation methods

B_1 , B_2 , B_3 and B_4 are the regression coefficients for each Independent variable

ε = Error term

Correlation analysis was done so as to establish a causal link between water access and rural livelihoods strategies. In all the analysis planned, Microsoft SPSS version 15.0 was used as software tool.

3.6.2 Purpose of data analysis.

Quantitative and qualitative data collected was inspected, cleansed, transformed and modeled with the main aim being to discover any useful information, suggest conclusions and make recommendations. In this study, the analysis was also done to test the research hypotheses as well as answer the research questions. The results of this analysis were represented in form of tables, charts and graphs for a clear understanding of the effect of water availability changes in Yatta Canal on the livelihoods of the community.

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION

4.0 Introduction

In this chapter, the study gives a presentation of results derived from field data analysis in an exhaustive manner. The presentation of data follows a stepwise approach dictated by the objectives of the study. As such, this section shall show the relationship between water availability and livelihoods by looking at various aspects of livelihoods such as farming, agri-business, water usage, income levels among others. The chapter gives the demographic representation of the community, analysis of water usage which includes farm sizes, proximity to the canal, farming type and irrigation methods. Finally the chapter looks at the public participation in Yatta Canal water management and how it affects water availability.

4.1 Demographic Analysis

All information regarding age, sex, marital status, the level of education and area of residence were captured in the demographic survey of the study area. The survey was done in the entire area and the sample size was 90 respondents. Those interviewed were either household heads, any adults found within a homestead or individuals working in farms along the canal.

4.1.1 Respondent's Gender

The study on gender aimed at ascertaining gender specific perspective when it comes to water availability changes in Yatta Canal and its effect on livelihoods. Members of the public specifically along the canal were interviewed by way of administering questionnaires. Those interviewed included 40% female and 60% male respondents as shown in figure 5.

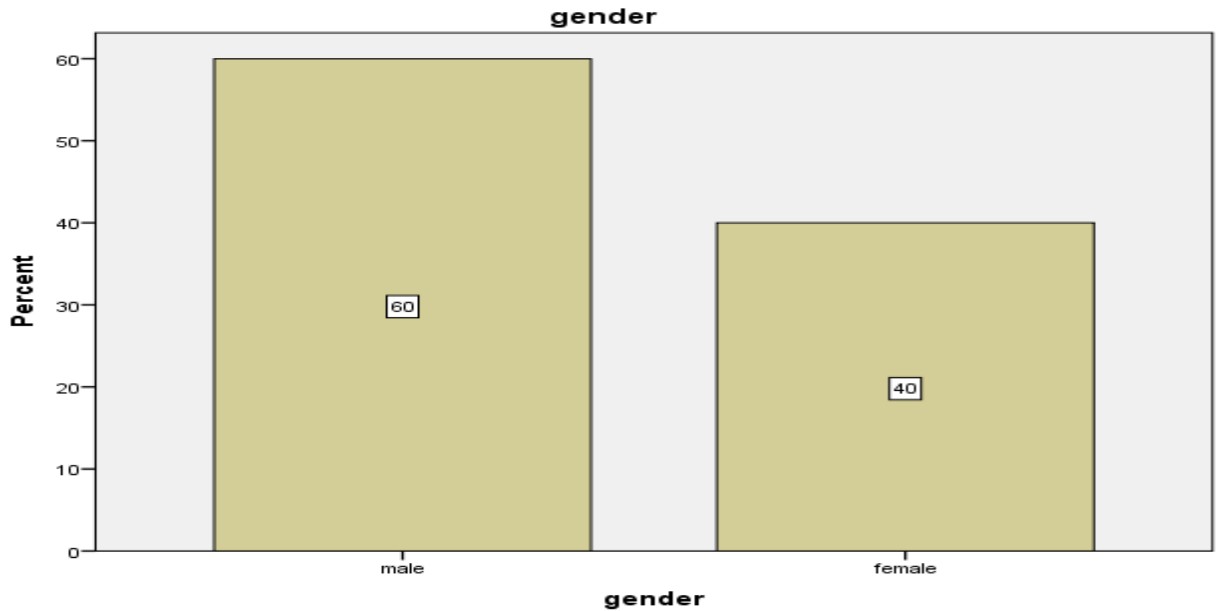


Figure 6: Respondents by gender

Source: Field data (2017)

Gender analysis focused on the perspective of both genders with respect to water availability changes in Yatta Canal and its impact on livelihoods, as both genders are affected differently by water shortage. The readiness of males to respond and participate in the exercise informed why gender participation in management of water resources is skewed towards men. The analysed results indicate more males were interviewed compared to females represented as 60% and 40% respectively. This also implies that more men are engaged in more activities within the canal doing irrigation farming as a form of livelihood as opposed to the female gender.

4.1.2 Respondent's Age

From the findings shown in figure 6, the population around Yatta canal is mainly made of individuals who fall under the youth bracket that is between 18 – 30 and 30 – 40 years of age. This age group constituted most of the respondents as they were the ones working in the farms or doing the casual labour along the canal. It is generally considered that the youth are energetic and as such Yatta ward is endowed with labour that can be used to improve the livelihoods of the community. Also, the availability of labour to work in the farms along the canal puts a high demand on water

from the canal to be used for agricultural production and as a result negatively affecting the water availability in the canal. With minimal or no water in the canal the farming is hampered and so is the jobs and livelihoods of those dependent on farming.

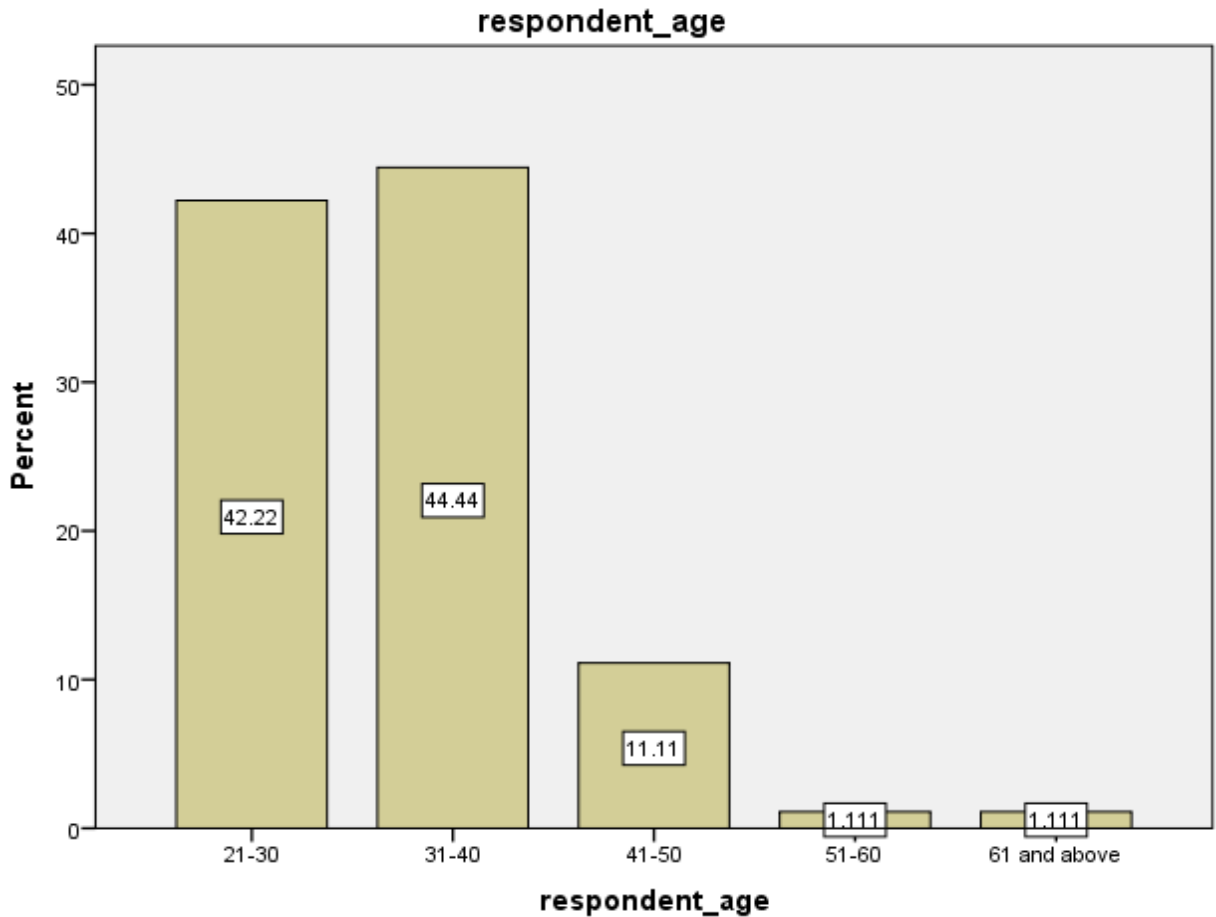


Figure 7: Age classification of Kithimani, Yatta Sub County in Percentage

Source: Field data (2017)

4.1.3 Family Size

The survey on family size shows that most families usually comprise of 2 – 4 members representing a 66% of the respondents. The 5 – 7 family size brackets comprised of 33% of the respondents while 1% of the respondents comprised of individuals staying alone per household, i.e. no family, as shown in figure 7.

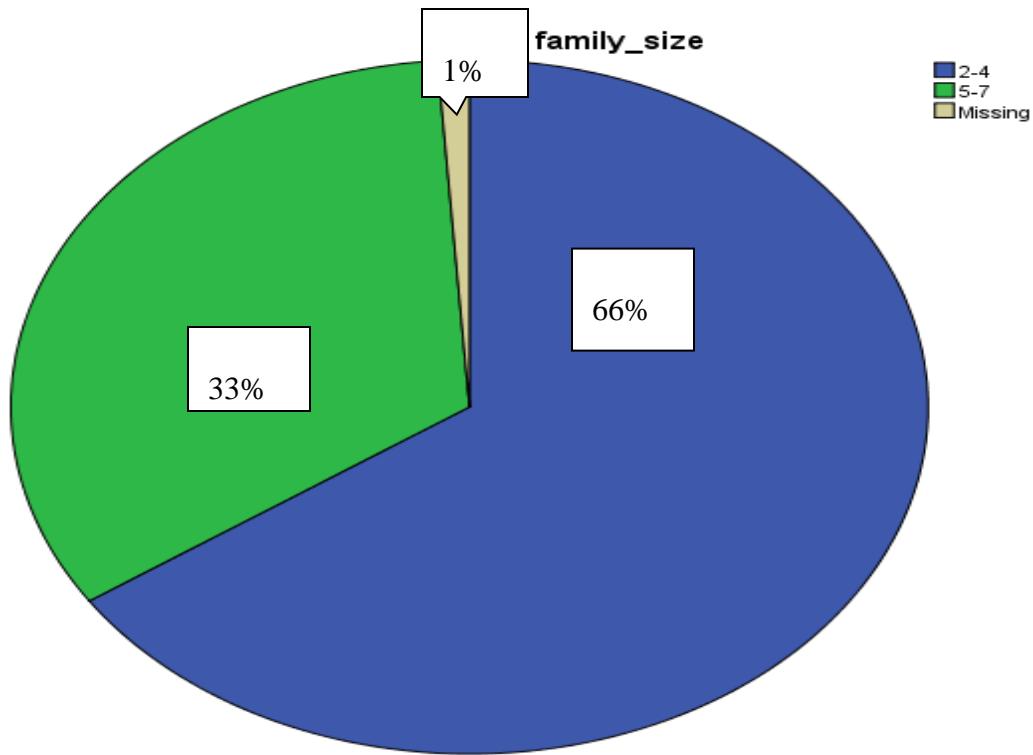


Figure 8: Family sizes pie chart

Source:Field data (2017)

Family sizes often translate to an increased demand in water. Bigger families often need more water for domestic purposes as was observed as the case with 2 – 5 and 5 – 7 family household sizes. Smaller family households of 1- person household required lesser water thus a lower demand for water from the canal.

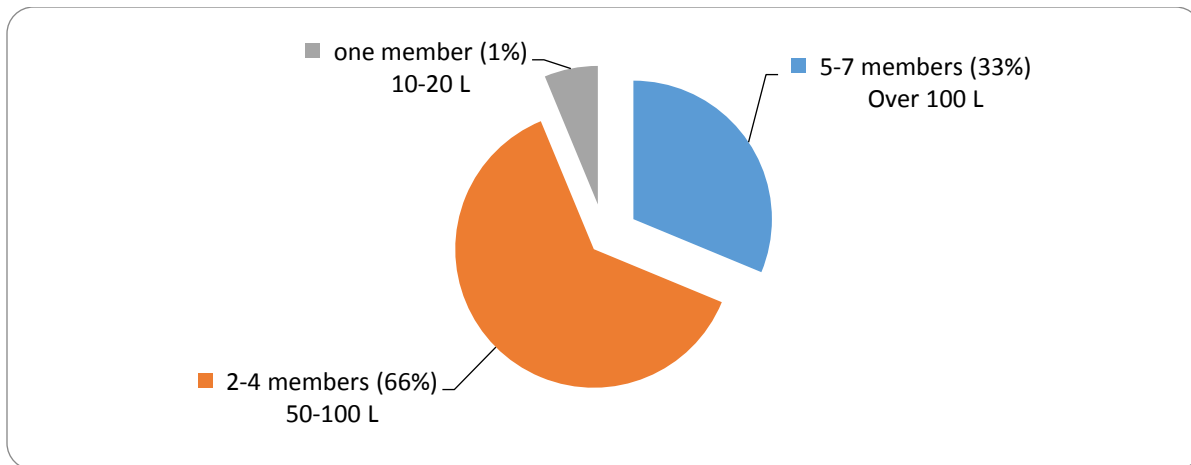


Figure 9: Family sizes and water consumption pie chart

Source: Field data (2017)

4.1.4 Occupation

As shown in figure 9, a bigger proportion of the residents of Yatta ward are in the informal sector, i.e. they do not work for a structured salary. Most of them are unskilled, casual laborers working on farms for a pay, work on own farms as subsistence or commercial farmers and *bodaboda* riders who double up as commercial or subsistence farmers. Of the respondents 71.11% fell into this category. 16.67 % of study population fell under the formal work force. These include teachers, secretaries and other workers from the government and private sector. 12.22% of the study population are involved both in the formal and informal sector, that is, in addition to their formal work, they are engaged in farming, mostly for commercial purposes. This means that a greater portion of the Yatta work force is dependent on Yatta Canal water for their source of income, which is agriculture. Much of the agricultural activity practiced along the canal is horticultural farming of high value crops such as maize, beans, millet, sorghum, cassava, mango, water melon, French beans, banana and tomato, which are sold to the local and nearby markets in Nairobi or exported to other countries. As such neglecting their plight with respect to water availability will be neglecting their livelihoods.

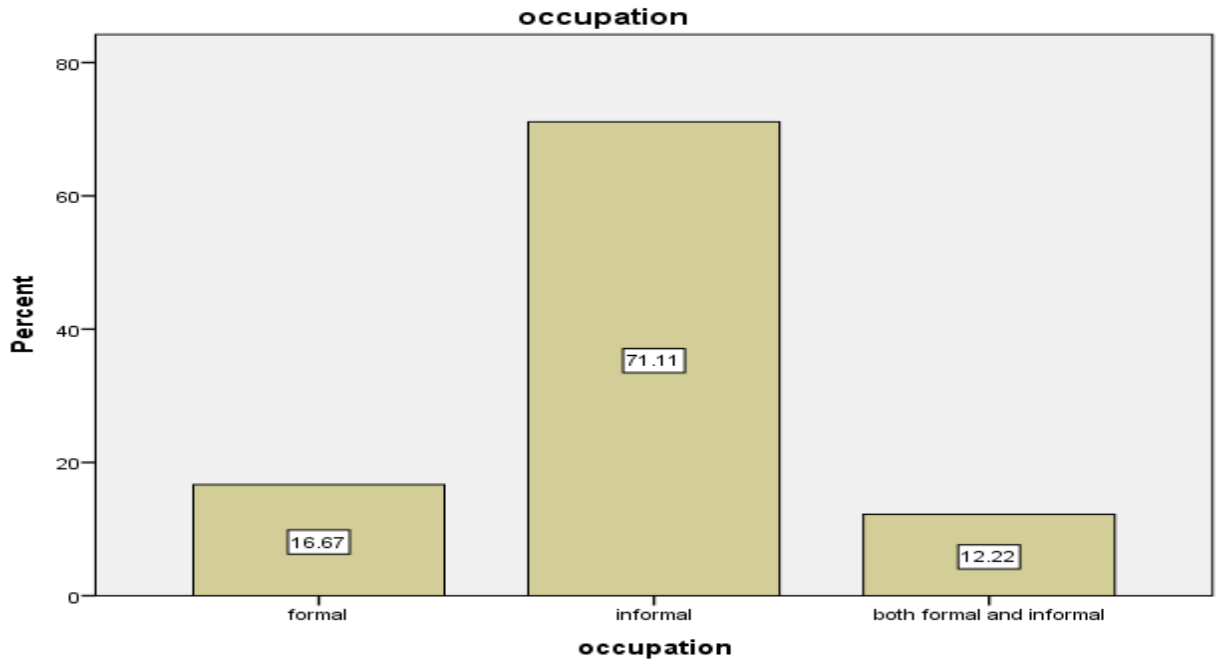


Figure 10: Respondents Occupation

Source: Field data (2017)

4.1.5 Education

In the study, 10.11% of the respondents had received only primary school level of education. Those at colleges/University represented just 12.36% of the total respondents interviewed. 25.86% had some form of specialized training in a tertiary institution, 51.69% indicated that majority of the respondents had education up to the secondary level and higher as indicated in Figure 10.

According to the study, most households had between 1 – 5 children in primary school. All the households interviewed had 120 students in primary school level. The households with children in secondary schools were only 8 with between 1-2 children in school. Those with children in colleges/University were only 2. These were interpreted to show that most residents find education past secondary school as way too expensive, especially for those in the lower income bracket. For most families, students who don't attain direct entry into a tertiary institution end up doing casual jobs around the canal to contribute to family income. The availability of casual labor along the

canal and daily cash earnings might be the key factor that contributes to low levels of education in the sub-county and by extension the study area.

As such low educational levels recorded, informed the substandard agricultural and irrigation systems witnessed in Yatta Canal (such a furrow irrigation) that end up using a lot of water from the canal. When there is water shortage in an area, much time that could be spent seeking education is spent looking for water thus affecting education levels and subsequently livelihoods of the community.

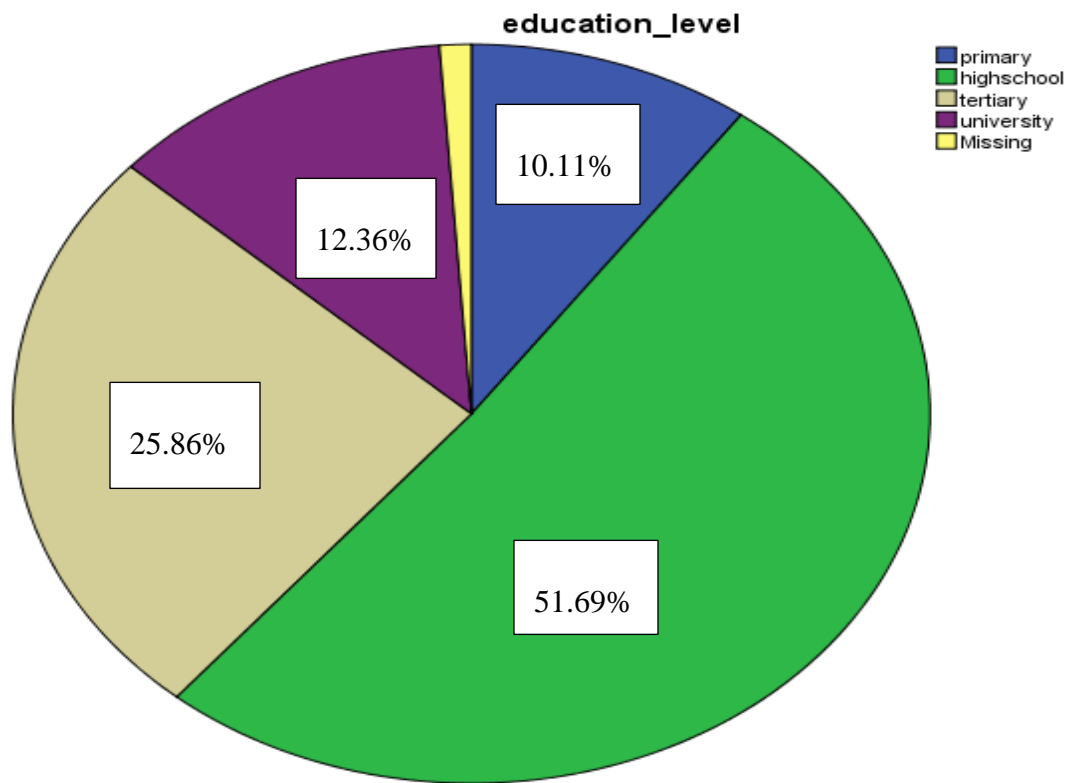


Figure 11: Education Level

Source: Field data(2017)

4.1.6 Income levels

As depicted in figure 11, the study revealed that 38.89% of the respondents earned between 15,000 to 30,000 shillings monthly. The next biggest bracket of earners, earn even lower amounts of up to a maximum of 15,000 shillings per month. It is worthy to note that these are the casual laborers

or small scale farmers whose income depends on either their day's work or the agricultural outputs sold in the markets.

There's a sharp decline on the number of respondents as the amount of monthly pay increases. These few top earners belong to the formal sector and sometimes double up as commercial farmers. Those earning between Ksh 0 to 30,000 have to squeeze in all their household needs, such as education, food, health, cloths among others into this income. Thus, proper supply of water to farms will ensure that there is enough agricultural produce that can be sold hence improving the income level of the Yatta Canal residents as well as their livelihoods.

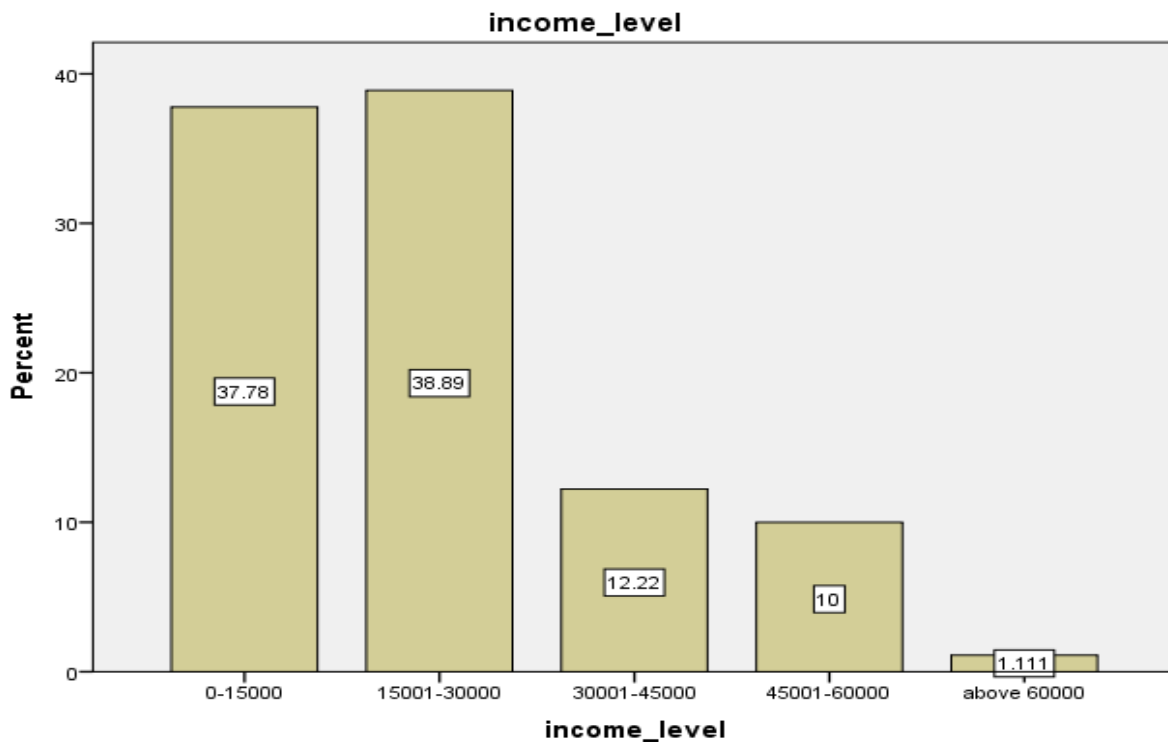


Figure 12: Income Level

Source: Field data (2017)

4.2 Water usage

The study sought to establish the water usage patterns in Yatta ward and how these patterns affect water availability in Yatta canal by analyzing water usage in amounts from different water sources around the canal. These patterns/factors included proximity of farms to the canal, farm sizes,

amount of water usage per day, irrigation types, and prevalent water use, farming type and presence of water storage facilities.

These parameters directly affect water availability in Yatta canal by informing the demand for water. The more the demand the lesser the water available in the canal especially as one moves down stream. Also these parameters affect water availability by affecting the quality of the water available. Activities so close to the canal expose the canal to degradation such as siltation and other forms of pollution. This in turn affects the livelihoods of the community as less water is available for the various uses and the community is also exposed to waterborne diseases due to use of the low quality water.

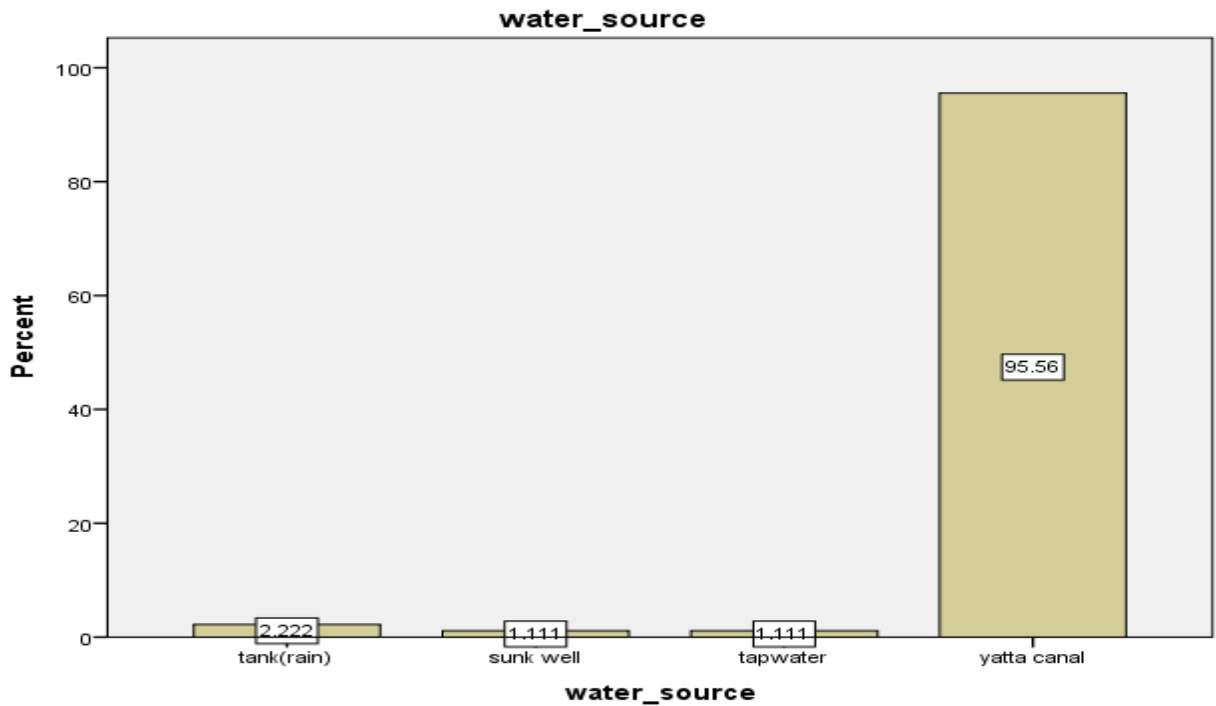


Figure 13: Prevalent water sources

Source: Field data (2017)

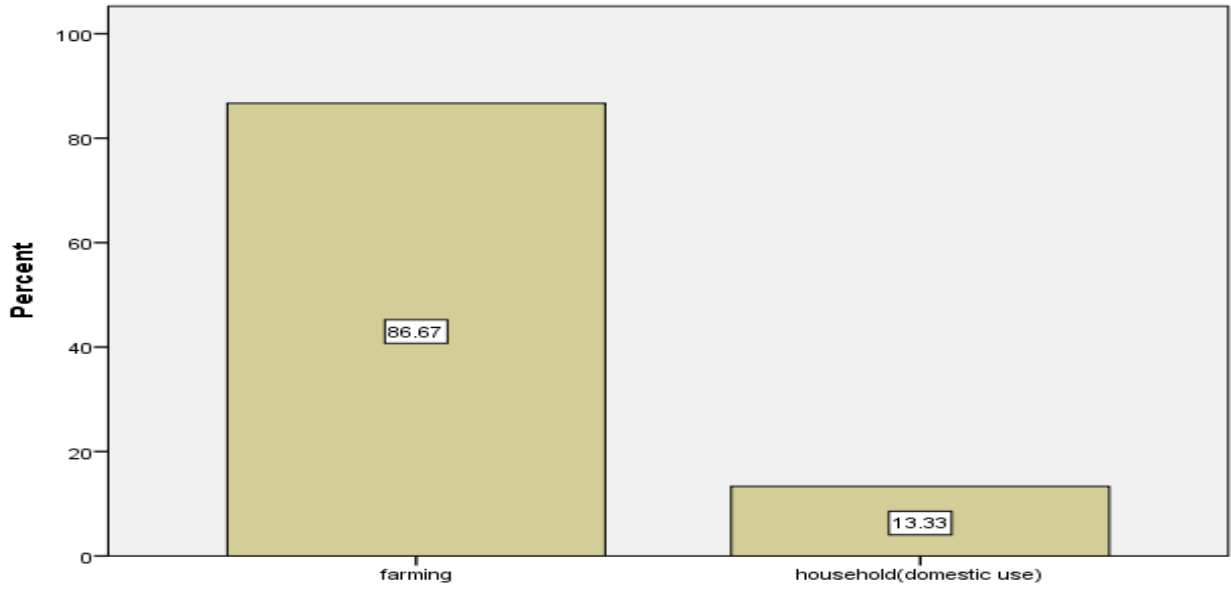


Figure 14: Prevalent water uses

Source: Field data (2017)

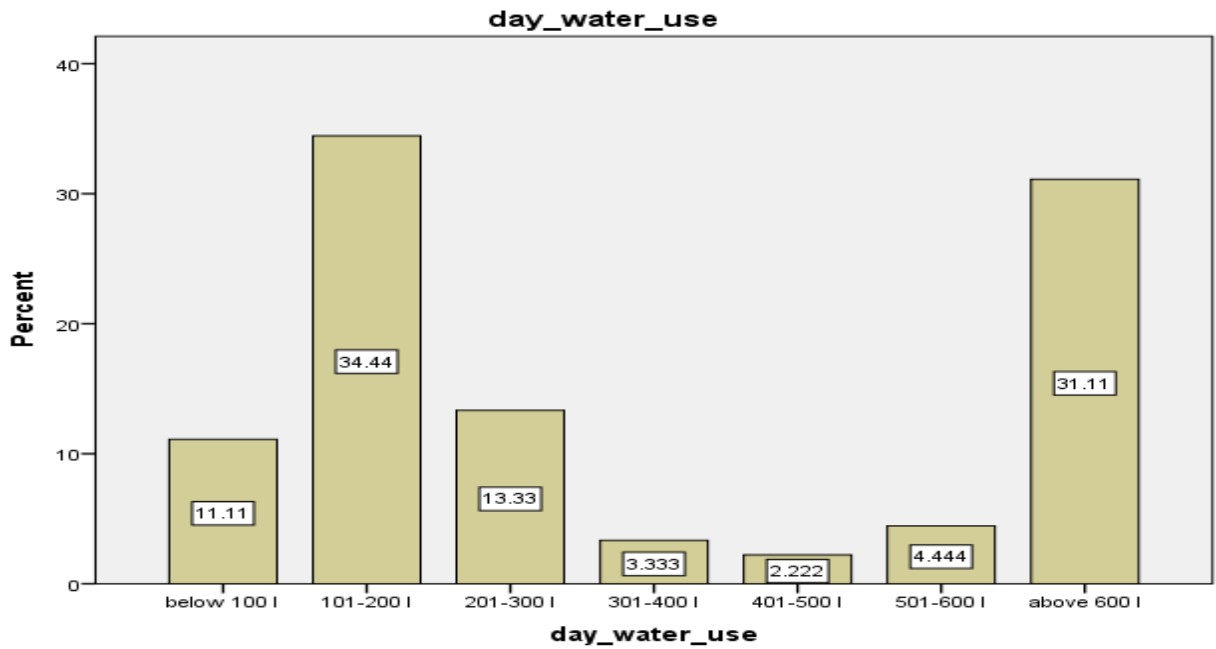


Figure 15: Daily water usage in litres

Source: Field data (2017)

The study found that the residents heavily depend on the canal for their day to day activities. Majority of water needs which is equivalent to 95.56%, is met by the canal while the remaining needs are catered for by water stored in tanks from rain water harvesting, sunk shallow wells and tap water representing, 2.22%, 1.11% and 1.11% respectively, as shown in figure 12. Most of the water is used for farming, 86.68%, while only 13.33% of the water is used for domestic purposes, as shown in figure 13. Figure 14 shows that 31.11% of population used above 600 liters per day for farming and domestic purposes. The high dependence on water from Yatta canal puts a strain on the canal thereby reducing the amount of water available. This is especially so as most of the water is used for farming thus the amount of water reduces as it flows downstream.

4.2.1 Farm sizes

Farm sizes determine the amount of water needed to practice productive agriculture. Bigger farms have a capacity for bigger agricultural productivity hence larger amounts of water needed for these agricultural activities. This in turn puts a lot of strain on the water supply from the canal. Much water is used to irrigate farms, especially those in the up-stream reaches or the headwaters. As a result those farms downstream suffer intermittent water supply shortages. During dry seasons agricultural production is hampered especially for irrigation farm dependent residents. Figure 15 shows the highest farm ownership (28.89%) is between 0.8-1.5 hectares of land. Farm sizes between 1.5 and 2 Hectares accounted for about 19% and those above 2 hectares accounted to 14.44% ownership. The owners of these farms practice large scale commercial farming, growing tomatoes, french peas, fruits among others, which are sold in regional and international markets. However these farms draw a lot of water from the canal and as well as exposing the canal to pollution, for those close to the canal, in case of surface runoff.

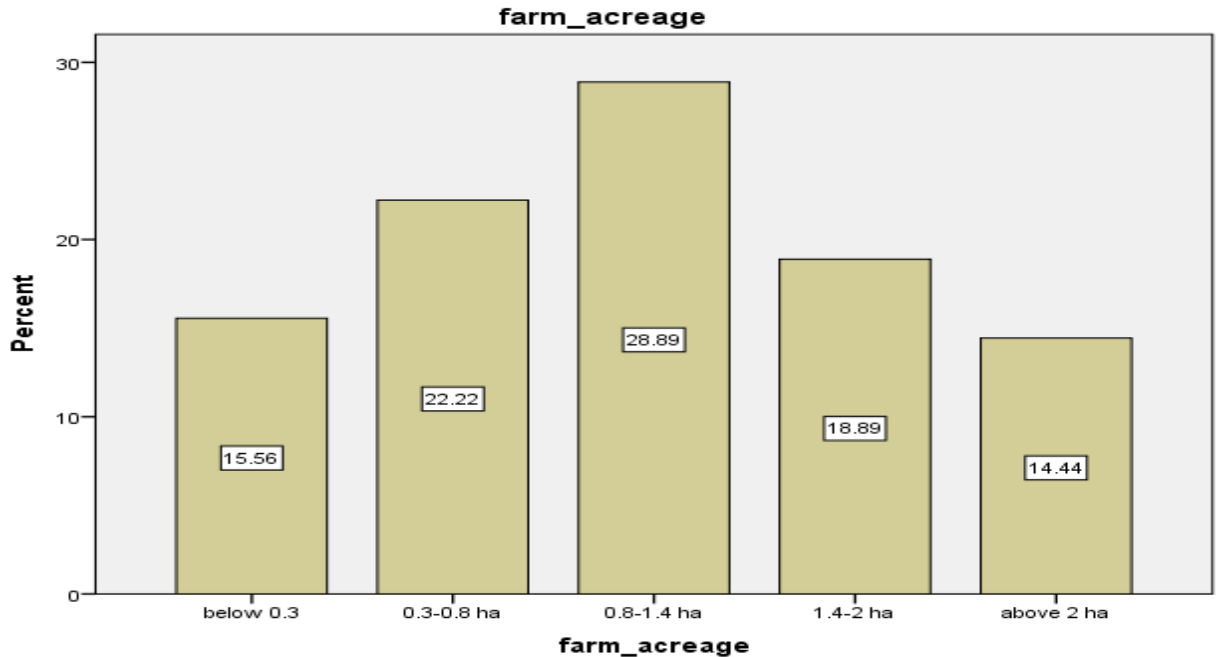


Figure 16: Farm sizes

Source: Field data (2017)

4.2.2 Proximity to the canal

Proximity to the canal affects water availability in the canal in terms of how much is channeled into the nearby farms as the closer the farm to the canal the lesser the amount of investments in water storage facilities and the more water drawn directly from the canal. Farm owners closer to the canal have simply dug out outlet farrows along the canal into their farms as shown in figure 16. These outlets are rarely closed hence little water is left to continue downstream. This has an effect of reducing the water available in the canal especially for people downstream, who complained of barely getting any water. Reduced water amounts affect the livelihoods of the farmers farming downstream. This is particularly acute during dry seasons as farms dependent on the canal remain uncultivated.



Figure 17: Water diversions along the canal

Source: Field data(2017)

Farms closer to the canal also expose the canal to the dangers of water pollution and siltation. In case of rains, the canal is exposed and as a result all the surface runoff carries all the debris into the canal. This affects the canal as more the debris are in the canal, the lesser the water available the more impacts felt due to water related problems. Figure 17 demonstrates how the canal is prone to siltation due to overland runoff and soil erosion.



Figure 18: Siltation in the canal

Source: Field data (2017)

4.2.3 Farming type.

The study established that a greater proportion of the population which is up to 57.78% engages in commercial farming as compared to 42.22% of the population who practice subsistence farming, as shown in figure 18. Even though the latter sells some of their farm produce, most of their agricultural outputs are for consumption by the family. The commercial farmers on the other hand engage in large scale farming for the purposes of selling most of their farm products. Commercial farmers have as a result invested heavily on irrigation and water storage facilities. Commercial farming thus puts a greater demand for water on the canal and therefore reducing the amount of water as it flows downstream. This affects the livelihoods of the farmers downstream since they can't get enough water for their agricultural activities. Water availability thus affects the livelihoods of the residents of the Yatta canal by affecting agricultural output for both subsistence and commercial farmers. Low supply of water negatively affects farm produce outputs hence commercial farmers don't have enough to sell to cater for their household needs.

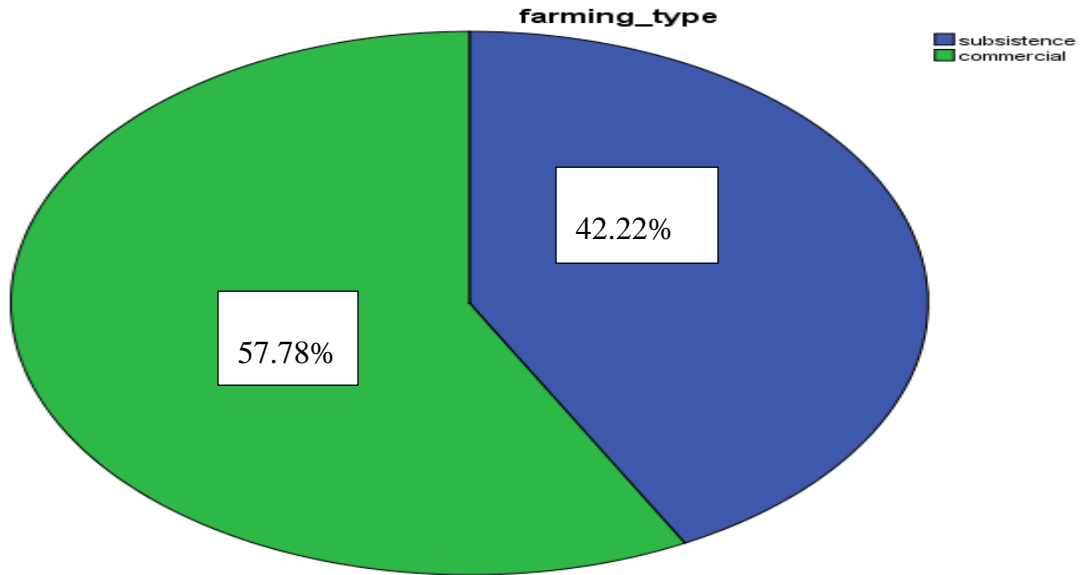


Figure 19: Farming type

Source: Field data (2017)

4.2.4 Irrigation methods

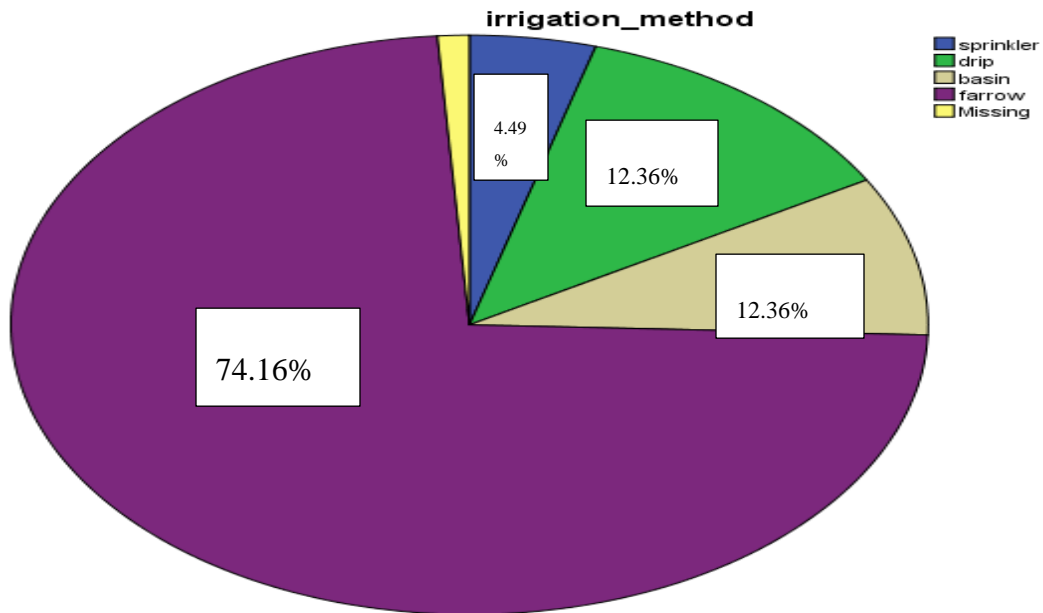


Figure 20: Irrigation methods

Source: Field data (2017)

As shown in figure 19, the study established that the most practiced form of irrigation, up to 74.16%, is farrow irrigation, especially on the lower side of the canal, with minimal to zero mechanization as they take advantage of gravity. This is done by digging out diversions along the canal. Farrow irrigation uses a lot of water as compared to other forms of irrigation and does not encourage storage of water for future irrigation. The next practiced form of irrigation is drip irrigation, at 12.36%, practiced mostly by commercial farmers. Other forms of irrigation are basin irrigation at 8.99% and sprinkler irrigation practiced by 4.49% of the population. The study found out that the form of irrigation practiced and water storage is determined by proximity to the canal, on which side of the canal the farm lies and the water levels in the canal. In addition, the form of irrigation affects water availability as much water is diverted from the canal such that very little quantities reach users downstream and some users along the canal don't even get the water. This has a potential of causing conflicts in the water usage between the upstream and downstream users which calls for proper management and regulation in the water use along the canal.



Figure 21: Drip irrigation

Source: Field data (2017)



Figure 22: Storage and irrigation facilities

Source: Field data (2017)

The study found that only 37.78% of the population have some form of water storage while a bigger majority 62.22%, as shown in figure 22, do not have any and depend wholly on the canal for their daily water usage. Most of these that don't have water storage tanks live close to the canal and draw their water directly from the canal for as long as the water keeps flowing.

The implication of this is overdependence on the canal for daily water use thus negatively affecting water availability in the canal. In cases of lack of water flow in the canal, agricultural productivity is hampered and thus negatively affecting the livelihoods of these farmers. The 37.78% that have storage facilities however do not need to solely depend on the canal as they can pipe or store water from other sources such as rain water. This clearly does demonstrate the significance of water storage and sustainability of agricultural productivity without relying on water from the canal. The farmers need further training on the best irrigation practices to avoid water wastage from the canal hence reducing water availability.

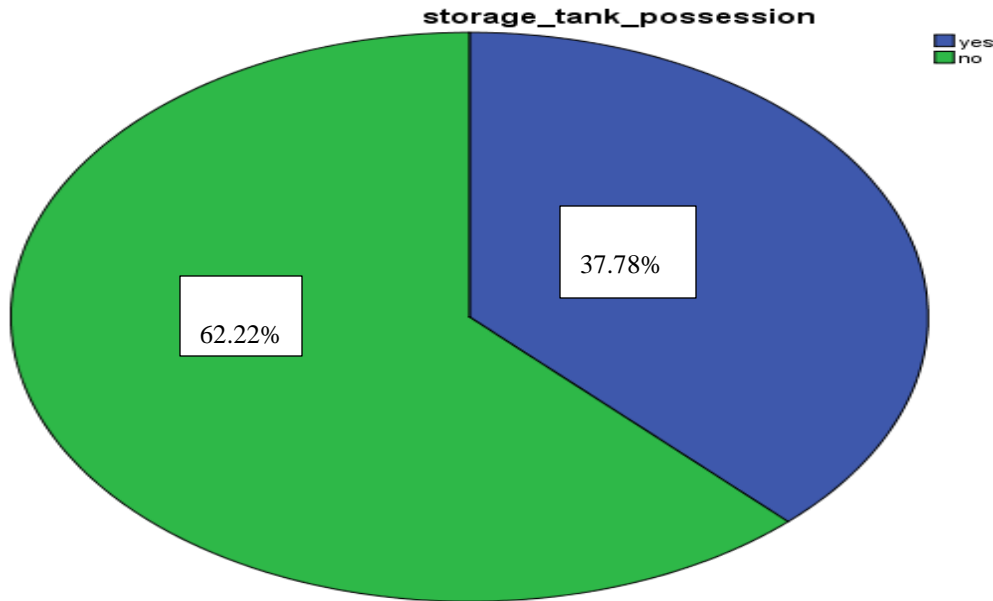


Figure 23: Storage tank possession

Source: Field data (2017)

4.3 Public Participation

Public participation is paramount in water resource management and the provision of water services. It is a constitutional requirement that any development affecting a community in any way, the said community has to be involved in the development from the planning to implementation and management of the development (Kenya Constitution, 2010).

As indicated in figure 23, the study revealed that the level of public participation in the Yatta ward as far as water resources management is concerned is low. Most of the respondents, 55.56%, reiterated that indeed public participation is very low especially with respect to management of Yatta canal. They feel that they are left at the mercy of top management and large scale commercial farmers who have farms upstream. The interviewed respondents were of the opinion that water developments are rarely advertised. But it is worth to note that even though there might be advertisements, they are not effective enough to reach the intended audience thus the feeling of poor public participation. However 44.44% of the population interviewed said that water development projects are normally advertised, especially on print media. The drawback with this

mode of advertisement, however, is only those who can read and/access a newspaper get to know of any upcoming development.

Lack of participatory approach in management of Yatta Canal not only impedes the success of the project but also makes projects more inefficient and less effective. Public involvement in project management ensures that management of the canal is tailored towards meeting their needs efficiently. As indicated in figure 23, a bigger percentage (55.56%) of the population feel the level of public participation is low and as a result feels left out in the management of water resources, particularly Yatta Canal. More involvement can help foster greater sense of ownership and responsibility for the canal and consequently sustainable use of the water from the canal by all stakeholders.

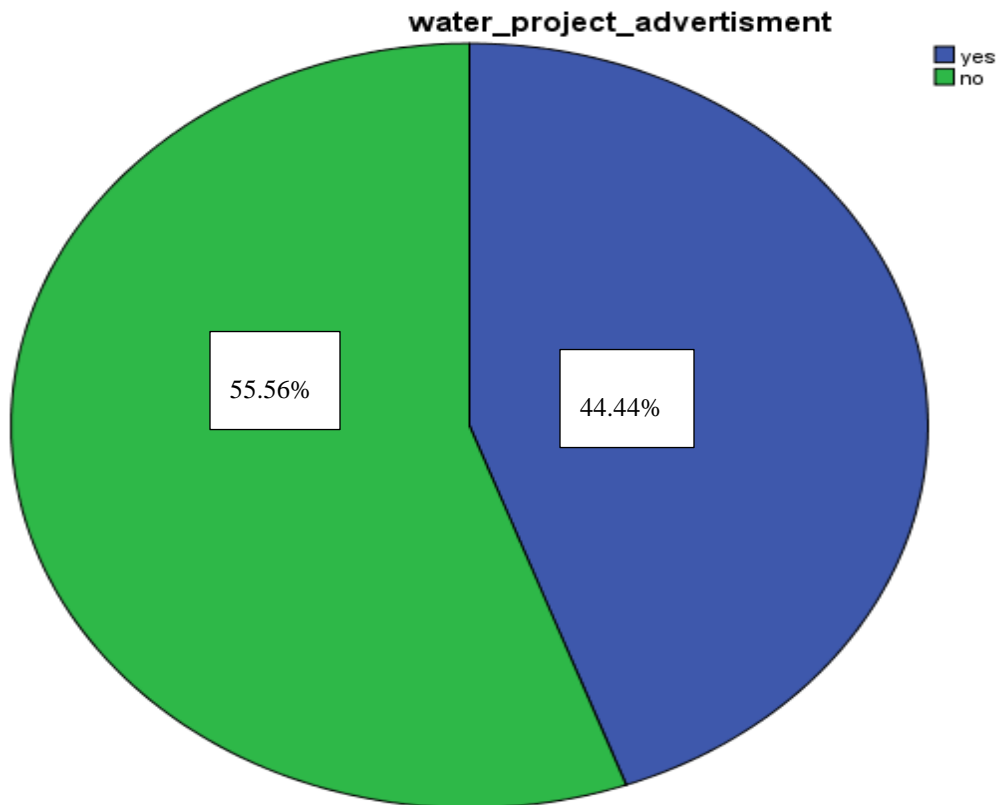


Figure 24: Water development advertisement

Source: Field data (2017)

4.3.1 Gender involvement in water resources management.

The study established that a majority of males, 91.11%, are involved in management of water resources as compared to 8.89% of their female counterparts as shown in figure 24. However, the population interviewed is of the view that this should change as the women are primarily most affected by changes in water availability. More women are involved in farming activities such as tilling and irrigating the farms. As such it is vital that they are involved in management of the canal. This can be achieved by enforcing affirmative action, where no more than two thirds of a particular gender should be appointed in water resources management.

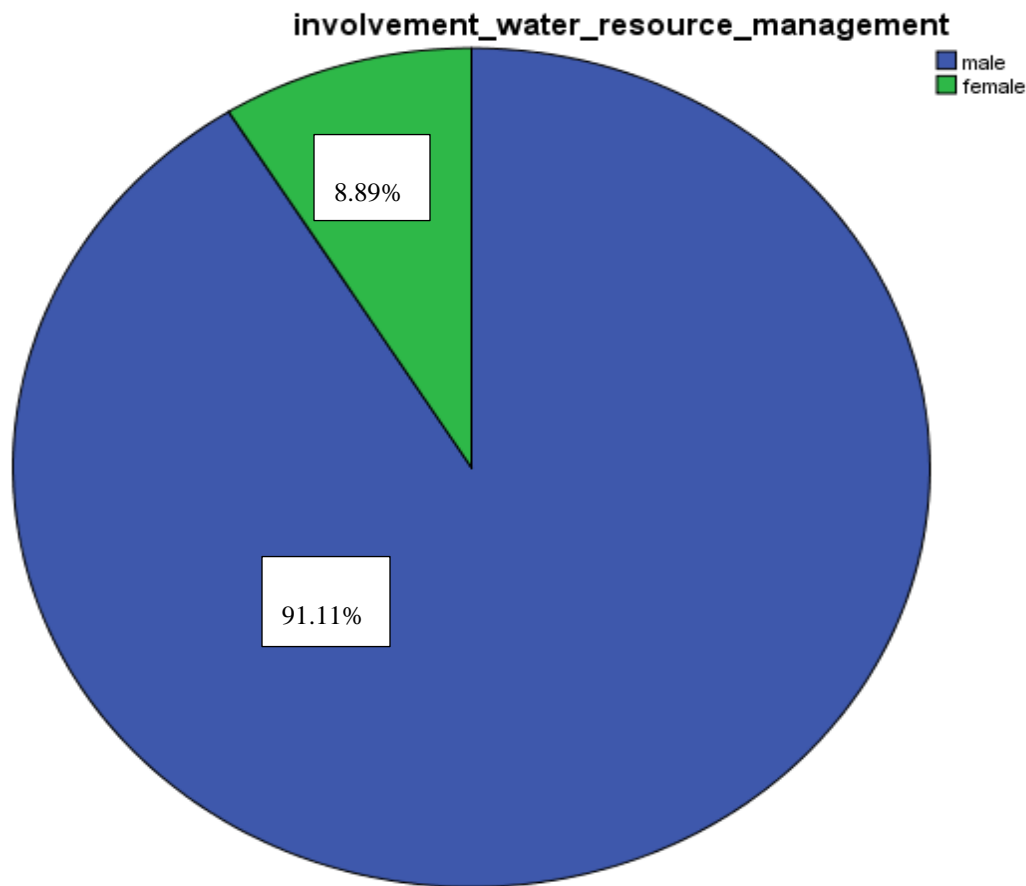


Figure 25: Gender involvement in water resources management

Source: Field data (2017)

4.3.2 Private – Public – Partnership

The study sought to establish the level of public participation, including private-public-partnership (PPP). This was to ascertain if there are other organizations involved in water resources management or provision of water services to Yatta Canal community. As shown in figure 25, only 16.67% of the respondents said that there exist other private water services providers. A majority, 83.33%, said they only know of YAWASCO (Yatta Water and Sewerage Company) water services which is a government organization. Poor levels of Private-Public-Partnership affects water availability as only one organization is tasked to ensure water availability. Proper PPP would ensure a concerted effort in provision of water and proper management of available water resources, especially Yatta Canal.

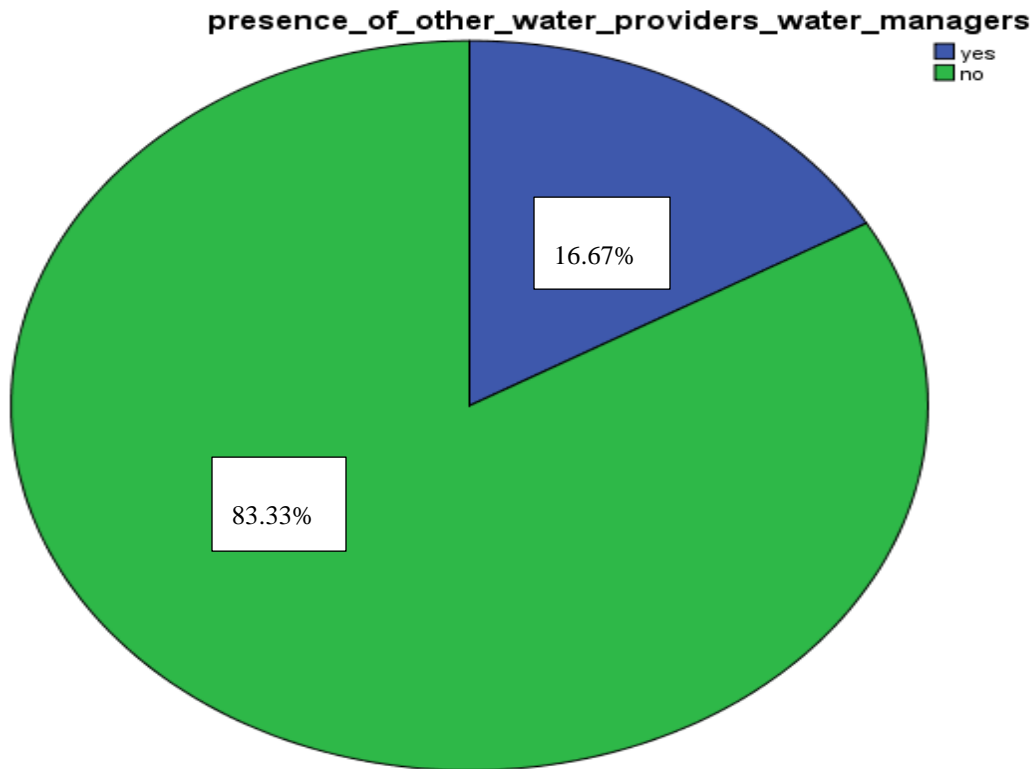


Figure 26: Presence of other water services providers

Source: Field data (2017)

Respondents were asked to rate the level of PPP in the ward with respect to water service provision and management. Respondents were given choices from 1 (being poorest) to 5 (being excellent). The research revealed that none of the respondents said good or excellent. A greater majority, 46.67% believed that the level of PPP in the ward is poorest, with only 8.89% thinking that the level of PPP was fair enough. Public participation in the sub-county was also rated poorly with most of the respondents, with only 8% of the population rating it as fair as shown in Figure 26.

Poor partnership between the public and private implies there is no synergy in the provision and management of water resources. This in-turn leads to poor provision of water services and a redundancy in management of water resources. This often leads to a poor link in provision of water infrastructure and services for improved livelihood. As a result the community along the canal has to incur extra cost for tanked/piped water or to draw water from the canal, further reducing their funds available for other necessities.

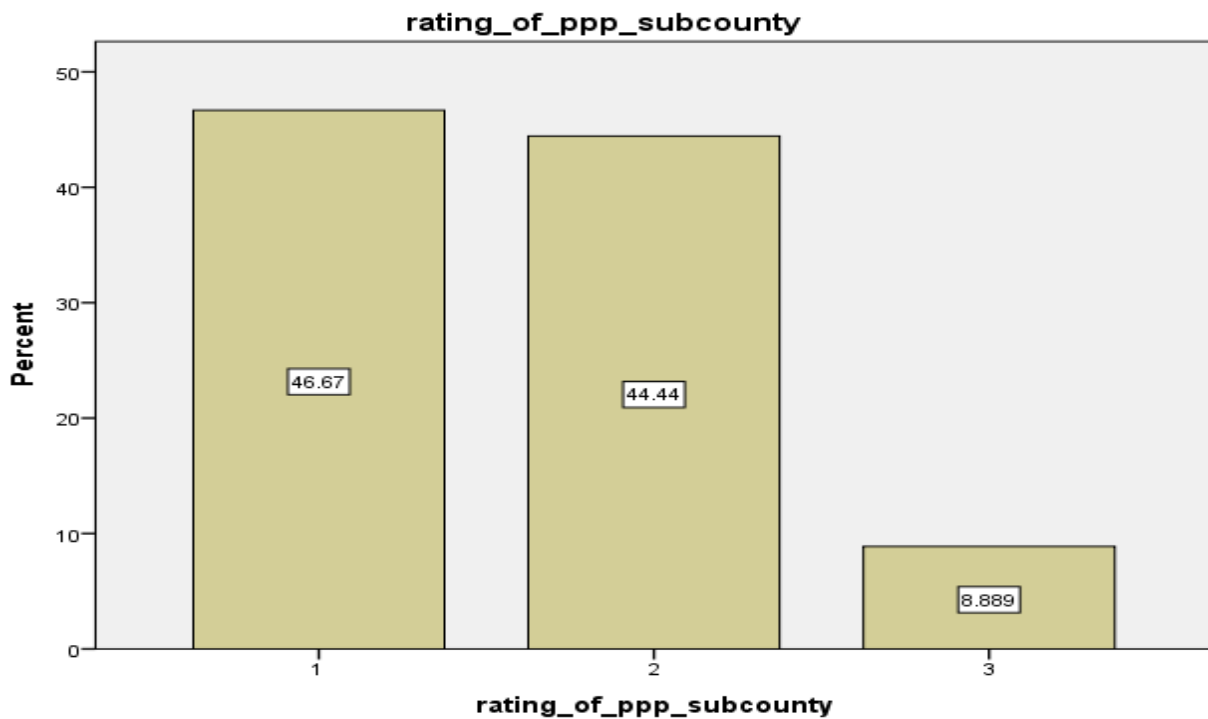


Figure 27: Private-Public-partnership rating

Source: Field data (2017)

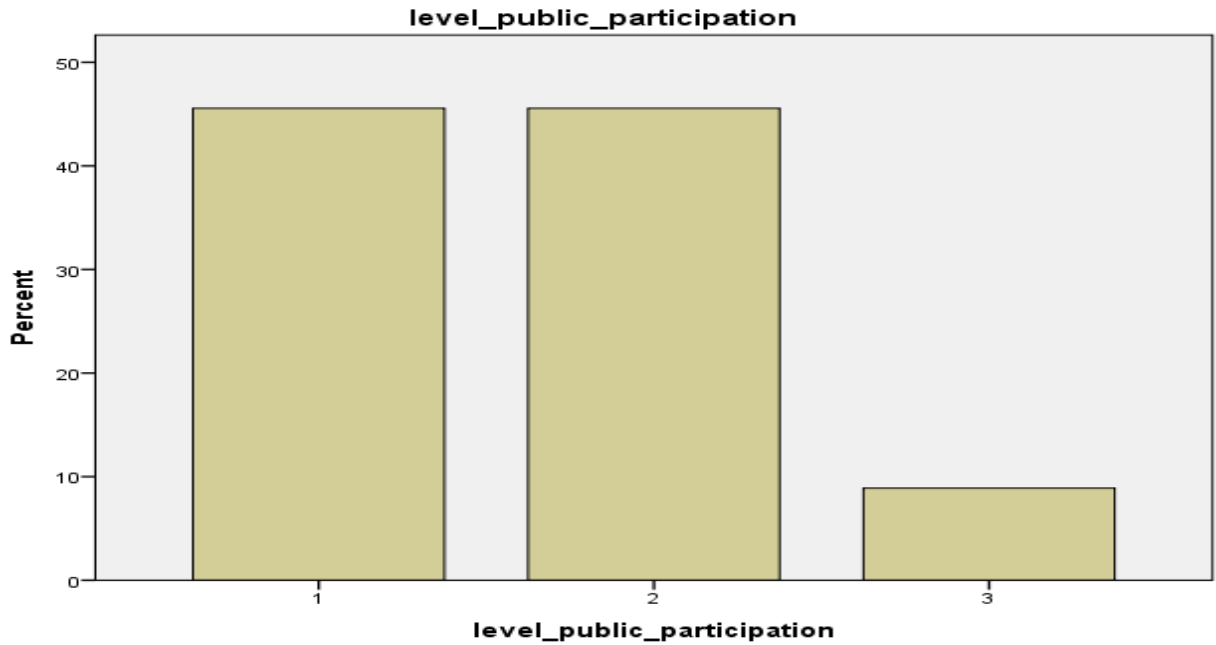


Figure 28: Public participation rating

Source: Field data (2017)

4.4 Inferential statistics

In order to enhance data analysis, a number of statistical methods were applied. These include; descriptive analysis and inferential statistics. They also include the Analysis of Variance (ANOVA), correlation analysis and regression as presented in the following sub-sections.

4.4.1 Regression analysis

Multiple regression analysis method was performed in order to analyze the relationship between study variables. The results of this regression analysis are as described in table 4.1;

Table 2: 4.1Regression analysis

Model	R	R Squared	Adjusted R Squared	Std. Error of the Estimate
1	.464 ^a	.215	0.178	.91136

Predictors: (Constant), farm size, proximity to canal, farming type, irrigation methods

Dependent variable: income level (livelihood)

Source: Field data (2017)

According to Table 4.1 above, R squared is the coefficient of determination which tells us the variation in the dependent variable due to changes in the independent variables. Based on Table 4.1, the value of R squared is 0.215 which means that 21.5% variation in the livelihood (income level) of the Yatta Canal residents was due to variations in farm size, proximity to canal, farming type and irrigation methods. Hence, 21.5% of variation in the livelihood of the Yatta Canal residents was explained by the four predictor variables under study (that is, farm size, proximity to canal, farming type, irrigation methods) while 78.5% of variation in the livelihood of the Yatta Canal residents could be explained by other factors not in the study.

4.4.2 Correlation analysis

Pearson correlation was carried out to establish the correlation between changes in water availability and the livelihoods of Yatta Canal residents. Farm size, proximity to the canal, farming type and irrigation methods were used to denote changes in water availability while income level denoted the livelihoods of Yatta Canal residents. Results of the Pearson’s correlation coefficient (as illustrated in Table 4.2) depict a significant positive correlation between farming type ($r=0.409$, $p\text{-value} = 0.000$) as well as farm size ($r=0.297$, $p\text{-value} = 0.004$) and the livelihood of the residents of Yatta canal, implying that any positive changes in farming types and farm sizes would lead to an increase (or improvement) in the livelihoods of Yatta Canal residents. In addition, the results indicate that there was an insignificant positive correlation between irrigation methods ($r=0.001$, $p\text{-value} = 0.994$) and the livelihood of the residents of Yatta canal, implying that any changes in irrigation methods would positively affect the livelihoods of Yatta Canal residents, though not significantly. Further, the results indicate that there was minimal or no correlation between proximity to the canal ($r=-0.025$, $p\text{-value} = 0.812$) and the livelihood of the residents of Yatta

canal, implying that any changes in proximity to the canal would negatively affect the livelihoods of Yatta Canal residents, though not significantly.

Table 3: 4.2 Pearson correlation results

		Livelihood (Income level)	Farm size	Proximity to the canal	Farming type	Irrigation methods
Livelihood	(r)	1				
(Income level)	Sig. (2 tailed)					
	N	90				
Farm size	(r)	.297**	1			
	Sig. (2 tailed)	.004				
	N	90	90			
Proximity to the canal	(r)	-.025	-.146	1		
	Sig. (2 tailed)	.812	.170			
	N	90	90	90		
Farming type	(r)	.409**	.211*	-.036	1	
	Sig. (2 tailed)	.000	.046	.737		
	N	90	90	90	90	
Irrigation methods	(r)	.001	.087	-.056	-.148	1
	Sig. (2 tailed)	.994	.414	.597	.164	
	N	90	90	90	90	90

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Source: Field data (2017)

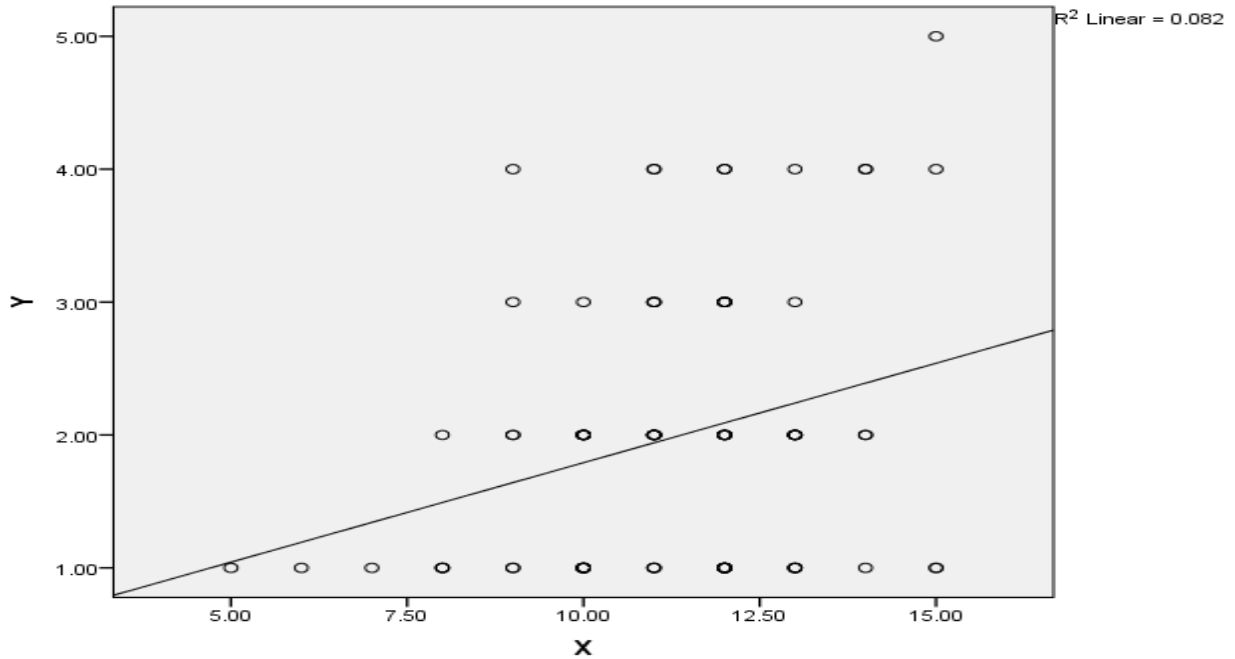


Figure 4:30 Correlation plot

Source: Field data (2017)

The correlation plot in Figure 4.30 illustrates the correlation between changes in water availability in Yatta Canal and the livelihoods of the Yatta Canal residents. In the above correlation plot, Y represents livelihood of the residents of Yatta Canal denoted by their income level while X represents changes in water availability in Yatta Canal denoted by an aggregation of farm size, proximity to the canal, farming type and irrigation methods factors. The regression correlation plot result indicates that the livelihood of the residents of Yatta Canal was positively correlated with changes in water availability in Yatta Canal. However, the positive correlation was weak as denoted by R^2 value of 0.082 which implied that changes in water availability in Yatta Canal occasioned by farm size, proximity to the canal, farming type and irrigation methods factors explained only 8.2% of variation in the livelihood of the residents of Yatta Canal.

Table 4: 4.3 ANOVA (Analysis of Variance)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.356	4	4.839	5.826	.000 ^b
	Residual	70.599	85	.831		
	Total	89.956	89			

a. Predictors: (Constant), farm size, proximity to canal, farming type, irrigation methods

b. Dependent Variable: income level (livelihood)

Source: Field data (2017)

Analysis of Variance (ANOVA) consists of calculations that provide information about levels of variability within a regression results and forms a basis for tests of significance. The "F" column provides a statistic for testing the hypothesis that all (regression coefficients) $\beta \neq 0$ against the null hypothesis that $\beta = 0$ (Weisberg, 2005). For this study, the predictor variables were farm size, proximity to canal, farming type, irrigation methods while the response variable was income level which denoted livelihood. From the findings in Table 4.3, the significance value is .000 which is less than 0.05 implying that the study's regression model was statistically significant in predicting how the predictor variables (farm size, proximity to canal, farming type and irrigation methods) influenced the response variable (the income level of the residents of Yatta Canal). The F critical at 5% level of significance was 2.48. Since F calculated value of 5.826 is greater than the F critical value of 2.48, this also showed that the overall model was fit.

Table 5: 4.4 Regression results

	Unstandardized		Standardized	t	Sig.
	Coefficients		Coefficients		
	B	Std. Error	Beta		
(Constant) Livelihoods	.079	.643		.122	.903
Farm size [X ₁]	.173	.079	.219	2.193	.031
Proximity to canal [X ₂]	.019	.085	.022	.225	.823
Farming type [X ₃]	.746	.202	.369	3.695	.000
Irrigation methods [X ₄]	.043	.112	.038	.383	.703

Source: Field data (2017)

Based on the regression results shown in Table 4.4, the regression model becomes;

$$Y = 0.079 + 0.173 X_1 + 0.019 X_2 + 0.746 X_3 + 0.043 X_4$$

The predictor variables (farm size, proximity to Canal, farming type and irrigation methods) constant at zero, the income level (livelihood) of the residents of Yatta Canal would be at 0.079. Further, any unit increase in farm sizes leads to a 0.173 unit increase in the income level (livelihood) of the residents of Yatta Canal; any unit increase in proximity to the Canal leads to a 0.019 unit increase in income level (livelihood) of the residents of Yatta Canal; a unit increase in farming types would lead to a 0.746 unit increase in the income level (livelihood) of the residents of Yatta Canal. A unit increase in irrigation methods leads to a 0.043 unit increase in the income level (livelihood) of the residents of Yatta Canal. In addition, 2 predictors (farm size and farming type) had p values less than 0.05 implying that they had a significant influence on the income level (livelihood) of the residents of Yatta Canal while proximity to the Canal and irrigation methods had p values greater than 0.05 implying that they had an insignificant influence on the income level (livelihood) of the residents of Yatta Canal. From these findings, it is implied that farm sizes and farming type were the critical water usage aspects to residents of Yatta Canal.

The study used the regression results coefficients' significance values to test the study hypotheses that farm size, proximity to canal, farming type and irrigation methods had no significant influence

on the livelihoods of the Yatta Canal residents, at 95% confidence level. The hypotheses testing results are as shown in Table 4.5.

Table 6: 4.5 Hypotheses Testing Results

Hypotheses	Regression coefficients' p value	Confidence level Sig. Value	Result	Decision
H₀₁ Farm size has no significant influence on the livelihoods of the Yatta Canal residents	0.031	0.05	0.031<0.05	Reject H ₀₁
H₀₂ Proximity to canal has no significant influence on the livelihoods of the Yatta Canal residents	0.823	0.05	0.823>0.05	Fail to reject H ₀₂
H₀₃ Farming type has no significant influence on the livelihoods of the Yatta Canal residents	0.000	0.05	0.000<0.05	Reject H ₀₃
H₀₄ Irrigation methods have no significant influence on the livelihoods of the Yatta Canal residents	0.703	0.05	0.703>0.05	Fail to reject H ₀₄

From findings in Table 4.5, at 95% confidence level, the null hypotheses on farm size and farming type yielded p-values of 0.031 and 0.000 respectively and which were < 0.05 and hence both were rejected. Consequently, their alternate hypotheses that farm size and farming type had a significant influence on the livelihoods of the Yatta Canal residents were accepted. The findings further indicate that, at 95% confidence level, the null hypotheses on proximity to canal and irrigation methods yielded p-values of 0.823 and 0.703 respectively and which were > 0.05 and hence both were accepted. Consequently, the researcher failed to reject the hypotheses that proximity to canal and irrigation methods had no significant influence on the livelihoods of the Yatta Canal residents. From these findings, the study concludes that both farm size and farming type had a significant

influence on the livelihoods of the Yatta Canal residents while both proximity to canal and irrigation methods did not have significant influence on the livelihoods of the Yatta Canal residents.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 INTRODUCTION

This Section discusses the summary of research findings, discussions conclusions drawn from the study. This chapter also seeks to present the recommendations adopted from the study, which sought to assess the impact of water availability changes to the general success and improved livelihoods in the Yatta-Sub County. The chapter will present the recommendations based on the findings of data collected and conclusions made from the analyzed data. Additionally, the chapter seeks to highlight the research implications generated from the current study.

Several factors bring about a change in the demand for water such as increased population, reduced water availability due to failed rains and prolonged dryspells, bigger farm sizes and farm proximity to the canal, the type of farming and the predominant method of irrigation.

5.1 Findings

Seasonal variations on water availability from Yatta Canal (and other different sources) were recorded in Yatta Canal basin and water availability in Yatta Canal varies with location of the residents of the Yatta Canal community i.e. upstream or downstream, left or right side of the canal, proximity to the canal etc.

The average water consumption per household is 600 litres per day, 95.6% of the household in Yatta have poor access to water and 76.67% of the community along Yatta Canal belongs to the poor socio-economic status. Burden of fetching water lies disproportionately more on female child and female adult compared to their male counterparts.

A positive correlation ($r=0.811$ for human factors, $r=0.774$ for natural factors and $r=0.638$ for stakeholder involvement) was established between these water changes contributors and livelihoods of the rural households along Yatta Canal.

Agricultural productivity by households was seen to be impeded by inadequacy of water for agricultural use, hence accentuating food insecurity and trade in agricultural products among rural communities living along Yatta Canal.

The participation of other stakeholders (residents, CBOs, NGOs, and Donor Agencies) apart from the government was not enough to meet the water supply challenges of the rural communities along Yatta Canal.

Yatta Canal is not adequately protected from siltation and pollution and this affects water availability and quality and there's poor investment in water storage facilities especially for communities along the canal.

5.2 Discussion

Natural Water availability in an area is dictated by climatic parameters. With the amount of rainfall usually limited, water available for human use is dependent management of available natural water resources (Van-Wijk-Sijbesma, 1998).

Present survey reported that the rural communities along Yatta Canal depend heavily on Yatta Canal, which draws water from Thika River, other sources being rainfall, water vendors and ground water as their natural sources of water. This result is in agreement with several reports positing that rural households rely on rainfall, spring catchment, steams, ponds and dung well for their domestic water use (Merz, Nakarmi, Shrestha, Dahal, Dangol and Shah, 2003; Phill-Eze and Okafor, 2009).

Yatta Canal water availability is dependent on hydrological characteristics of the area and activities upstream. Household's reliance on canal water ensures all season availability of water for domestic use provided reduced water usage upstream, controlled diversions and protection from excessive evaporation. In the present study, the respondents' reliance on canal water differs with the location of the rural community.

There is a close link between hunger and poverty, with 70 % of the world's 1.1 billion absolute poor people living in rural areas. The majority of the 850 million malnourished people live in rural areas (Rockstrom, Lannerstad and Falkenmark, 2007).

These rural poor people mainly rely on agriculture for livelihood. However, the productivity of agriculture is constrained by hydrological challenges such as poor and erratic rainfall patterns and long dry spells. Farmers in the rural communities surveyed in the present work, posit that water constitutes major constraint to agricultural productivity and hence food insecurity. For instance, water stress at the flowering stages for maize does reduce yield by 60 %. (Rockstrom *et al.*, 2007).

From my survey, disease burden was remarkably heavier with the poor households with concomitant poor access to water and hygiene. 79% incidence of cholera was recorded for the households with very poor access to water compared with 20 % incidence in households with good access to water.

Community participation has gained popularity in the development discourse and practice, particularly in environmental management in relation to water resource management. The importance of involving both women and men in the management of water and sanitation has been recognized at the global level, starting from the 1977 United Nations Water Conference at Mar del Plata, the International Drinking Water and Sanitation Decade (1981-90) and the International Conference on Water and the Environment in Dublin (January 1992). These explicitly recognize the central role of women in the provision, management and safeguarding of water. Reference is also made to the involvement of women in water management in Agenda 211 and the Johannesburg Plan of Implementation 2. Moreover, the resolution establishing the International Decade for Action, "Water for Life" (2005-2015), calls for women's participation and involvement in water-related development efforts. The Water for Life Decade coincides with the timeframe for meeting the Millennium Development Goals (MDGs).

Women participation in planning, operation, and management of water schemes in selected rural communities of Yatta Sub-County does not conform to the forgoing international conventions and protocols on gender mainstreaming in water resource management. From the study, the

respondents reckon that 8.89 % of women are sometimes involved in water project planning, operation and management as compared to 89.11% of the male counterparts.

Human impacts on the quality and quantity of water threaten the socio-economic stability and prosperity and the resilience of the available natural capital. As communities and ecosystems continue to heavily depend on static or dwindling water supplies, there is increasing risk of failures in socio-economic systems including drying up water resources (ecosystems transformation). In Yatta Sub-County, the study revealed that there is restriction on the quantities of water drawn from the canal, which leads to overdraft and thus lesser and lesser quantities flows downstream. This has to be addressed if all the communities along the canal are to benefit from its waters.

The study found strong positive correlation between human factors ($r=0.811$, $p\text{-value} < 0.05$), natural factors ($r=0.774$, $p\text{-value} < 0.05$) as well as stakeholder involvement ($r=0.638$, $p\text{-value} < 0.05$) as water management aspects and the livelihood of the residents of Yatta canal. This implied that water changes associated with human factors, natural factors and stakeholder involvement had a significant positive influence on the livelihood of the residents of Yatta canal area. This concurs with Mburu *et al.*, (2015) who found that both human and natural factors were major contributors to water changes which ended up having a major impact on human livelihoods particularly among poor communities. The findings also agreed with Uchenna and Campus (2012) who argued that extreme variability in water availability arising from both human related and natural phenomena had immense effect on the livelihoods of communities particularly in rural settings in Africa.

5.3 Conclusion

From the study objectives and findings, water availability changes in Yatta canal is brought about by a number of factors. One such factor is predominant commercial activity, in this case is farming which puts a great demand on water from the canal. Another factor affecting water availability in Yatta Canal is farm proximity to the Canal. The closer the farm is to the canal the more the use of water from the Canal as those close to the Canal practice furrow irrigation, dig outlets along the canal which are never closed hence end up wasting a lot of water. Farm sizes and the type of farming also affect water availability as bigger farms use a lot water as compared to smaller farms.

World's most vulnerable people are located in rural communities where they employ various coping mechanisms in a bid to escape a variety of forces that work to keep them in perpetual poverty. Among them, water, according to my research is a key correlate to the livelihoods of rural communities. The livelihoods of rural communities are plagued by extreme variability in water availability, which is further exacerbated by climate change.

Poor access to water, especially during dry seasons, limits their resilience and livelihoods and exposes them to food insecurities by inhibiting agricultural productivity. The health of the rural community is also affected by disease burden, attributed to poor access to water and sanitation. This affects livelihoods as available funds are spent to treat the sick and workforce is kept from work.

5.4 RECOMMENDATIONS AND RESEARCH IMPLICATIONS

Recommendations to policy makers

5.4.1 Farm sizes

The study recommends that the people living in Yatta Ward should find alternative sources of water since relying on the Yatta canal is not sustainable. The canal is not sufficient to satisfy the demand of water and thus alternative methods such as sinking boreholes and digging dams should be considered. Contrary to the current trend, they should invest heavily storage facilities to ensure they tap enough water during the rainy season. This will ensure the water will cater for their needs when the canal water is insufficient.

5.4.2 Proximity to the canal

The study recommends that the farms closer to the canal should use the water sustainably to ensure even the farms that are far away from the canal can get the water. The current trend is to dig furrows along the canal to divert water to farms. This is highly wasteful as the water usage is not accounted for. The farms should device sustainable ways of getting water for the purposes of

farming. Moreover, there is need to avoid any form of pollution since the farms close to the canal pose a danger of polluting the water.

5.4.3 Farming type

The current study recommends the farmers who are doing farrow irrigation along the canal to improve on the irrigation methods to increase their yield subsequently. The study has established most families rely on the irrigation for farming. Therefore, if they can improve the farming methods, they would be increase the yield and thus improve their livelihood.

5.4.4 Irrigation methods

Additionally, the study recommends the families along Yatta Canal to improve their their methods of irrigation as opposed to the current furrow irrigation. Drip irrigation is instead advised as it ensures water usage is monitored. Water storage facilities should also be invested in to reduce dependence on the canal and ensure a constant supply of water throughout the year.

5.4.5 Public Participation

The study recommends that public participation in management of water resources and especially Yatta canal should be enhanced. The public (55.56% of the respondents) felt they are left out and not involved in the management of the canal. However, improved public participation would enhance the success of the canal and other water development projects carried out in Yatta ward. This means the public would understand what the government is doing, and they would support or give suggestions on management of water resources in the ward.

5.4.6 Gender involvement in water resources management

The study recommends that engagement of women in water resource management should be improved. According to the study, the management of water resources is male dominated as only 8.89 felt that women are involved. The women are directly affected by the lack of water and thus

they should be in the forefront of water management projects. In the future, more women should be engaged in giving ideas and directly managing the water resources in Yatta ward.

5.4.7 Private – Public – Partnership

The study recommends the private-public-partnership in the water resource management in Yatta ward should be enhanced. The private-public-partnership helps complete projects in the community and thus it would be recommendable to have more private-public-partnership in Yatta ward to address the water crisis.

5.5 Research Implications

The study implications for this research will be to open the eyes of the public to the problems they have been going through. Most of the people living in Yatta ward has faced the problem for decades but they not been realized the statistics of the problem they have been going. Therefore, from the research, they will see the problem and determine to resolve it.

Moreover, the policy makers will come up with policies to ensure they arrest the problem in Yatta ward. Some of the policies to be created include private public partnership. The policies will help the ward to become better in water resource management. It is evident the water management has a problem in the ward. Therefore, the study will become a starting point of solving the problem in the ward.

The scholars, students and researchers will take the study and use it as a resourceful tool to understand the water problem in Yatta ward. The study will also trigger them to become determined to solve the issue by carrying out further research on the impact of water availability changes to the general success and improved livelihoods.

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APPENDICES

APPENDIX 1: HOUSEHOLD QUESTIONNAIRE



University of Nairobi

AN ASSESSMENT OF WATER AVAILABILITY IN YATTA CANAL AND ITS IMPACT IN LIVELIHOODS IN YATTA SUB-COUNTY, MACHAKOS COUNTY

I Ms. Agnes Sila Ndunge, a post-graduate student at University of Nairobi, request for your assistance in gathering research data. I am conducting a research project to assess the impact of water availability in Yatta Canal on the livelihoods in Yatta Sub County, Machako County. To meet the objectives of the study, several techniques are being used including conducting key informant interviews and household questionnaire. The information obtained will be used solely for informing this study and will be confidential. Thank you very much.

QUESTIONNAIRE

NAME _____

SECTION A: DEMOGRAPHICS

- I. Gender of respondents
 - 1. Male 2. Female
- II. Marital status
 - 1. Single 2. Married 3. Widowed 4. Divorced
- III. Occupation of respondent(s)
 - (i).....
 - (ii).....
 - (iii).....
 - (iv).....
- IV. Age of respondent
 - 10-20 21-30 31-40 41-50 51-60 61 and above
- V. Family size
- VI. Level of education
 - Primary High School Tertiary University
- VII. Income level (Ksh)
 - 0-15,000 15,001-30,000 30,001-45,000 45,001-60,000
 - 60,001 and above

SECTION B: LAND USE AND IRRIGATION PATTERN

VIII. Farm acreage

Below 0.3ha 0.3-0.8ha 0.8-1.4ha 1.4-2ha above 2ha

IX. Proximity to Yatta Canal

Within 6m from the canal 7-12m 13-18m 19-24 above 25

X. Method(s) of irrigation

.....
.....
.....
.....

XI. Type of farming

Subsistence farming Commercial farming

SECTION C: SOURCE AND DEMAND FOR WATER

XII. Where do you get your water from?

Tank (Rain) Sunk well Tap water Yatta canal Others, specify

XIII. How often per week do you get piped water

1. 2. 3. 4. 5. 6. 7.

XIV. Please state your prevalent use for water

Farming Household (domestic) Fishing Industrial

XV. On average, how much water do you use a day?

Below 100L 101-200L 201-300L 301-400L 401-500L 501-600

Above 600

XVI. Do you face an irregular water supply? Yes No

XVII. If yes, do you have a storage tank?

(a). Capacity of storage tank (Litres) _____

(b) Construction cost (Ksh.) _____

SECTION D: WATER SAFETY

XVIII. Perception of household regarding the quality of water:

Safety level/source	Tank (Rain)	Sunk well	Tap Water	Others (Specify)
Not safe				
Not so safe				
Somewhat safe				
Very safe				
Very safe				
Cannot say				

XIX. Coping mechanism for unsafe water

Boiling Cloth filtering Aqua guard Others (specify)

XX. Incidence of water borne diseases (last 2 years):

Name of disease	No. members of family affected	No. of days of illness	Expenditure on medication (Ksh)	Loss of life (if any)
Malaria				
Cholera				
Typhoid				
Dengue				
Tuberculosis				
Skin infection				
Others				

XXI. In the last 1 year, how many days of the school has the child missed due to illness?

3-5 days 5-7 days >7 days not missed

XXII. How many days have the adult missed work because of illness?

3-5 days 5-7 days 7 days not missed

SECTION E: PUBLIC PARTICIPATION

XXIII. Are water development projects normally advertised?

Yes. No.

XXIV. Between males and females, who are involved more management of water resources?

Males females

XXV. Apart from the government agencies, are there other organizations involved with water provision and water resource management

Yes. No.

(b). if yes, state them below.

- i.
- ii.
- iii.
- iv.

XXVI. How would you rate the level of PPP in your sub county? (1 being lowest and 5 being highest)

1. 2. 3. 4. 5.

XXVII. How would you rate the level of public participation in your ward and sub county as far as water resource management is concerned? (1 being lowest and 5 being highest)

1. 2. 3. 4. 5.

XXVIII. Any other recommendation/comments

.....
.....
.....
.....
.....

APPENDIX 2. OBSERVATION SCHEDULE

The observation study method will help the researcher gather primary information on the characteristics of the study area in respect to water resource management, water infrastructure, and users of water among others.

The following are the specific aspects the researcher focused on.

- 1. The physical state of the water infrastructure
.....
.....
- 2. Physical state of Yatta canal
.....
.....
- 3. People fetching water i.e. age and gender
.....
.....
- 4. Sizes of farms
.....
.....
- 5. Location of the farms
.....
.....
- 6. Types of crops grown
.....
.....
- 7. Other water users (industrial e.g. brick making)
.....
.....
- 8. Sanitary facilities
.....
.....