

**Effects of climate change-induced flooding on onsite sanitation
services: A case study of Kanyama Compound in Lusaka, Zambia**

By

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**A dissertation submitted to the University of Zambia in partial fulfilment of the
requirements of the degree of Master of Science in Sanitation**

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DECLARATION

I, Miyanda Habanyama, affirm that this dissertation is a product of my independent effort. It has not been presented for any degree or recognition at the University of Zambia or any other institution globally. I have duly acknowledged and referenced all the sources and materials utilized in this thesis.

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Date.....

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CERTIFICATE OF APPROVAL

The University of Zambia approves the dissertation of MIYANDA HABANYAMA, as fulfilling part of the requirements for the award of the degree of Master of Science in Sanitation.

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DEDICATION

To my beloved daughter Nomsa and son Thiqah Dinde. This research endeavor is a testament to the love and inspiration you both have showered upon me. Nomsa, your unwavering belief in my abilities and your boundless enthusiasm for learning have been a source of constant motivation. Your resilience and determination remind me of the importance of tenacity in the face of challenges. Thiqah Dinde, your curious mind and inquisitive spirit have ignited my own passion for discovery. Your innocent yet profound questions have pushed the boundaries of my understanding, urging me to delve deeper into the realms of knowledge.

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LIST OF ACRONYMS

BORDA	Bremen Overseas Research and Development Association
CBD	Central Business District
CBS	Container Based Sanitation
CCDRs	Country Climate and Development Reports
CRWU	Creating Resilient Water Utilities
CSO	Central Statistics Office
CUs	Commercial Utilities
DMMU	Disaster Management and Mitigation Unit
ESAWAS	Eastern and Southern Water and Sanitation Association
ESAs	Environmental and Social Assessments
FSM	Fecal Sludge Management
GHGs	Greenhouse Gases
IEC	Information, Education, and Communication
KMO	Kaiser-Meyer-Olkin Measure
LWSC	Lusaka Water Supply and Sanitation Company
MLGRD	Ministry of Local Government and Rural Development
MOH	Ministry of Health
MWDS	Ministry of Water Development and Sanitation
NGOs	Non-Government Organizations
NCDs	Nationally Determined Contributions
NWASCO	National Water Supply and Sanitation Council

O&M	Operation and Maintenance
OSSs	On-site Sanitation Systems
PUA	Peri-Urban Area
SDG	Sustainable Development Goals
SI	Statutory Instrument
SPSS	Statistical Package for Social Sciences
SUR	Seemingly Unrelated Regression Model
UNICEF	United Nations Children Emergency Fund
VIP	Ventilated Improved Pit Latrines
WASH	Water, Sanitation, and Hygiene
WHO	World Health Organization
WSS	Water Supply and Sanitation
ZEMA	Zambia Environmental Management Agency

ABSTRACT

Kanyama, a densely populated peri urban area in Lusaka, Zambia, is characterized by its high poverty levels and inadequate infrastructure, making it particularly vulnerable to environmental challenges. This research addresses the pressing issue of climate change-induced flooding and its effects on onsite sanitation services in Kanyama. Employing both qualitative and quantitative methods, the research involved 210 respondents from six wards in Kanyama. Through systematic random sampling of households and purposive sampling of key informants, the study collected data using a questionnaire and in-depth interviews. The data was evaluated using predictive models of Root Mean Square Error and R-squared values in the Statistical Package for Social Sciences (SPSS Version 22). The findings highlighted adverse effects on OSSs through contamination of water caused by the users of the facilities, infrastructure damage, and overflowing of pit-latrines/septic tanks contributed by the climate change-induced flooding. Whereby, majority of respondents, 68%, reported witnessing changes in temperatures, while 63% demonstrated an understanding of climate change. Notably, 73% agreed, having experienced changes in rainfall patterns. Moreover, 72% of respondents in Kanyama have had observed increased floods, with only 28% indicating otherwise. The analysis indicated that, The R-squared values of 0.431, 0.427, and 0.373 obtained in the statistical analysis reveal significant relationships between flood-related variables and their effects in Kanyama. Specifically, these values indicate that 43.1% of the variance in water contamination, 42.7% in infrastructure damage, and 37.3% in the overflowing of pit-latrines/septic tanks can be explained by the flood area cover, inundation depth, and flood rains. These figures suggest that these independent variables, related to the extent and severity of flooding, substantially influence the outcomes studied. Although not all variability is captured, a considerable portion is, demonstrating the robustness of the models in highlighting the key factors contributing to flood impacts in this community.

The chi-squared statistics calculated for the study—234.16 for water contamination, 214.564 for infrastructure damage, and 152.132 for overflowing of pit-latrines/septic tanks—demonstrate substantial discrepancies between observed and expected outcomes. Suggesting that flood-related variables profoundly impact water safety, infrastructure integrity, and sanitation system functionality in Kanyama. Such statistical results highlight the critical influence of flooding on exacerbating these issues, reinforcing the necessity for targeted interventions and robust flood management strategies in this vulnerable community. The qualitative data results, identified key themes, including awareness of climate change effects, diverse beliefs about climate change causes, varying community awareness levels, and the necessity for tailored education. The study also showcased strategies through themes, employed by public-private partnerships, government initiatives, community engagement, subsidized services, and health risk prevention to address sanitation challenges. A sustainability framework aimed at improving onsite sanitation services during floods is proposed, emphasizing drainage systems, awareness campaigns, infrastructure development, waste management, and partnerships to enhance community resilience against climate change-induced flooding. The findings emphasize the vital role of continuous collaboration between government, private organizations, and communities to foster awareness, promote climate resilience, and empower residents, ensuring sustainable solutions and improved sanitation services amidst changing climatic conditions in Kanyama.

KEY WORDS: *Climate Change, Flooding, Onsite Sanitation, Sustainability Model*

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents an introduction to the study on the impact of climate change on onsite sanitation service delivery. The first section presents the background of the study. The following section brings to the fore the problem statement, purpose of the study, objectives of the study, research questions, significance of the study, delimitation, and limitations. The final section of the chapter then spells out the operational definitions and the summary of the entire chapter.

1.1 Background

Around 1.9 billion people globally lack access to basic sanitation, while more than a third of urban dwellers lack access to safely managed sanitation systems (WHO/UNICEF JMP (2021). Climate change is a global phenomenon that significantly impacts human health and the environment. Effective sanitation systems are crucial for public and environmental health, particularly in densely populated urban areas where the risks from unsafe excreta disposal are compounded because of excreta volumes and the probability of exposure. Climate change is a global phenomenon affecting various sectors of society, including sanitation service delivery. The effects of climate change can damage or destroy sanitation infrastructure, disrupt services, and inhibit the system's efficacy. Climate Change can make achieving universal access to safely managed sanitation more expensive and slower (UNESCO, 2017). With increasing population growth, urbanisation and industrialisation, the collection, treatment, and disposal of increasing quantities of wastewater remains a major challenge for municipalities and utilities in developed and developing countries. Climate change not only affects lives and livelihood but also make social and socio-economic system of the country vulnerable. As a result, social discrimination, deprivation, dissatisfaction, unacceptability, and migration are increasing significantly (WaterAid, 2012).

Excess rain or drought can lead to threats to sanitation, ranging from increased concentrations of pollutants, a lack of adequate water flow for sewage, and flood-related damage to physical assets. The consequences of the increases in average and extreme temperatures that climate models project are the changes in the incidence of several critical excreta-related diseases, an increase in water consumption and the extent and rate of algae growth in nutrient-enriched surface waters. While there are many toolkits and recommendations for adapting to climate

change globally, there are few on sanitation. The scant information on sanitation focuses primarily on technological change and system vulnerability as adaptation measures (Sinisi & Aertgeerts, 2011).

Onsite sanitation systems use various infrastructure, technologies, and service arrangements. Homogeneous systems using centralized sewerage and treatment are concentrated in High-Income Countries. Cities in Low Middle-Income Countries are characterized by complex and (partially) decentralized and fragmented systems dominated by (non-sewered) faecal sludge management (FSM) services. These typically rely on onsite containment with manual or mechanical emptying and road-based faecal sludge (FS) conveyance to a treatment facility. Most of these systems are designed to allow infiltration of the supernatant into the ground (soil-based treatment). However, these systems are typically ineffectively planned and built in crowded metropolitan areas, leading to insufficient supernatant treatment.

In settlements without sewerage systems, sanitation relies on on-site systems such as pit toilets and septic tanks. These systems are vulnerable to weather and climate change, often leading to overflow and environmental pollution. Flooding can block roads and access points, isolating areas with on-site sanitation systems like pit toilets and septic tanks. This isolation hinders services that empty these systems, increasing the costs and difficulties associated with transporting excreta by truck. Increased waterlogging from floods is anticipated to result in groundwater flooding of pits, tanks, and sewers, which will have an effect on both the groundwater and the treatment procedures (UNICEF, 2017).

Marginalized and vulnerable populations, such as low-income people, indigenous communities, and other disadvantaged groups, generally have decreased resources to adapt to climate change. These populations generally have very little or no input into the decisions affecting their lives, particularly concerning sanitation. People in general will make a major effort to make themselves safer, especially if provided with the necessary information and resources, but there are limits to what a community or household can do. Although households can plan to avoid flooding or be ready for it, they are typically unable to construct the infrastructure that would best help to lessen the consequences of flooding on their houses and sanitation facilities.

Adaptation needs vary with the particular climate vulnerability experienced by an area or settlement, including the economic, institutional, and socio-economic context. Effective adaptation capacity requires that people have assets, flexibility, learning, and social organization, as well as the power and freedom of choice to activate adaptation responses. Good

policy, planning and implementation can result in, at best, partial adaptation; there also needs to be intrinsic adaptation where the people affected by climate change alter their behaviour and environments to adapt. In addition to government-planned adaptation, community-based adaptation is crucial. Beyond creating technology-based climate change solutions, it aims to empower people, increase their capacity for adaptation, and lessen their vulnerability (Cinner et al., 2018).

In Zambia, the effects of climate change are already felt as more intense or prolonged precipitation, more frequent or intense rainstorms, more variable or declining rainfall or runoff, and increasing temperatures, including temperature extremes. These climate change effects can cause or exacerbate hazards or changes such as flooding, erosion, or changes in ground and surface water levels that directly affect the sanitation service chain. Owing to this, the research looked at the effect of flooding on onsite sanitation service delivery at the household's level and linking this flooding to climate change as a cause where the current rainfall pattern is different from what it was in the past in terms of rain period and the amount of rain ranging from heavy to abnormal. The effect on the onsite sanitation services is widespread, including structures collapsing, structures overflowing and household members failing or abandoning the facilities, leading to unsafe methods of human waste management. This further leads to an outbreak of waterborne diseases, such as diarrhoea, dysentery, and cholera. Furthermore, the research sought to find out the climate change interventions that are being implemented in the area by different organisations and stakeholders. Understanding the effects of climate change on the delivery of sanitation services is necessary, and policy and legislation must include measures to prevent, reduce, and mitigate these effects with a focus on strengthening the community ability to adopt climate-resilient sanitation options. Based on this background, this study intended to examine **the** effects of climate change induced flooding on onsite sanitation services related to in Kanyama compound of Lusaka District.

1.2 Statement of the problem

Despite the potentially severe consequences, there is little research on how climate change may affect sanitation, especially in developing nations (Howard et al., 2016). Primarily, the studies have focused on changing precipitation patterns and consequent flood risks for cities relying on sewer-based urban waste- and storm water management or included a broader overview of potential climate change effects and impacts but also focused on sewerage (Sorre, Kurgat & Musebe, 2017). Over the years, scholars have examined the resilience and adaptability of

different sanitation technologies and applied the Vision 2030 sanitation resilience categories to specific countries (Cinner et al., 2018). Kanyama compound, Lusaka, Zambia, like many low-income urban areas in developing countries, relies on onsite sanitation systems due to a lack of access to centralized sanitation infrastructure. Climate change has introduced new challenges to providing safe and reliable onsite sanitation services in Kanyama, which is mainly including increased flooding. This challenge exacerbates existing problems such as inadequate sanitation facilities, poor maintenance, and inadequate waste management, negatively affecting public health and the environment. However, there has not been a comprehensive assessment of the evidence base for the likely effects of flooding on the range of urban onsite sanitation systems or components of such systems generally found in low and middle-income countries like Zambia.

1.3 Main Objective

The main objective of this study was to examine effects of climate change-induced flooding on onsite sanitation services in Kanyama compound of Lusaka district.

1.4 Specific objectives

1. To establish the physical, operational, and health-related effects of climate change-induced flooding on onsite sanitation services in the Kanyama compound.
2. To determine the extent of awareness and understanding of Kanyama residents regarding the effects of climate change-induced flooding on onsite sanitation services.
3. To identify government and stakeholders' sanitation strategies that have been implemented to address climate change-induced flooding on onsite sanitation service delivery.
4. To propose a sustainability framework that addresses the environmental, economic, and social impacts of climate change-induced flooding in the Kanyama compound.

1.5 Research questions

1. What specific impacts does climate change-induced flooding have on the infrastructure, public health, service continuity, and environmental contamination of onsite sanitation services in Kanyama compound?

2. How do different segments of the Kanyama community perceive the risks and effects of climate change-induced flooding on onsite sanitation services, and what factors influence their levels of awareness and understanding?
3. What specific types of strategies such as policy interventions, infrastructure projects, and community engagement initiatives have been implemented by the government and other stakeholders in Kanyama Compound to address the challenges posed by climate change on onsite sanitation services?
4. What key components and principles should be included in a sustainability model to effectively mitigate the effects of climate change-induced flooding in Kanyama Compound, and what challenges and opportunities might such a model encounter?

1.6 Significance of the study

The significance of this study lies in its comprehensive analysis of the effects of climate change-induced flooding on onsite sanitation services in Kanyama, providing crucial insights for both local decision-makers and global stakeholders. By identifying targeted adaptation measures, the research directly contributes to improving living conditions, enhancing public health, and minimizing disruptions to sanitation services in the local community. Specifically, the study outlines practical adaptation strategies such as elevated sanitation infrastructure and community-based resilience training, tailored to the unique challenges faced by Kanyama and potentially other similar settings.

Moreover, the findings of this study offer valuable global lessons on the resilience of sanitation systems against climate-induced flooding, highlighting specific, novel insights that can be applied in other vulnerable communities worldwide. This research addresses a notable gap in the existing literature by focusing on a scarcely explored intersection of climate change, flooding, and sanitation in low-income urban areas, thereby enriching the academic discourse.

The study also sets a foundation for future research by suggesting areas for further investigation, such as the long-term socio-economic benefits of resilient sanitation systems or the effectiveness of specific adaptation measures. It articulates the socio-economic and health benefits of improved sanitation infrastructure, such as reduced disease incidence and lower healthcare costs, emphasizing the broader implications of enhancing sanitation resilience. By providing a detailed empirical contribution and suggesting concrete future directions, this study

not only advances the academic understanding of climate change impacts on sanitation but also serves as a critical resource for practical, actionable solutions that enhance global resilience and sustainability in sanitation management.

1.7 Delimitation

This study took place in Lusaka district, particularly Kanyama. Kanyama compound is a peri-urban area located in the northwest of Lusaka, Zambia. It is one of the largest compounds in Lusaka, with over 525,902 people living in informal settlements (CSO, 2022). The area is characterized by poor sanitation infrastructure, inadequate waste management systems, and limited access to clean water. The focus of this study is on the effects of climate change on onsite sanitation service delivery.

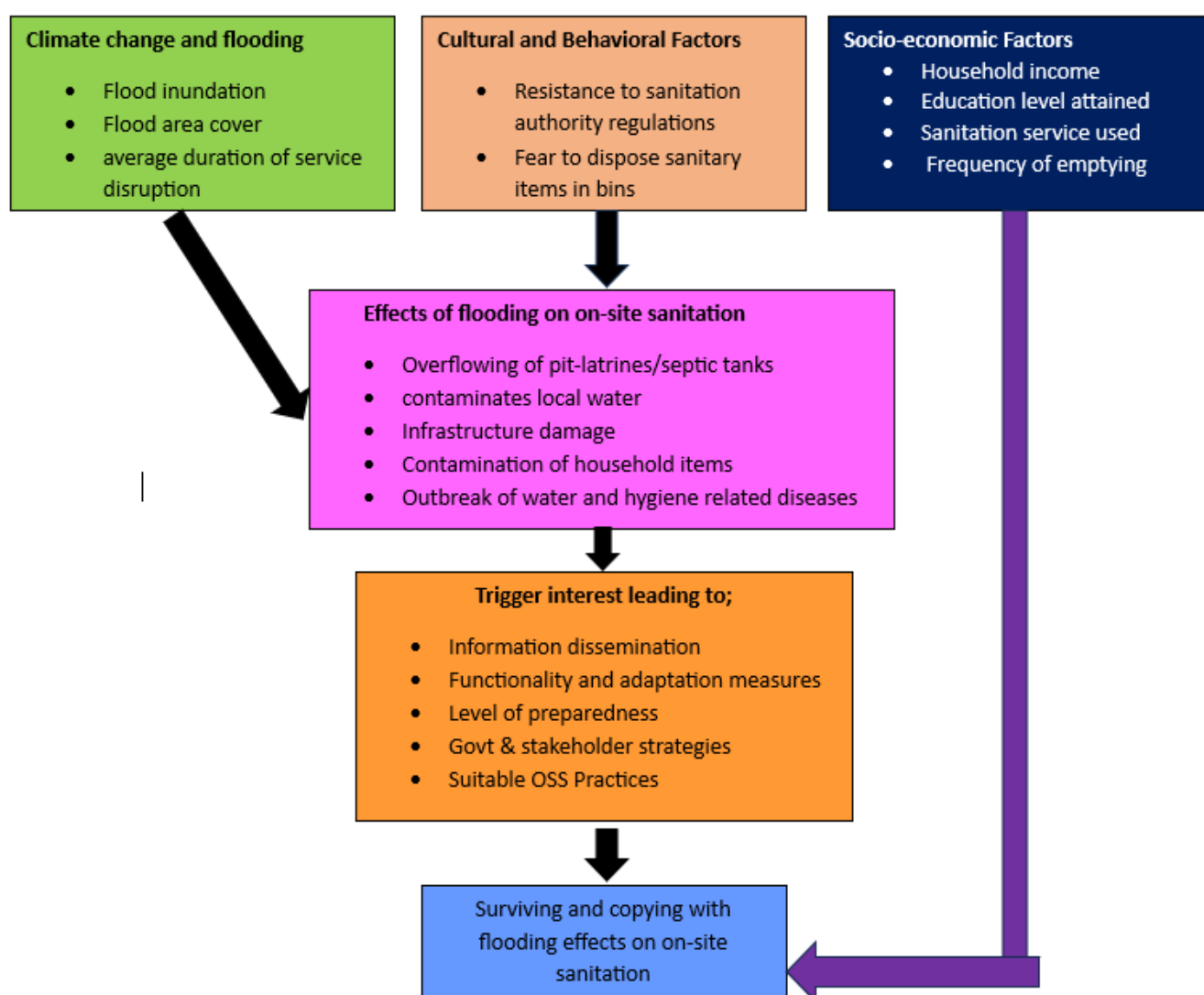
1.8 Conceptual framework

The conceptual framework for understanding the effects of floods on on-site sanitation services revolves around three key objectives which leads to the proposal of a sustainable framework. Firstly, exploring the effects of flooding on the on-site sanitation service chain involves considering variables such as flooding, onsite sanitation infrastructure and services. The interaction here is clear: the severity of flooding directly influences the functionality of sanitation infrastructure and the effectiveness of waste management systems. As floods intensify, the vulnerability of on-site sanitation services increases, necessitating adaptive strategies.

Secondly, the knowledge and awareness levels within the community play a pivotal role. Variables such as community awareness, education levels, and information dissemination are crucial components. The interaction suggests that higher community awareness and education levels correlate with an increased understanding of the effects of flooding on on-site sanitation services. Effective information dissemination strategies are essential in this context, acting as catalysts in enhancing community awareness. This awareness is integral for fostering community preparedness and adaptive measures. Examining the strategies implemented to address on-site sanitation service delivery challenges involves variables such as community strategies, government policies, and stakeholder involvement. The interaction emphasizes that the effectiveness of these strategies is influenced by both community awareness levels and practical considerations related to flooding impacts. Government policies and stakeholder collaboration can either enhance or hinder community-driven strategies. Thus, a comprehensive

approach involving all stakeholders is vital for improving on-site sanitation service delivery in the face of changing climatic conditions and increased flooding.

The conceptual framework (**Figure 1.1**) underscores the interconnectedness of flooding, community awareness, and implemented strategies. Understanding these interactions is imperative for a holistic assessment of the effects of floods on on-site sanitation services in Kanyama Compound and for developing effective and sustainable strategies to address the identified challenges.



Source: (Adapted and Modified from Simpilo Syabwanta 2018)

Figure 1.1: Conceptual Framework on effects of flooding on onsite sanitation services related to climate change.

1.8 Theoretical framework

The Socio-Ecological Systems theory (SES), developed by Ostrom (2007) provided a comprehensive method to study the impacts of climate change-induced flooding on onsite sanitation services, exemplified by the Kanyama Compound in Lusaka, Zambia. This theory highlighted the crucial interconnections between social systems, such as community health and economic stability, and ecological systems, including local water cycles and land conditions. By focusing on these interdependencies, the SES framework helped identify how floods disrupted not only the physical sanitation infrastructure but also the broader community welfare and environmental integrity.

In practical terms, the application of the SES framework in Kanyama guided the creation of resilient sanitation solutions that balanced human needs with environmental sustainability. This involved integrating community-driven, flood-resistant sanitation technologies with ecosystem-based approaches to flood management. Such integrated solutions aimed to bolster both infrastructure resilience and community adaptability, ensuring sustainable sanitation practices even in the face of recurrent flooding.

Moreover, the SES framework encouraged a cyclic approach to learning and policy adaptation, which was vital in dynamically changing environments like Kanyama. Feedback from ongoing projects was used to continuously refine and improve sanitation management strategies. This adaptive policy-making was essential to address the evolving patterns of climate change and shifting community needs, enabling the maintenance of effective sanitation services and the mitigation of flood risks in the long term.

This study was also guided by the Theory of Waste Management developed by Eva Pongrácz, Paul Phillips and Riitta Keiski in 2004 (Pongrácz, 2006). The Theory of Waste Management represents a more in-depth account of the domain and contains conceptual analyses of waste, the activity upon waste, and a holistic view of waste management goals. Waste Management Theory is founded on the expectation that waste management is to prevent waste from causing harm to human health and the environment. The proper definition of waste is crucial to constructing a sustainable waste management agenda. It is largely the case that current legislation attends to existing waste. Definitions emerging from this condition may, however, conflict with waste prevention goals, because something that already exists cannot be prevented from arising. When a material is labelled ‘waste’, it is treated as such; consequently, despite its explicit wish for waste prevention, implicitly, the legislation essentially amasses waste. The inherent philosophical implication of such definitions is that they cannot facilitate a sustainable waste management system.

1.9 Operational Definitions

Effects: refers to changes, consequences, or outcomes that result from a particular action, event, or situation.

Flood: refers to an overflow of water onto land, caused by various factors, including heavy rainfall, and human-induced causes.

Global Warming: In the context of the research, refers specifically to the long-term trend of rising average global temperatures due to human activities, particularly the emission of greenhouse gases.

Climate: refers to long-term shifts in temperatures and weather patterns.

Climate Change: Human induced changes taking place in the world’s climate, especially trends towards global warming, which will deeply impact upon the ecosystem.

Climate variability: In the context of the paper focuses on how annual or seasonal changes, like varying rainfall during the wet and dry seasons, impact the performance of onsite sanitation systems

Resilience: refers to the capacity of Kanyama Compound's onsite sanitation systems to withstand, adapt to, and recover from the adverse impacts of climate change.

Sanitation: is the management of human excreta, defined here as faeces, urine, and menstrual blood

Sanitation services: To the organized management and disposal of human waste and sewage, including the infrastructure and processes involved in the collection, transport, treatment, and disposal or reuse of human excreta and wastewater.

Sanitation system is a series of technologies and services for managing human waste (or resources), i.e., for their collection, containment, transport, transformation, utilization, or disposal (Tilley et al., 2014).

Sanitation service (value) chain refers to the fit and combination of sanitation technologies in place and the quality of services provision within existing institutional arrangements (Spuhler and Lüthi, 2020).

On-site sanitation system is a system that stores human excreta in an in-situ containment, with partial in-situ treatment and/or for collection to treatment or to reuse or to safe disposal.

Strategies: High level plan to achieve one or more goals under conditions of uncertainty or a careful plan or method for achieving a particular goal usually over a short or a long period of time.

Principal Component Analysis (PCA): PCA is a statistical technique used for identifying patterns in data and expressing the data in a way that highlights their similarities and differences.

Factors Extracted: After conducting PCA on the responses from the survey participants, three significant factors related to flooding in Kanyama were identified:

Kaiser-Meyer-Olkin (KMO) Measure: The KMO test measures the suitability of data for factor analysis. In this case, the KMO value was 0.81, indicating that the input variables were suitable for PCA.

Bartlett's Test of Sphericity: This test checks whether or not the correlation matrix is an identity matrix (meaning variables are uncorrelated). A significant p-value (< 0.000) suggests that there are correlations between variables, validating the use of PCA.

Root Mean Square Error (RMSE): Used to evaluate the accuracy of predictive models.

Factor loadings: Indicate the correlation between the variables and the extracted factors.

Chi-squared Statistics: Used to assess the difference between observed and expected data.

R-squared Values: Indicated the percentage of variation in outcomes explained by flood-related variables.

Waste: typically refers to human excreta and other sewage materials that are produced within the community.

1.10 Organization of the Thesis

This thesis was organised into six chapters. The first chapter comprises of the introduction, statement of the problem, purpose of the study, objectives of the study, general research question, research questions, significant of the research study, conceptual and theoretical framework of the study, and operational definition of concept. Chapter two consists of the literature reviews in theme using the objective. Chapter three contains of the methodological outline of the study. The fourth chapter of the study is the presentation of findings. The fifth chapter involve the discussion of findings and lastly the seventh chapter comprises of the conclusion and recommendations generated from the study.

1.11 Chapter Summary

This chapter presented an introduction and outlined statement of the problem. It also defined the purpose of the research, laid out the study objectives, and articulated the research questions. Moreover, it discussed the significance of the study, conceptual and theoretical framework of the study, and operational definition of concept. The chapter concluded with, organisation of the dissertation and a summary.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides a thorough review of the literature. In general, the goal of a review is to critically examine a part of a published body of information by summarising, classifying, and comparing previous research findings, literature reviews and theoretical pieces.

2.1 Status of the literature on climate-resilient sanitation

Since the scientific brief on Vision 2030 (WHO, 2010) that brought attention to the issue, the literature on climate change and sanitation has been gradually growing. There is now emphasis on the physical shocks and stressors that climate change will have on sanitary infrastructure, but there is also a growing body of literature on other factors, which is briefly detailed below. Evaluation of adaptation efforts and actual examples of adaptation are still in their infancy. Most studies have focused on the impact on infrastructure, but a recent review of studies on urban sanitation and climate change shows that the impacts on non-sewered sanitation are understudied (HydeSmith et al., 2022).

Studies on flooding and drought show that sanitation systems can fail in a variety of ways, including collapsing pit latrines, flooding and rising ground water levels that affect onsite system operation, blockages, overflows, or backflows caused by too little or too much water in sewers or decentralized systems, and coastal treatment systems affected by rising sea levels (Howard, 2022).

An inclusive sanitation system adaptable to climate change is described in recent research, together with local government adaptation measures (Willetts et al., 2022). Proactive management techniques, such as proactive desludging before the wet season, preventative maintenance, system monitoring and warning systems, and enhanced drainage management, are one element (Clemenzen et al., 2020). Ongoing but unresolved efforts to measure resilience (Howard et al., 2021) exist. Research to date discusses the restricted availability of climate finance (Dickin et al., 2020). Except a World Bank article that shows the possibility for greater costs (Hallegatte, 2019) and a WaterAid roadmap for finance, there is little information available on the costs of resilient services (WaterAid, 2021).

Although there is a wealth of literature on the impacts on water and sanitation services that poor and marginalized populations are vulnerable to (IPCC, 2022), there is little information on user

engagement strategies. Early thoughts on user involvement tactics are presented in Indonesia (Willett et al., 2022) and in the programs of important development agencies (Gordon and Hueso, 2021).

Methane and nitrous oxide are released during the breakdown of faeces. As a result, all sewage systems produce greenhouse gases. More than anticipated direct emissions were discovered by research in Kampala, with operational factors (such as hauling garbage) being a less significant source of greenhouse gases (Johnson et al., 2022). Reduced anaerobic storage durations (by more frequent desludging of onsite systems), adoption of centralized wastewater treatment systems with gas capture, or usage of dry systems (composting systems) maintaining aerobic conditions are likely required for reducing emissions.

More health dangers are associated with the numerous sanitation system malfunctions that occur during weather events (WHO, 2018). Recent studies show that open defecation may recur during climate events. In cities, common combined sewers (sewers with stormwater) overflowing following heavy rain provide considerable hazards of pathogen exposure (Goore et al., 2015). Moreover, cholera, cryptosporidiosis, rotavirus, typhoid, and other diarrhoea disorders are more common when there has been a lot of rain or flooding (Levy et al., 2016). Moreover, flooding has been linked to increased skin conditions (Alderman et al., 2012). In Bangladesh, a study found that the wet season had greater *E. coli* levels in drains than the dry season did (Amin et al., 2020).

2.2 Impacts of climate change on sanitation

The impacts of climate change such as drought and flooding are first felt on water supply quality and use. Climate change can disrupt water supplies and sanitation facilities leaving contaminated water and putting millions of lives at risk (UNICEF, 2016). When people lack clean water, people are at risk of diseases such as diarrhea. Most regions in the world at risk of droughts and floods have low levels of access to water and sanitation, and the populations living in these areas are extremely vulnerable (UNICEF, 2016). Further study is necessary to understand how to boost access to sustainable water sources and enhance sanitation to deal with a changing environment, nevertheless, in order to address the problem of climate change. Increased frequency of floods, which significantly influence the urban water supply and sanitation sector, together with more frequent droughts and higher average temperatures that lead to severe water stress, are all signs of the impact of climate change (World Bank, 2013).

Climate change is expected to impact the hydrological cycle and rainfall patterns across Africa which will put pressure on water availability, demand, and accessibility, which has great influence on economic development. In the African continent, the water sector is very sensitive to climate change. Climate change is expected to hamper water and sanitation infrastructure operations and services (WHO, nd). Current population patterns and water use trends show that countries in “Africa will exceed the limits of their economically usable, land-based water resources before 2025”. However, the impact of climate change on sanitation across the continent will be felt in different ways. It will change the amount of water in some areas while decreasing it in others.

Urbanization is growing rapidly in Africa; the percentage of people living in urban areas is expected to grow from 36% in 2010 to 50% in the year 2030 (World Bank, 2015). According to UN-HABITAT, “Over 25% of the world’s 100 fastest-growing cities are now in Africa and this rapid growth raises concerns over water security. Water security concerns partly arise as utilities responsible for piped water and sewerage struggle to keep pace with population growth and demand for such services”. However, the inhabitants of informal settlements rely on water vendors who sell water or from illegal water pipe connections, which are inadequate (Gronwall et al., 2010). Climate change is expected to have an enormous impact on sanitation service delivery.

Unplanned urban development has been taking place because of an increase in urban population. Under such circumstances, pit latrines, uncollected waste and other environmental pollution hazards are widespread and most likely contaminate ground water sources. Initially, residential sites were constructed at a distance from such hazards. The contamination of well water is linked to inadequate well protection and well lining which might be an entry point for sewage in the underlying underground water sources from surrounding pit latrines (UNICEF, 2017).

The majority of the literature regarding the impact of climate change on water deals with water resources, but the literature on the specific threats to sanitation services is growing. Howard and Bartram (2013) provide a global assessment of the resilience of water and sanitation technologies and management systems. They provided assessments of the robustness of technologies under several climate scenarios. The threats from climate change relate to changes in temperature and in precipitation, leading to changes in hydrology and water demand, as well as to storm events that damage water and power supplies. The threats relate to increasing

unpredictability in surface water flows and a consequent change in demand for groundwater, as well as floods and declining water availability. These changes may be experienced in the same location at different times. Changes may be experienced through short-term, unpredictable events and slow-onset events. The impacts of climate change on sanitation infrastructure are a mix of positive and negative, depending on the nature of the changes likely to occur with climate change and changes in the types of technologies demanded by households. The literature on climate impacts on sanitation is extremely sparse, even though the impacts will be at least as significant as those for water supply and may have greater impact in some circumstances.

In countries likely to become drier, the impact on simple onsite sanitation infrastructure may be positive, as groundwater pollution risks may reduce as the distance between the base of pits and groundwater (and hence travel time for pathogens) increases. Drying environments may also mean that seasonal groundwater flooding of pits will be less frequent. Such technologies may be vulnerable to damage and destruction from short-term flood events. By contrast, both declining water availability and increased flooding will pose major threats to sewerage and septic systems reliant on water. Securing sufficient water to ensure conventional sewers function as designed may be problematic and, even for modified sewerage, securing sufficient volumes of water for flushing and operation may be challenging. Declining water flows may adversely impact water quality in rivers receiving wastewater, although at present, the low rates of treatment in sewerage systems indicate that other factors may be more important than climate change in the foreseeable future (UNICEF, 2017).

Where annual rainfall increases or there is a shift to higher intensity events, the impacts on sanitation may be more profound. For onsite sanitation, the risks are primarily related to flooding and may have very serious public health implications. All onsite systems are vulnerable to flooding, and under more severe conditions, this may result in widespread spillage of fecal matter in the environment and to contamination of drinking water supplies. In a review of sanitation technologies, Sherpa et al. (2010) concluded that only dry urine-diverting latrines could be considered resilient, mainly because the absence of water made the construction of watertight tanks fully aboveground feasible. Howard et al. (2016) deemed pit latrines more resilient due to the modifications that could be made. Septic systems were considered vulnerable because of the potential of floatation brought on by rising groundwater levels, in addition to floods and the release of the tank's contents into the environment.

Fecal sludge management (FSM) chains may be vulnerable to climate impacts. In urban areas in particular, FSM as a system is gaining traction as the demand for low-cost toilets drives the demand for simple pit latrines, but space constraints preclude approaches used in rural areas (replacing latrines once a pit is full). Typically, FSM chains involve collecting and transporting waste in vehicles, with disposal in a treatment facility. Clearly, flooding risks will impact emptying vehicles' ability to access communities if roads become impassable (UNICEF, 2017).

2.3 Vulnerability to climate change-related diseases

The effects of climate change will be progressively felt in the African region. Climate change and urbanization will cause more unpredictable events and disease burden (IPCC, 2007). The analysis of climate data for precipitation and temperatures show that cholera epidemics are related to El- Niño years and are triggered by unusually warm and wet seasons, and surveys showed that the affected communities are highly vulnerable (Olago et al., 2007).

Most urban inhabitants are poor and rely on either small business incomes or self-employment. Only 8% in the urban informal settlements had a source of income from formal employment (Olago et al., 2007). Monthly incomes of the urban poor are quite low. Poverty increases risk and susceptibility to diseases such as cholera and malaria because they lack funds to access medical facilities. Further, the health care systems in the lake basin areas cannot cope with climate-induced diseases such as cholera, thus rendering the communities vulnerable to climate variability and change.

The links between events associated with climate change and disease are increasingly well-documented. Increases in global temperature have been linked to increasing rates of diarrheal disease. Carlton et al. (2004) found positive relationships in all-cause diarrhea and diarrhea caused by bacterial infections and increases in ambient temperature. There was no relationship between viral infections and increases in ambient temperature. There was significant regional variation, with bacterial infections being most strongly related to increases in temperature in tropical zones. Carlton et al. note that this requires further evaluation as many of these settings have low access to water and sanitation and pre-existing high infection rates. WHO (2009) estimates climate change will cause an additional 48,000 diarrheal deaths in 2030.

In a review of extreme water-related weather events, Cann et al. (2009) concluded that outbreaks were commonly associated with contamination of drinking water supplies. In a systematic review of the relationship between flooding and health, Alderman et al. (2008) found that infectious disease outbreaks are much more likely in areas with poor water and sanitation

services. They found that infectious disease epidemics tended to occur only when there was mass population displacement by floods and that there was good evidence of increased water-related disease after floods. Leptospirosis was identified as causing epidemics during floods and as a key post-flood pathogen with cholera, hepatitis A and E, and pathogenic *E. coli* outbreaks post floods.

2.4 Vulnerability of slum dwellers to climate change

The existing literature encompasses a lot of definitions, concepts, and methods to contextualize vulnerability. “Vulnerability is the propensity or predisposition to be adversely affected” (IPCC, 2012). “It is a dynamic concept, varying across temporal and spatial scales and depends on economic, social, geographic, demographic, cultural, institutional, governance and environmental factors” (FAO/OECD, 2012). On the other hand, the United National Development Programme describes vulnerability as “A human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard” (UNDP, 2004).

Urban vulnerability in low-income settlements is influenced by location. Few low-income settlements are well planned and well located (Satterthwaite et al. 2007). The pro-poor populations tend to live in slums or informal settlements, where the houses are self-built and sub-standard. The settlements lack adequate water, drainage, and basic facilities, and are situated in risk-prone areas (World Bank, 2010). About one billion people in the world lived in these conditions in 2010, and the figure is expected to rise by 1.4 billion by 2020 (WDR, 2010).

Africa’s urban informal settlement dwellers are specifically vulnerable to the negative health effects of global climate change and rapid urbanization (WHO, 2009). There is a need for further research to understand the impacts of climate change on the health in the urban informal settlements, to come up with context-specific and appropriate adaptation strategies. Public health interventions in Africa must put in consideration the relationship between urbanization and climate change and their impact on health on pro-poor urban populations (WHO, nd). In the African context, the ramifications of climate change will be exacerbated by burgeoning population growth, potentially resulting in heightened migration to urban areas, a standpoint contested by Potts. Despite a significant surge in sub-Saharan Africa's urban population since 1990, the proportion of individuals without access to improved drinking water sources (17 per cent) and sanitation facilities (57 per cent) has endured a consistent pattern. Those deprived of

access, typically residing in flood-prone areas on marginal land, face challenges. Areas with secure and legal water sources often rely on water kiosks, operated by local service providers, serving as a compromise compared to household connections. These kiosks, supported by the main water utility, face limitations due to a lack of financial and technical capacity. Similarly, the urban poor, seldom connected to sewage networks, resort to on-site sanitation like pit latrines, with responsibilities varying based on national and local regulations. Climate change is poised to significantly impact these service providers, exposing gaps in current water management and sanitation practices, which have predominantly been ad hoc in sub-Saharan African utilities, addressing short-term concerns without a systematic approach to climate vulnerability. Despite debates over the feasibility for water managers in low- and middle-income countries to incorporate climate change into their daily management practices, adapting to present climate variability is an integral aspect of water management, with the efficiency hinging on utilities' governance. Current efforts at various government levels and international institutions are underway to initiate climate change adaptation, especially in the water resources sector. However, a comprehensive vulnerability analysis and impact assessment are largely absent in low- and middle-income countries, necessitating a shift from generic global impact assessments to more locally focused adaptation mechanisms. Adaptations should prioritize enhancing the resilience of water providers to climate variability, acknowledging that future long-term changes may introduce unforeseen risks to projects.

2.4. 1 Scenario in Zambia

Despite being endowed with a substantial amount of Southern Africa's water resources, Zambia faces water scarcity due to intricate seasonal and temporal rainfall patterns and insufficient investment in infrastructure. In contrast, Kanyama, characterized by its flat and rocky terrain, serves as the city's natural drainage plain, leading to severe flooding. Water provision relies on community cooperatives, employing boreholes and kiosks licensed by the city's primary water utility through a Memorandum of Understanding. Additionally, some families resort to using shallow wells for drinking water, despite their designated non-consumptive use. Sanitation facilities predominantly consist of pit latrines, supplemented by ecosan programs and efforts to elevate latrines. Zambia faces significant climate change risks, anticipating heightened floods and droughts and a reduction in miombo woodland and maize yields. Projections indicate an increased mean temperature, with more frequent "hot" days and nights and fewer "cold" instances. Anticipated rises in total rainfall, rainfall intensity, and extreme events, especially droughts and floods, further compound the challenges.

The scenario is formulated for Lusaka based on precipitation variations. Elevated precipitation is likely to raise the main river (Kafue) and groundwater levels, intensifying localized flooding. Conversely, reduced precipitation could lower the groundwater level, with most respondents believing that current groundwater abstractions surpass recharge levels, rendering them unsustainable.

Conversely, increased rainfall or rainfall intensity may lead to flash floods damaging boreholes, kiosks, septic tanks, and pit latrines. Poor drainage exacerbates these challenges, potentially causing an influx of climate-driven migrations, intensifying land pressure and compounding limited latrine-emptying options. In contrast, Kanyama is most susceptible to increased rainfall, causing prolonged flooding episodes, as observed during the 2009–2010 flood lasting three months (Muller, 2017). Flooding results in infrastructure collapse, water supply contamination, disruption of sanitation service provision and widespread repercussions on livelihoods, education, and health. Strategies to mitigate health risks from flooded latrines include assistance with emptying and elevating latrines, and the prospect of decentralized sewerage in the long term. However, such adaptations hinge on improved drainage, a challenge given that the poorest households, unable to afford upgrades, own the most problematic latrines.

In Kanyama, the priority is reducing localized flooding, requiring collaboration with the council and utility to develop and clear drains of rocks and debris. Health risks from inundated latrines necessitate assistance with emptying and elevating latrines. Long-term solutions include considering decentralized sewerage, contingent on improved drainage. Technical support and financial mobilization by the local water utility (Lusaka Water and Sewage Company) are crucial, alongside the council establishing better planning and zoning legislation. Expanding the water kiosk network is also proposed to ensure every household's proximity to a water kiosk, facilitating access to safe water during floods, thereby enhancing community health.

2.5 Awareness and knowledge of climate change

Previous research shows widespread awareness of the issue of climate change. In England, 99% of the public have heard of either 'climate change', 'global warming' or 'the greenhouse effect', although the term 'climate change' alone is less widely recognised than 'global warming'. Similarly, two-thirds of the British public say they know 'a great deal' or 'a fair amount' about 'global warming', compared to 59% who claim this level of knowledge about 'climate change' (Norton & Leaman, 2004). The proportion claiming to understand 'global warming' in Europe is slightly higher at 72%. The gap in awareness by terminology may be due to the media's

predisposition to use "global warming" rather than "climate change," the phrase preferred by scientists and decision-makers (Corbett & Durfee, 2004).

In Africa, the awareness and knowledge of climate change vary significantly across different demographics, similar to trends observed in Asia, Europe, and America. Studies indicate that men, graduates, and middle-aged individuals generally possess higher levels of awareness about climate change. For instance, in Sub Saharan region, it might be observed that a higher percentage of men are aware of the causes and impacts of climate change, while women may more frequently identify unrelated factors like ozone depletion as causes (adapted from DEFRA, 2002). Additionally, individuals with higher educational attainment or specific science qualifications are likely to have a deeper understanding of climate change processes and its consequences, such as sea level rise, reflecting a broader trend where education correlates with climate change awareness (Hargreaves et al., 2003).

Furthermore, the media's role in shaping public perception of climate change in Zambia could mirror that of broader international trends. For example, individuals who consume content from more in-depth news sources might demonstrate better knowledge of accurate and inaccurate causes of climate change compared to those who rely on less detailed sources. This disparity suggests a need for targeted educational initiatives that cater to varying levels of existing knowledge and access to information across different social classes. Such differences underline the importance of incorporating diverse educational strategies within Zambia to effectively raise awareness and understanding of climate change across all sections of the population, thereby promoting informed and inclusive responses to environmental challenges (Bibbings, 2004).

2.6 Strategies to mitigate the impacts of climate change

On a national scale, Nepal has included sanitation goals in their Nationally Determined Contributions (NDCs), and the Kampala City Council has adopted the national climate action plan at the local level by establishing budgeting and accounting procedures that consider climate change's effects on urban sanitation. The National Adaptation Plan for Fiji includes sanitation-related adaptation strategies (WHO, 2018).

A comprehensive national strategy on sanitation and climate change is being developed in Bangladesh. A specialized technical assistance unit (CWIS-FSM Support Cell) with experience in disaster risk reduction, including sanitation in emergency response, has been developed throughout the nation to support institutional capacity. This team is working on advocacy to

connect mitigation and sanitation in the nation's National Adaptation Plan. In addition, Bangladesh's recently updated WASH strategy considers climate risk. The Environmental Protection Agency in the US launched the Creating Resilient Water Utilities (CRWU) effort to give utilities the useful equipment, instruction, and technical support they need to become more resilient to climate change (WHO, 2018).

The Country Climate and Development Reports (CCDRs) of the World Bank are used as a strategic instrument to start conversations with nations that can muster political will and leadership and assign institutional duties. The World Bank is working to include WASH in all CCDR documents, even though some nations have begun integrating sanitation in their CCDRs (WHO, 2019).

An SDG roadmap that incorporates WASH in climate resilience is being developed by Indonesia's national planning organisation, Bappenas. They are being produced concurrently to build upon one another, use the chance to advocate at the ministerial level, and inspire political will. In 2022, Indonesia served as the host country for the SWA Sector minister's summit, which featured climate change as a theme and served as a platform for advocacy at the highest levels. Early work on monitoring frameworks has begun, and there is discussion over the proper ratio of "process" and "outcome" indicators (Johnson, 2022).

By considering the effects of climate change on their sanitary infrastructure development projects and related institutional improvement, the African Water Facility at the African Development Bank and the Asian Development Bank are promoting institutional reform through their investment funding. The African Sanitation Policy Guidelines, published in 2021, are a significant document that emphasises the necessity of sanitation systems and ancillary elements like drainage and urban land use planning and control to be climate change resistant. The fact that decision-makers must make several decisions concurrently to build resilience is a fundamental difficulty because they lack the institutional framework and capacity to support this. In order to help them with these choices, the WASH sector should share best practice examples for enhancing resilience and modifying current systems (Johnson, 2022).

In Zambia, national level stakeholders are engaging with climate actors including the meteorological department in the UK, better to understand the linkages between urban sanitation and climate events, to improve access to relevant climate data, involving local authorities in the process. They are also working across multi-sectoral actors to formulate guidelines for climate resilient sanitation and risk assessment tools (WHO, 2019).

To gather baseline data and track the GHG emissions from sanitary infrastructure at the national level, GIZ is collaborating with Zambia's water companies and the national regulator. This is a wonderful illustration of institutional utility will and political regulator will, as these organisations typically prioritise coverage over maximizing climate resilience and mitigation. In order to develop legislation and establish standards moving forward, the engagement of NGOs or private sector implementers can be vital in providing evidence influenced by climate risk. For instance, the Lusaka Water Supply and Sanitation Company and Bremen Overseas Research and Development Association (BORDA) in Zambia have gathered considerable data on the demand for pit emptying services and have noted seasonal changes, including notable increases during the wet season. In order to reduce overflows during the rainy season, they are utilising this evidence to support government officials who are developing rules on pit siting with respect for locations with a high-water table (WHO, 2018).

With measures like advising treatment facilities to be lined with sulphur-resistant cement to prevent corrosion, designing septic tanks for faecal sludge with low total suspended solids, and using biogas digesters for primary treatment of faecal sludge to trap GHG gases that are to be burned, BORDA is working on different ways to adapt sanitation infrastructure in Zambia to be climate resilient. École Polytechnique de Thiès is developing a multi-sector, government-funded programme in Senegal to lower emissions from sewage waste. This involved constructing a biogas plant to meet the catchment communities' energy demands and using the energy from the biogas plant to purify water. Sludge's potential as a feedstock for the biogas plant was also investigated by the university. Similar to this, African Development Bank (ADB) is promoting various technological solutions for onshore and offsite sanitation that encourage the reuse of sludge and wastewater by using a circular economy strategy (WaterAid, 2021).

2.7 Research gaps

Firstly, most studies on lay people's perceptions of climate change were conducted in developed countries, leaving the scientific world largely ignorant about the development of public understanding in developing and least developing countries. To be precise, too little is known in the literature about perceptions of people dubbed as possible victims of climate change impacts. Existing literature, thus, is able to explain public understandings of climate change only in the countries largely charged as being "responsible" for the global warming problem due to their emissions of the greenhouse gases. As such, these studies emphasize public understanding and response to "mitigation" of climate change while the issues of "adaptation"

are largely ignored. The study of how public perceptions of climate change risks are developing in nations bearing the brunt of the effects of climate change, but which have made relatively modest contributions to greenhouse gas emissions, is becoming more and more in demand in academia.

Secondly, the volume of literature is mainly drawn from quantitative analysis of public perception and behaviour, which is now able to describe the level of public knowledge, understanding and attitude towards climate change risks and related issues to a large extent. Yet, factors that actually influence behavioural actions of individuals in dealing with climate change risks, and why, remain unexplained. In many ways, the quantitative approach based on generating research questions and hypothesis from existing theoretical models and testing them against empirical data (Flick, 2009) has been unable to answer these questions. It is therefore necessary to address this existing methodological deficiency.

There remains a need for qualitative research on the ways in which individuals define, perceive, and understand risks of climate change and related issues within a specific socio-cultural context. Third, although risk perception and communication are not mutually exclusive, most studies have approached the phenomena separately. There remains a gap in integrating these two concepts in understandings of public perceptions of climate change. Additionally, only a handful of studies attempt to identify individuals' different sources of climate change knowledge, influencing their perceptions. Even in these studies, the primary focus is on the role of the news media in communicating climate change to the people.

This is partially comprehensible given that the majority of the studies were carried out in industrialized nations where the news media is the main source of information on climate change. However, there is a need for academic attention because both formal and informal means of communication may also significantly impact how the public understands and reacts to the impacts of climate change. This feature becomes even more crucial in traditional communities where much of the communication still takes place outside of the mainstream media.

2.8 Chapter Summary

This chapter provided a comprehensive overview of the existing literature on climate-resilient sanitation, detailing the effects of climate change on sanitation services and the vulnerability of populations to climate-related diseases. It specifically addressed the susceptibility of slum dwellers to climate change, with a focused examination of the situation in Zambia. The chapter also evaluated the current level of awareness and knowledge concerning climate change, highlighting the strategies implemented to mitigate its impacts. Furthermore, it identified significant research gaps that need addressing to enhance the effectiveness of these strategies and improve resilience against climate change's effects on sanitation.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter provides a detailed account of the methodology employed in the study, focusing on the effects of flooding on onsite sanitation services related to climate change in Kanyama compound, Lusaka District. The study site, Kanyama settlement, is a dynamic area characterized by high population density, inadequate sanitation facilities, and susceptibility to waterborne diseases during the rainy season. The chapter outlines the research design, sampling procedures, data collection tools, and analytical methods used to explore the complex dynamics between climate change-induced flooding and onsite sanitation services in Kanyama.

3.1 Study site

The study area, Kanyama settlement, is an improvement area, which was legalized in 1999 by the Ministry of Local Government under the statutory and improvement areas Act of 1999. The settlement is located 7 km west of the Central Business District (CBD). It is bordered by Los Angeles and Mumbwa roads on the western and eastern sides respectively (Figure 3.1). The population was 525,902 as of 2022 (CSO, 2022). Kanyama is characterized by its substantial informal housing and reliance on onsite sanitation facilities. (CSO, 2022) with 90,995 informal housing units that rely on onsite sanitation facilities for excreta disposal (Nyambe, et al., 2014). Most residents live in rented multi-roomed dwellings that accommodate more than one family. Its proximity to the city's CBD is responsible for its big size and high population density, as most of its residents are primarily migrants from the rural areas coming to seek employment opportunities in the city especially the CBD. Access to adequate sanitation and the existence of service like solid waste collection is very poor in the settlement. The low access to sanitation facilities, unavailability of an effective FSM system, a porous geology as the area is sited on dolomite and a high-water table perpetuates outbreaks of water borne diseases such as cholera and typhoid during rainy season. During the 2017/2018 cholera outbreak in the city of Lusaka, Kanyama peri urban area (PUA) alone accounted for over 1,000 cholera cases (WHO/MoH, 2018), making it one of the worst affected areas in the country. Selection of Kanyama settlement as a study area was dictated by availability of an FSM enterprise in the area and recent flashfloods in the past rain seasons. In the study area, Kanyama Water Trust offers faecal sludge desludging services in partnership with Lusaka city council.



Figure 3.1: Research site: source (Chamisa, 2022).

3.2 Research design

This study adopted a mixed-methods research design to investigate the effects of climate change-induced flooding on onsite sanitation services in Kanyama compound, Lusaka District. The research focused on household heads, utilizing systematic random sampling to select 210 respondents across all six wards. This mixed-methods approach offers a comprehensive exploration of the research topic, combining quantitative precision with qualitative depth. By integrating these methodologies, the study enhances the credibility and richness of its findings, contributing valuable insights into the intricate dynamics between climate change-induced flooding and onsite sanitation services. Through systematic data collection and rigorous analysis, the research aims to inform effective strategies and policies, not only benefiting the local context in Kanyama but also providing valuable lessons for similar vulnerable communities globally.

3.3 Sampling procedure and sample size

This research Sampling Procedure and sample size

This research employed a systematic random sampling for the households and purposive sampling of key targeted stakeholder's key informant interviews for both qualitative and quantitative data. With an estimated population of over 525,902 people living in Kanyama. Using the sample size calculation formula below, 214 households were surveyed and 5 stakeholders implementing sanitation in Kanyama were interviewed. The household heads were targeted since they are responsible for the well-being of their families. Systematic random sampling was used to select the houses that were to be sampled in all six wards as well as household heads for the research instruments. In selecting the houses to be sampled, all wards were listed down randomly and every 6th house in the list was chosen for sampling. To arrive at the sample size of 214 a formula below was used.

$$N = \frac{z^2 \cdot p \cdot q}{e^2} \quad \text{Given values:}$$

$$N \text{ (population size)} = 525,902$$

$$e \text{ (margin of error)} = 0.067 \text{ (6.7\% expressed as a decimal)}$$

$$p = 0.5$$

$$q = 1 - p = 0.5$$

$$Z \text{ for a 95\% confidence level is approximately } 1.96$$

Now substitute these values into the formula

$$n = ((1.96)^2 \cdot 0.5 \cdot 0.5) / (0.06)^2$$

$$n = (3.8416 \cdot 0.25) / 0.004624$$

$$n = 0.9604 / 0.004624$$

$$n = 214$$

Therefore, the sample size (n) needed for a population of 525,902 with a margin of error of 6.7% is approximately 214.

This research returned a response rate of over 98% (210 out of 214) considered to be very high in survey research, indicating a successful data collection process and lending credibility to the study's outcomes. Such a high response rate is indicative of the respondents' engagement and

interest in the subject matter, which enhances the quality of the data collected. Additionally, most statistical techniques are robust enough to accommodate this level of non-response without compromising the integrity of the analysis. This response rate reinforces the generalizability of the study's conclusions and signifies that the findings are reflective of the broader population's perspectives and experiences.

3.4 Piloting of research instruments

The questionnaire utilized in this study was meticulously crafted by the researcher and underwent a rigorous pilot testing phase conducted in one ward of Kanyama Constituency. This pre-study assessment involved the administration of 12 questionnaires, meticulously designed to capture relevant insights. These preliminary questionnaires constituted 5% of the total respondents anticipated for the broader study, as per the methodology outlined in Papachristou et al.'s work in 2023. The pilot testing allowed the researcher to fine-tune the questionnaire, ensuring its clarity, relevance, and effectiveness in extracting valuable data from respondents. This careful approach to questionnaire development and testing not only bolstered the validity and reliability of the study but also served as a testament to the researchers' commitment to precision and thoroughness in their research methodology.

3.5 Data Collection Tools

Table 1. data collection tools

S/N	DATA COLLECTION TOOL	METHOD OF COLLECTION	TOOL OF COLLECTION
1	Primary data	Structured questionnaire	Guided schedules
		In-depth interviews	Guided schedules
		Direct observations	Note taking, Photographs
		Participation observations	Note taking, Photographs
2	Secondary data	Documents, reports, journals, magazine, newspapers, and thesis.	• Reading • Reviewing

3.5 Data collection

Qualitative data was collected through in-depth interviews with key informants from Kanyama Water Trust (KWT), Lusaka City Council (LCC), Lusaka Water and Sanitation Company (LWSC), Chazanga Water Trust (CWT), and Plan International Zambia. including local government officials, community leaders, and representatives of non-governmental organizations working in the sanitation sector in Kanyama.

Quantitative data was collected through a household survey of 210 households using a questionnaire, while the other data was collected from the Meteorological Department of Zambia and Kanyama Hospital. The survey collected information on household demographics, sanitation facilities, water supply, waste management, and the effects of climate change on onsite sanitation service delivery. Using the structure under Ministry of Health (Kanyama level Hospital), the environmental health technologist (EHT), and the hospital volunteers administered the questionnaire at household level.

3.6 Data analysis

This study employed a comprehensive approach to data analysis, combining qualitative and quantitative methods to derive meaningful insights. The qualitative data collected was meticulously analyzed using the thematic analysis package Delve, allowing the researcher to identify recurring themes, patterns, and nuances within the responses. Thematic analysis provided a deep and nuanced understanding of the qualitative data, enabling the researchers to extract rich narratives and perspectives from the participants.

Simultaneously, the quantitative data gathered from the survey underwent a rigorous analysis using the Statistical Package for Social Sciences (SPSS Version 22). This robust statistical tool facilitated the systematic organization, interpretation, and presentation of quantitative data, ensuring the reliability of the study's findings. To delve even deeper into the quantitative data and extract underlying factors, the researchers employed Principal Component Analysis (PCA). PCA enabled the researchers to identify essential variables and reduce the dataset's dimensionality, simplifying the complex relationships within the data.

Furthermore, the extracted factors from PCA were subjected to a sophisticated statistical analysis known as the Seemingly Unrelated Regression (SUR) model. This advanced modelling technique allowed the researcher to explore the relationships among these factors, uncovering intricate connections that might not be apparent through individual analyses. By integrating

qualitative and quantitative analyses and employing advanced statistical methodologies, the study not only provided a holistic understanding of the research topic but also offered a nuanced and comprehensive perspective that enriched the research findings and contributed to a deeper understanding of the complex interplay between climate change-induced flooding and onsite sanitation services in Kanyama.

3.7 Validity and Reliability

To ensure the quality and trustworthiness of this study, the principles of validity and reliability played a pivotal role in the research process. The researcher piloted the research instruments and upheld a well-structured data collection and analysis approach. Qualitative data was subjected to thematic analysis using the Delve package, ensuring that the themes and patterns extracted represented the participants' responses. On the quantitative side, the utilization of the Statistical Package for Social Sciences (SPSS) and Principal Component Analysis (PCA) contributed to data validity by systematically organizing and interpreting the quantitative data. Furthermore, applying the Seemingly Unrelated Regression (SUR) model, which considered the relationships between extracted factors, added depth to the quantitative findings, enhancing their overall validity. Reliability was maintained through the careful design of questionnaires and the pilot testing, ensuring consistency in data collection. The rigorous and methodical analysis of both qualitative and quantitative data lent robustness to the research findings, assuring that they accurately reflected the complexities of the relationship between climate change-induced flooding and onsite sanitation services in Kanyama.

3.8 Limitations

The limitations in research were the constraints in design, methods or even researchers' limitations that affect and influence the interpretation of your research's ultimate findings.. Limitations in research can arise owing to constraints on design, methods, materials, and so on, and these aspects, unfortunately, may have an influence on your subject's findings. One major limitation to this study is that the findings cannot be generalized because it was done in one particular district with different environmental conditions. Some participants were a bit reluctant to take part in the study due to their hectic schedules and the nature of their jobs. Consequently, it was challenging to collect data from a large number of respondents. Some responders were not eager to divulge information since they would need compensation to do so. However, the study was carried out notwithstanding any difficulties that arose.

3.9 Ethical Consideration

Ethical clearance was secured from the University of Zambia Ethical Review Committee, underscoring the rigorous ethical standards adhered to in this study. Prior to commencing data collection, the study's purpose was clearly elucidated to all participants. Written consent was diligently obtained from individuals with literacy skills, demonstrating their informed and voluntary participation. For those unable to read and write, verbal consent, obtained orally, will be meticulous and respectful. The confidentiality of each participant was zealously safeguarded by eliminating any potential identifiers, including names, ensuring their privacy and anonymity. It is imperative to emphasize that all information gleaned from the study participants will be held in strict confidence, underscoring the unwavering commitment to ethical research practices and the dignity of every individual involved in this study.

3.10 Chapter summary

The chapter began with an overview that outlined the overall path of the methods used in the research. It then proceeded to describe the study site, providing context and geographical details crucial for understanding the setting of the study. The research design was elaborated upon, detailing the methodology and approach used to investigate the research questions. The sampling procedure and sample size were explained, offering insights into how participants were selected and the rationale behind the size of the sample. A section on the piloting of research instruments discussed the preliminary tests conducted to ensure the effectiveness and appropriateness of the tools used for data collection. The data collection tools were then detailed, followed by the actual data collection processes, highlighting the methods used to gather the necessary information. Data analysis was covered next, describing the statistical or qualitative techniques employed to interpret the collected data. The chapter also addressed the validity and reliability of the research methods and outcomes, ensuring the study met academic standards. Potential limitations of the study were acknowledged, providing transparency about any factors that could affect the results. Finally, ethical considerations were discussed, emphasizing the measures taken to conduct the research responsibly and ethically. This comprehensive chapter laid a solid foundation for understanding the research methodology and ensured the integrity and reliability of the study findings.

CHAPTER FOUR RESULTS

4.0 Introduction

This chapter delves into the intricate relationship between demographic characteristics, challenges faced, and the profound effects of flooding on onsite sanitation services. Through a meticulous analysis of gender distribution, educational levels, household income, residence duration, and sanitation facilities, the study provides a comprehensive understanding of the community's socio-economic context. Furthermore, the chapter sheds light on the knowledge and awareness levels of the community regarding climate change and its repercussions on sanitation services. By identifying key themes emerging from community perspectives, the chapter uncovers disparities in awareness and proposes tailored education programs to effectively bridge knowledge gaps. The strategies implemented by the community, government, and stakeholders are explored, highlighting collaborative efforts, infrastructure development, and policy initiatives. The culmination of these findings is encapsulated in a sustainability model, offering recommendations for improving onsite sanitation service delivery amidst the challenges posed by climate change.

4.1 Demographic Characteristics and general views of respondents

The socio-economic characteristics such as gender, educational level, household income, duration of respondents stay, family size, type of sanitation facility, number of people using sanitation facility, and frequency of emptying Sanitation facilities including general views of respondents on challenges of using onsite Sanitation facilities , waterborne disease prevalence changes, change in rainfall patterns, increased flooding experiences, and change in temperature patterns were investigated to understand respondents and further depicted through descriptive statistics. These were studied or undertaken to provide the general characteristics of the inhabitants of the research area.

4.1.0 Gender distribution

This is an important demographic characteristic in research that helps underscore the distribution of respondents. The distribution of respondents in terms of gender indicated female to be 138 and male 72.

4.1.1 Educational levels

The level of education serves as a crucial demographic characteristic in this research as it directly influences the knowledge and awareness levels of the respondents regarding the effects of floods on on-site sanitation services (Figure 4.1), those who indicated having not received education were 20, attended primary 74, secondary 73 and tertiary 43. A higher level of education is anticipated to correlate with an increased understanding of the intricate dynamics between flooding and sanitation infrastructure.

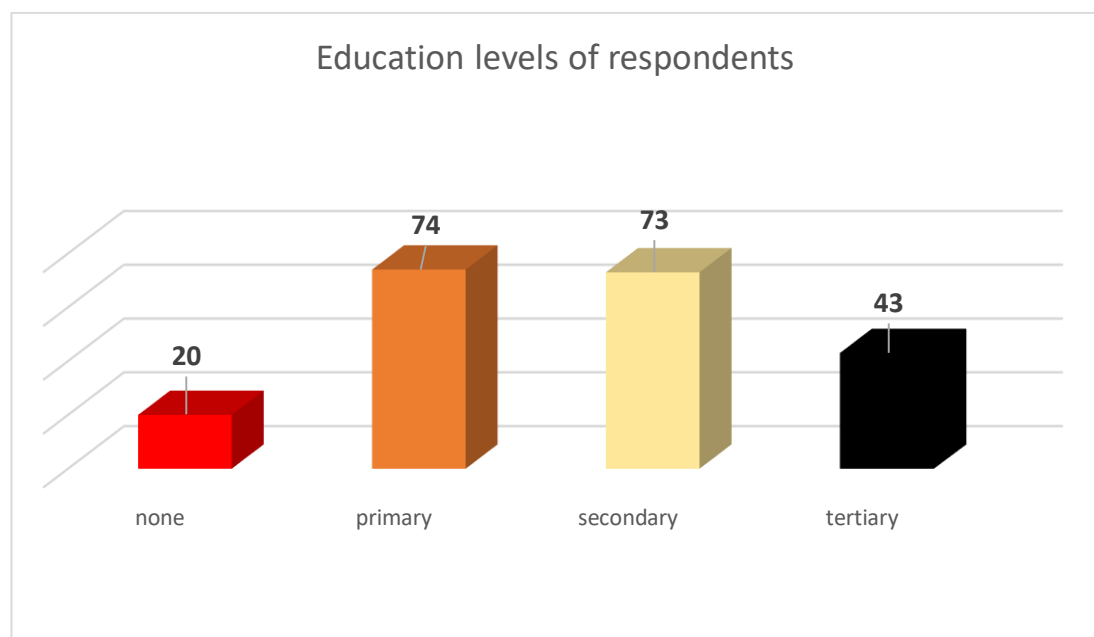


Figure 4.1; Education levels of respondents (source; filed data 2023)

4.1.2 Household income and Residence duration

As indicated in figure 4.3 below, the demographic characteristics of household income revealed that only 68 had income below k1000, 95 respondents had k1100 to k2000, 23 with k2000 to k3000, while 24 k3000 and above. Residence duration results showed that respondents who have stayed for a year were 44, above one year 40, between two years and three years 25 and above three years were 101. Household income is a key determinant of resources available to households for adapting to and recovering from the impacts of flooding on on-site sanitation services.

Residence duration, or the length of time respondents have lived in the area, is essential for understanding the community's attachment to and familiarity with the environment. Longer residence duration may imply a deeper understanding of local challenges and a stronger

sense of community. It can also offer insights into whether respondents have experienced and adapted to previous flooding events, influencing their awareness and preparedness. Collectively, these demographic characteristics contribute to a comprehensive analysis of the community's socioeconomic context and resilience in the face of climate change impacts on on-site sanitation services.

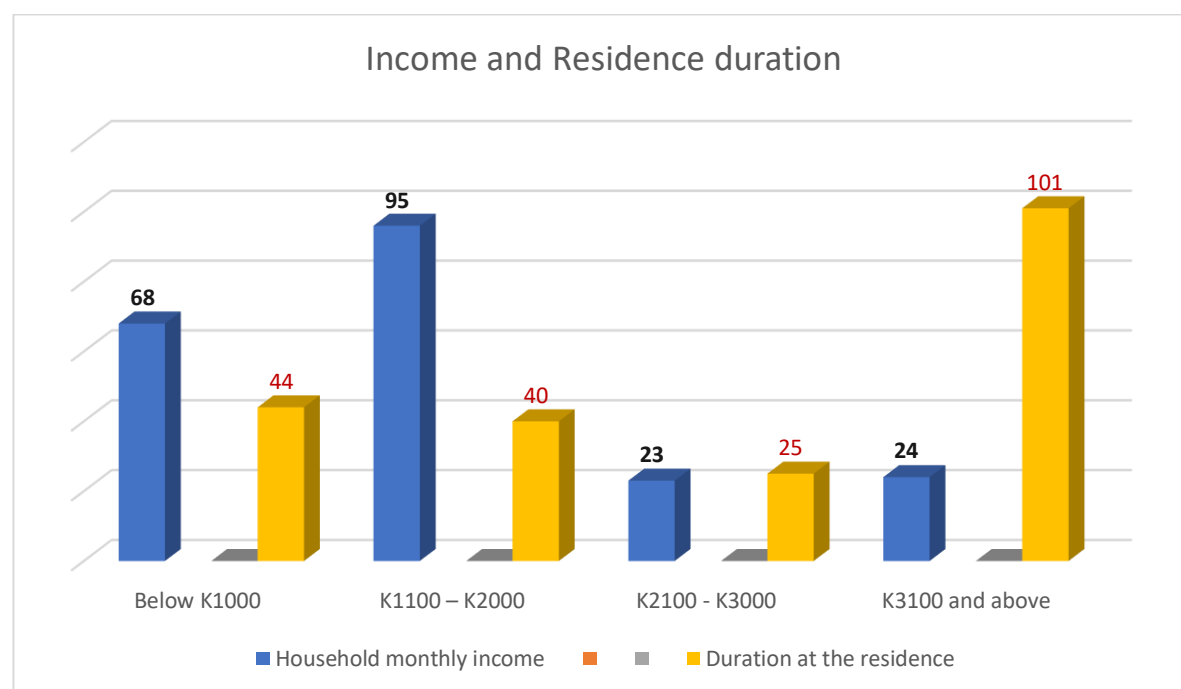


Figure 4.2: Household monthly income and residence duration (source field data 2023)

4.1.3 Type of sanitation facility and Duration of residence

The type of sanitation facility used by respondents provides insights into the existing infrastructure and the level of sanitation facilities available within the community. Understanding the variety of sanitation facilities allows for a nuanced examination of vulnerabilities to flooding, as different systems may have varying levels of resilience.

The duration of residence, or how long individuals have lived in the area, is vital for gauging the community's historical exposure to flood events and their adaptive capacity over time. Longer residence durations might indicate a greater familiarity with local conditions, potentially influencing respondents' awareness, preparedness, and adaptive strategies in the face of recurring flood events. Analyzing these demographic characteristics indicated in (**Figure 4.2**) enriches the research by shedding light on the diversity of sanitation services and the community's historical experiences, thereby enhancing the overall understanding of the effects of floods on on-site sanitation services in Kanyama Compound.

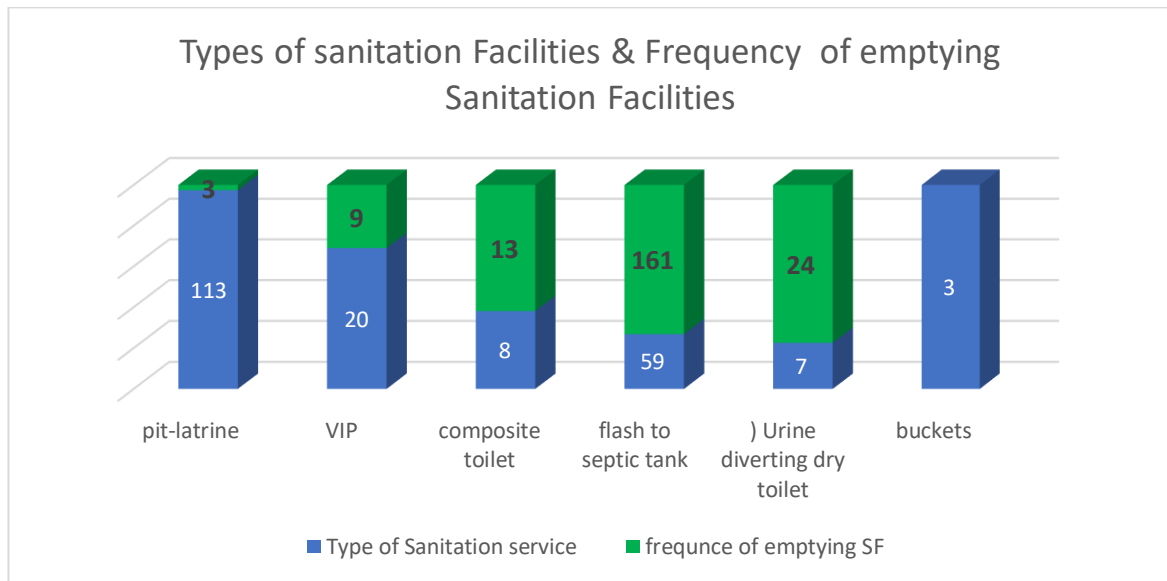


Figure 4.3: Sanitation facility and frequency of emptying SF (source; field data 2023)

4.1.4 Challenges of using onsite SF

Regarding access to sanitation facilities, about 56% of respondents reported challenges of using onsite sanitation services, while about 44% indicated no issues (see Table 2). Moreover, Figure 7's pie chart reveals that 72% of respondents observed increased floods in Kanyama, with only 28% reporting the opposite.

Table 4.1 Challenges of using onsite sanitation facilities.

q3	Freq.	Percent	Cum.
0	93	44.29	44.29
1	117	55.71	100.00
Total	210	100.00	

**q3 indicates question 3 in the questionnaire*

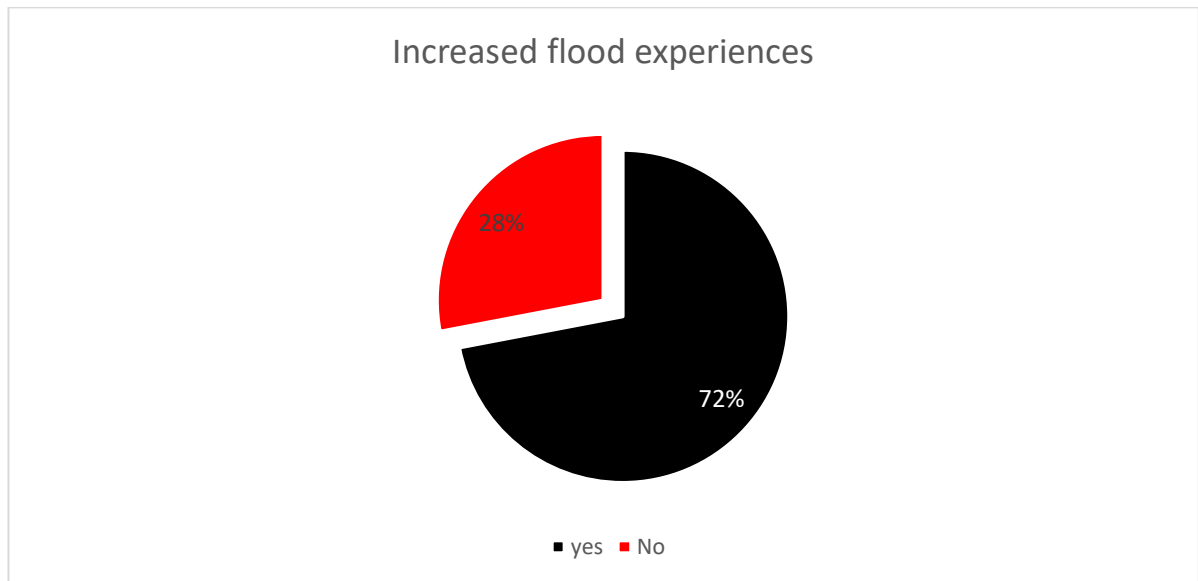


Figure 4.4. Responses on increased flooding experiences in Kanyama (source; field data 2023)

The visual narrative captured through pictures below, vividly portrays the escalating impact of increased floods in Kanyama. The images sum up the stark reality of inundated streets, infrastructure resting in floods, and the tangible consequences on the daily lives of residents. Each photograph serves as a distressing snapshot, revealing the prevalent challenges to on-site sanitation services.



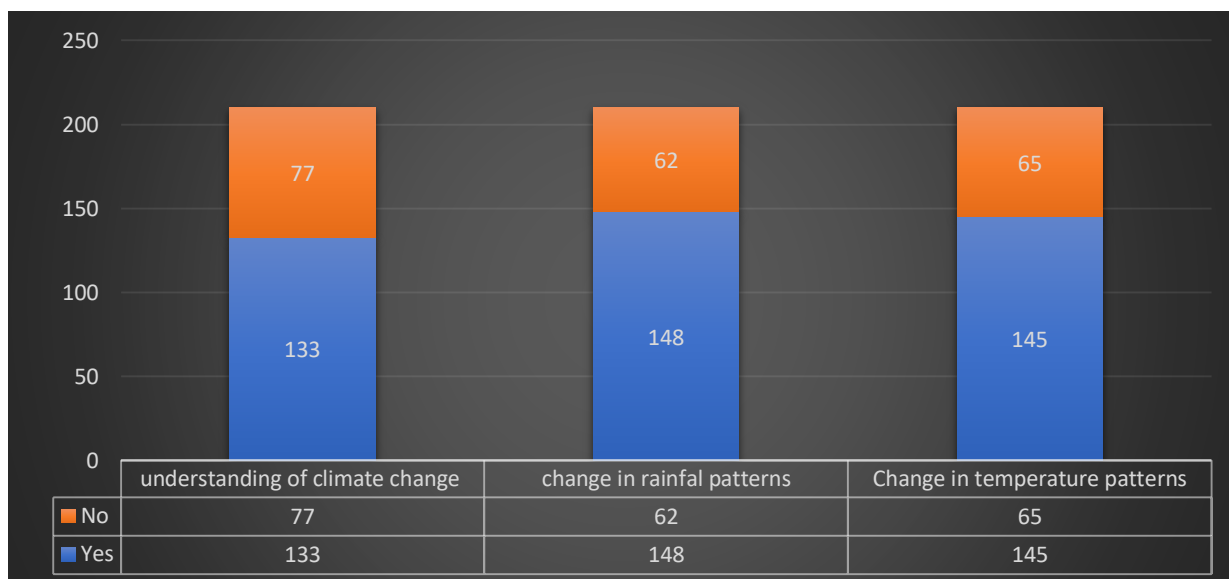
Image (source; field data 2023)



Image (source; field data 2023)

4.2 Understanding climate change, temperature, and rain patterns variations

Figure 4.5. below showed that understand of climate change and related issues; yes 133 and no 77, change in rainfall patterns; yes 148 and no 62, and change in temperature patterns; yes 145 and no 65. This segment delves into the community's understanding of the changing climate, providing context for their preparedness and adaptability to increased flooding. The results indicate the agreement of the respondents in possessing an understanding to climate change, changes in temperature and rainfall patterns as well.



Note: the highest numbers, 133, 148, and 145 indicate respondents that answered (yes) and lower numbers indicated (No) responses.

Figure 4.5: Understanding climate change, temperature, and rain patterns variations
(Source; field data 2023)

4.2.1 Effects of Climate Change-induced Flooding on Onsite Sanitation Services.

Table below presents data across different wards in Kanyama, detailing the mean scores and standard deviations for several flood-related effects. The average scores across wards for water contamination (0.76) and infrastructure damage (0.67) highlight these as significant issues. The high mean values indicate that these problems are common and severe across the affected areas. The standard deviations provide insight into the variability of responses. For example, the relatively high standard deviation in the scores for infrastructure damage (ranging from 0.17 to 0.504 across wards) suggests variability in how infrastructure damage is experienced or perceived across different areas.

This implied that there are severe flood effects on onsite sanitations that are faced by the communities and worsened by the flooding incidences. The questionnaire respondents indicated that communities lack clean water during flood incidences due to floodwater spreading human waste into water supplies. They further revealed that the collapse of toilets is experienced, while some toilets also fill up and spill into the environment. There is also an increased problem of water quality when sanitation facilities are affected. The diseases that affect communities during flooding are diarrhoeal diseases including typhoid; dysentery, especially in children; cholera; malaria; and bilharzia.

Table 4.2: Means and Standard Dev. of flooding factors effecting Kanyama.

Name of wards		Inundation Depth	Flood duration and area cover	Contamination of household items	Infrastructure damage.	Outbreak of water and hygiene related diseases	Surface Water quality	Overflowing of pit-latrines/septic tanks
1	Mean	0.14	0.51	0.27	0.46	0.52	0.26	0.15
	Std. Dev	0.342	0.321	0.431	0.504	0.505	0.444	0.363
2	Mean	0.45	0.57	0.48	0.97	0.93	0.87	0.51
	Std.dev	0.248	0.291	0.323	0.17	0.263	0.341	0.503
3	Mean	0.32	0.61	0.19	0.58	0.58	0.43	0.53
	Std. Dev	0.392	0.231	0.212	0.499	0.499	0.505	0.505
4	Mean	0.56	0.63	0.51	0.54	0.12	0.15	0.44
	Std. Dev	0.214	0.145	0.492	0.502	0.326	0.363	0.501
5	Mean	0.65	0.34	0.17	0.37	0.64	0.52	0.27
	Std.D	0.233	0.342	0.132	0.321	0.413	0.142	0.152
6	Mean	0.76	0.55	0.51	0.47	0.18	0.71	0.64
	Std.D	0.123	0.423	0.312	0.213	0.354	0.321	0.371
Totals	Mean	0.64	0.65	0.61	0.67	0.68	0.76	0.62
	Std.d	0.302	0.405	0.512	0.356	0.506	0.023	0.013

The standard deviations helped to highlight the diversity or spread of responses within each category, providing a measure of how much individual data point, deviate from the mean. Higher standard deviations indicated greater variability, while lower standard deviations suggested more consistency in responses across the different wards. **Table 4.3** shows the rotated PCA of major factors of flooding in Kanyama constituency. From the PCA result, three factors namely, Flood area cover/duration and contamination of water, inundation depth and Infrastructure damage, and flood rains and overflowing of pit-latrines/septic tanks were extracted based on the responses of the respondents. The value of the KMO test was 0.81, signifying that the acceptability of input variables for the PCA was suitable, though the test of the negative theory that the correlation matrix was an identity matrix reported a p-value < 0.000 , showing a connection between the variables. Consequently, PCA was, for that reason, a suitable technique for extracting flooding effects factors. Table 3. shows the retained principal component (PC) representing the different dimensions of the effects of flood incidences in Kanyama. Only variables with factor loadings of ± 0.3 and above at 1% overlapping variance were used to name the factors and were significant at a 1% probability level. The three retained variables were then renamed as outbreak and contamination of water, flooding and Infrastructure damage, flooding and overflowing of pit-latrines/septic tanks. The variables were then used as the outcome variables in the regression (SUR) model.

Table 4.3. Dimensions of effects of flooding on Onsite Sanitations-Principal component analysis (PCA)

Variables	Flood area cover/duration and contamination of water	Inundation depth and Infrastructure damage	Flood rains and overflowing of pit-latrines/septic tanks
Flood area cover and contamination of water	0.423	0.213	0.271
overflowing of pit-latrines/septic tanks	0.034	0.451	0.392
Outbreak of water and hygiene related diseases	0.432	0.433	0.371
Flood duration and area cover	0.064	0.123	0.072
Inundation Depth /rainfall	0.456	0.232	0.654
Contamination of household items	0.045	-0.153	0.032
Surface Water quality	-0.034	-0.243	-0.472
Eigenvalue	4	3	3.4
%variance	97		
correlation matrix	0.215		
KMO Test	0.92		
Barllet's test (p-value)	0.0000 ^α		
Chi-Square	973.753		

Note(s): α represents significance level at 1%.

In estimating factors of floods on Onsite Sanitations in Kanyama constituency a seemingly unrelated regression was employed, and the results are presented in Table 4.

Table 4.4. A seemingly unrelated regression model of effects of flooding on Onsite Sanitation in Kanyama constituency.

Variables	Flood area cover and contamination of water & outbreak of diseases			Inundation depth and Infrastructure damage			Flood rains and overflowing of pit-latrines/septic tanks		
	Coeff	Std.Err	p>z	Coeff	std. Err	p>z	coeff	std. Err	p>z
Family Size	0.21	0.063	0.046	0.421	0.046	0.000***	0.076	0.124	0.000***
Level of education	-0.26	0.063	0.041**	-0.192	0.145	0.032	-0.274	0.134	0.034
Duration of Residence	-0.41	0.008**	0.032**	0.0124	0.005	0.674	-0.234	0.312	0.752
Outbreak of water and hygiene related diseases	0.451	0.21	0.00***	0.345	0.034	0.032*	0.378	0.021	0.049*
Marital Status	0.07	0.31	0.671	0.026	0.340	0.56	0.112	0.153	0.712
Type of Sanitation Facility	-0.46	0.078	0.000***	-0.432	0.085	0.005*	-0.457	0.148	0.004**
Gender	-0.12	0.238	0.561	0.064	0.012	0.874	0.323	0.078	0.987
Household Income	-0.36	0.252	0.000	-0.616	0.002	0.001	-0.432	0.152	0.000***
Equation	RMSE	R-squared	chi2	p>chi2					
Flood area cover/duration and contamination of water and outbreak of diseases	1.400	0.431	234.16	0.000					
Inundation depth and Infrastructure damage.	1.530	0.427	214.564	0.001					
Flood rains and overflowing of pit-latrines/septic tanks	1.340	0.373	152.132	0.000					

Note(s): * Significant, ** Very Significant, *** Highly Significant.

The suitability of approximating the variables representing the effects of floods on onsite sanitation facilities and then estimating each of the variable's individually using SUR is obtained by the non-zero cross-correlation coefficients of the estimated equations' error terms. The results of the SUR model revealed that different factors affected the onsite sanitation in Kanyama. The theorized and verified independent variables were incorporated in the model as indicated in **Table 4.4**. The three retained factors of flood's effect on onsite sanitation as extracted by PCA had variants of negative and positive coefficients. Level of education had a negative and statistically significant effect on the three variables representing the effects of floods on the onsite sanitation facilities. This meant that the more one was educated the less the consequences of being affected by climate change-induced flooding. The coefficient of the type of sanitation facility generated a negative value across all variables and is statistically important in determining either there can be an 'flood area cover and contamination of water and outbreak of diseases', Flooding depth and infrastructure damage, and 'flood rains and overflowing of pit-latrines/septic tanks. The family size is also statistically significant, with a positive coefficient in outbreaks and contamination of water, and other two variables. The household income coefficient is negative on all the three variables with a higher negative correlation ' -0.616' on the flooding and infrastructure damage.

As indicated in table 4.4 above. The accuracy of the predictive model used was evaluated using Root Mean Square Error (RMSE), with values of 1.400, 1.530, and 1.340 for the variables under consideration. Lower RMSE value of 1.340, in the analysis indicated a higher accuracy of the predictive models. Additionally, R-squared values of 0.431, 0.427, and 0.373 for contamination of water, infrastructure damage, and overflowing of pit-latrines/septic tanks respectively, reflected the percentage of variation in these outcomes explained by flood area cover, inundation depth, and flood rains. The R-squared values signified a superior fit of the models to the data, indicating a significant relationship between flood-related variables and the observed outcomes. Furthermore, the chi-squared statistics values of 234.16, 214.564, and 152.132 were obtained for contamination of water, infrastructure damage, and overflowing of pit-latrines/septic tanks respectively. These higher chi² values suggested a substantial discrepancy between observed and expected data, highlighting the significant impact of flood-related variables on the outcomes studied.

4.3 Knowledge and awareness of the effects of flooding on onsite sanitation services

In exploring the knowledge and awareness of the residents in Kanyama compound regarding the effects of flooding on onsite sanitation services related to climate change, several key sub-themes were identified. Infrastructure vulnerability and service delivery challenges, human-induced causes and natural climate variability, direct damage to infrastructure and health risks and contamination, cultural and linguistic relevance and feedback and improvement. These subthemes collectively led to major themes as shown in (figure 4.6) below.

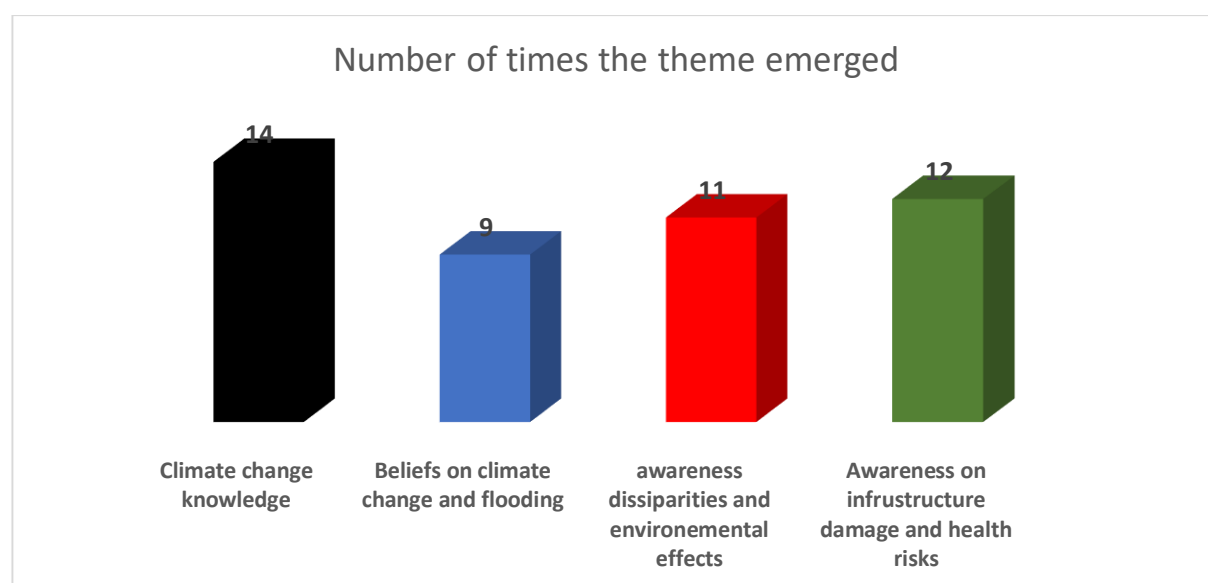


Figure 4.6. Themes emerged on awareness and knowledge on effects of flooding on on-site sanitation. (Source. Field data 2023)

Firstly, there is a broad understanding among residents about the impact of climate change on weather patterns, including intensified rains and unpredictable weather shifts, which directly affect onsite sanitation facilities such as septic's, latrines, and damages roads rendering emptying services difficult. A respondent confessed,

“It’s been noticed that there has been increased rains in the past seasons and extreme temperatures, making poorly constructed onsite sanitations, vulnerable to climate-related events like floods.”

Second theme is ‘diverse beliefs on climate change and floodings’. The community holds diverse beliefs regarding the causes of climate change and flooding events, with some attributing them to human-induced activities like heavy urbanization and increase in population, while others view them as part of natural climate variability. Additionally, a theme on ‘community awareness disparities’, indicated that there are disparities in community awareness,

with some individuals lacking knowledge about the link between climate change, flooding, and sanitation but many of the respondents actively portrayed knowledge of effects of floods on onsite sanitation services. One respondent said,

“I often attribute these occurrences to climate change as i witness firsthand the erosion, loss of infrastructure, and displacement of people due to flooding, reinforcing their belief in climate change impacts.”

Awareness on infrastructure damage and health risks. On this theme, Residents acutely showed awareness of the structural damages and health risks inflicting sanitation facilities, the contamination risks in groundwater and surface water, and the increased health risks, especially waterborne diseases, during and after floods are the direct consequences of climatic variations. A respondent indicated,

“We have witnessed, Debris carried by floodwaters, such as plastics, leaves, and other materials, can clog pipes and drainage systems connected to onsite sanitation facilities. This can impede the flow of waste, leading to blockages and malfunctioning toilets.”

Another respondent voiced,

“Here in Kanyama several people know that floodwaters contaminate groundwater sources, including wells and aquifers. If pit latrines or septic tanks are damaged, human waste and pathogens can seep into the groundwater, posing a significant risk to community water supplies.”

Another respondent confessed,

“Yes, people know and have experienced that Floodwaters can overflow and mix with sewage, creating a mix of human faeces and water, causing air pollution, and water-borne diseases like cholera, typhoid, and dysentery.”

Lastly, the theme that emerged was ‘lack of tailored education on climate change’. There is need to a tailored and community-driven approach in addressing awareness disparities about climatic variations and flood’s effect on onsite sanitation services. By incorporating local languages, culture, and active community involvement, these strategies aim to bridge the knowledge gap, enhance awareness, and empower the community to effectively tackle the challenges posed by climate change-induced flooding in the context of On-site sanitation services. The emphasis on continuous evaluation through feedback mechanisms further highlights the commitment to the ongoing improvement and relevance of these educational initiatives. A respondent said,

“There is a need for a targeted educational program addressing specific misconceptions and use of community-friendly language like Nyanja or bemba and interactive methods to engage residents effectively. Ensure that educational materials and workshops are conducted in the

local language and are culturally sensitive. Relate climate change and on-site sanitation issues to traditions, and everyday experiences for better understanding.”

One key informant indicated also,

“There is a need to Establish a feedback mechanism to continuously assess the effectiveness of educational initiatives. Regular surveys and community meetings can help gauge the impact of awareness programs and identify areas that still need attention.”

4.4 Strategies for Onsite Sanitation Service Delivery Challenges

The identified themes for strategies are public-private partnerships, infrastructure development, government initiatives and policies, community engagement and education, and subsidized services (**Figure 4.7**).

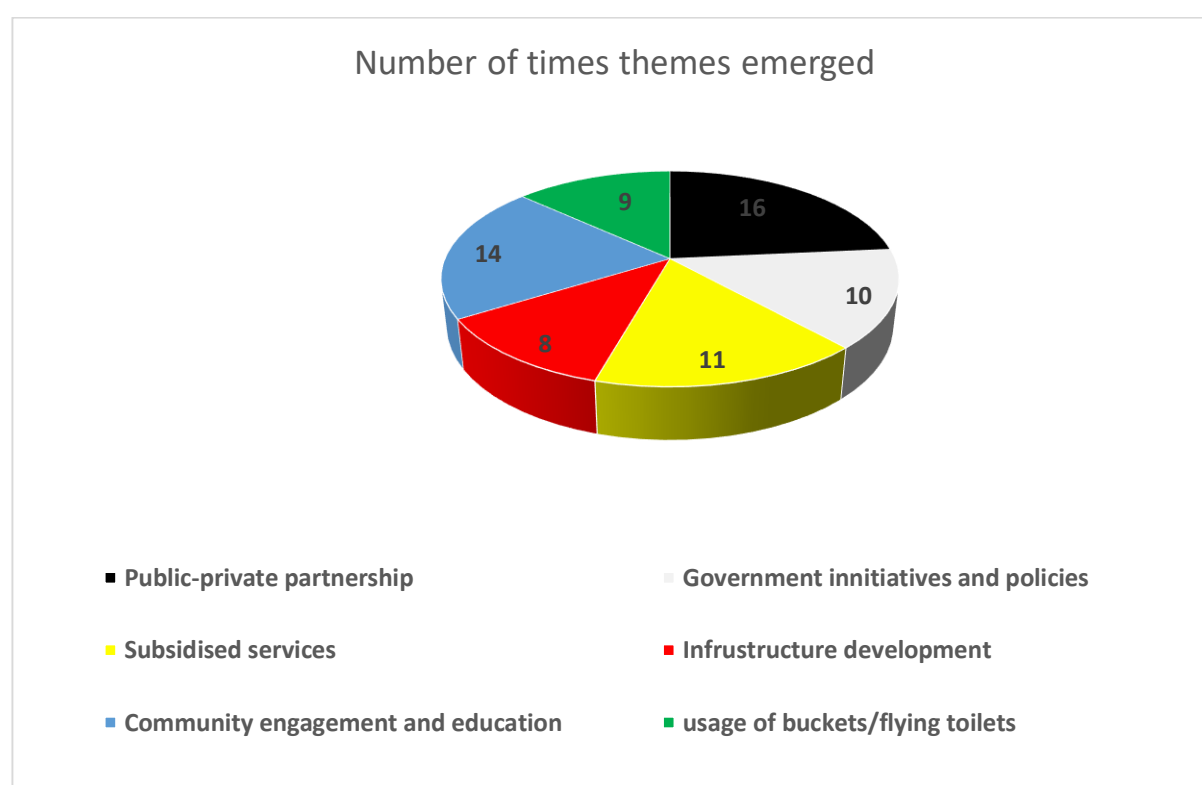


Figure 4.7. Themes emerged under strategies. (Source; field data)

Collaborations exist between public institutions (such as the Lusaka City Council and Lusaka Water and sewerage Company) and other private operators in building sealed septic tanks. LWSC has partnered with private businesses to provide pit emptying services and treatment sites in two peri-urban areas. Efforts to improve sanitation infrastructure, including the construction of sewer lines, drainage systems, and VIP toilets are in place. These initiatives aim to provide access to proper sanitation services in peri urban, Kanyama inclusive. Zambian

government has put more efforts to enhance sanitation service delivery through the implementation of a national sanitation policy and planning framework. Indicated by the key informant from Lusaka city council,

“The Zambian government launched a new national sanitation policy and planning framework. This framework sets out a vision for Safe, affordable, and sustainable water supply and sanitation services for all. The framework includes a number of strategies to improve onsite sanitation service delivery; strengthening the regulatory framework for onsite sanitation services; Promoting public-private partnerships, raising awareness of the importance of sanitation and hygiene, and subsidizing the cost of sanitation services for low-income households.”

There is also an ongoing implementation of subsidized sanitation services, where residents pay a reduced amount (20% of the total) for LWSC blue toilets. This approach aims to make sanitation services more affordable for low-income households. A key informant said,

“We are also building VIP toilets at a subsidized amount, where residents only pay 20% of the total amount.”

Community mobilization and education exists for promoting proper sanitation and hygiene practices by Plan International Zambia, a non-state actor. These promote WASH services in Kanyama and helps driving behavioral change related to sanitation among the residents.

"As Plan International Zambia, we provide Water, Sanitation, Hygiene (WASH) services in Kanyama compound to improve the overall well-being and health of the community. Our initiatives focus on implementing sustainable sanitation solutions, promoting hygiene practices, and ensuring access to clean water, clean toilets, effective waste management, designated hand washing stations, to empower residents empowering residents to lead a healthier life and foster a cleaner, safer environment for everyone.”

The final theme, under this objective is health risks prevention. Diseases like cholera, typhoid, and dysentery become rampant during floods due to poor sanitation. In view of this government is improving the sewer systems to be able to handle heavy rainfall and prevent the contamination of water sources during floods. This will ensure that sewage is safely transported away from residential areas and significantly reduce the risk of waterborne diseases. Lusaka City Council through private contractors is offering Flood-Resilient Toilet Designs. This is to curb spillage of faecal matter during floods. Informant from Lusaka City Council said,

“When residents want to erect a toilet, they come, and we offer them advice on how and where to build the toilet where we factor in climatic mitigative measures.”

The results identified the use of unconventional sanitation methods, notably "flying toilets" and the utilization of buckets, emerging as a coping mechanism in Kanyama Compound. Except, during floods and without functional and flood-resistant sanitation infrastructure, residents resorted to innovative yet makeshift solutions. Unfortunately, "Flying toilets" involved the disposing of human waste in plastic bags into flooded waters, while the use of buckets provided a portable waste disposal option into unsafe open areas when floods compromise conventional systems such as pit latrines. Despite offering immediate relief, these strategies pose environmental and health risks due to indiscriminate waste disposal. Respondents confessed,

“Since there are poor and inadequate toilets, people use plastics and buckets to help themselves, but they just throw in dumpy waters and open spaces.”

By implementing and improving these strategies, communities can enhance their resilience against waterborne diseases during floods, ultimately contributing to effective health risk prevention in the context of onsite sanitation.

4.5 Recommendations for Enhancing Onsite Sanitation Amid Climate Change

Due to the effects of flooding on onsite sanitation, awareness levels, strategies and literature reviews on the existing models, the researcher developed a comprehensive sustainability framework aimed at improving onsite sanitation service delivery in Kanyama, considering challenges such as lack of pressure point drainages, insufficient awareness campaigns on climate change, inadequate waste management, roads, drainages, and landscaping, lack of essential infrastructure, overpopulation, poor toilet construction integrity, limited partnerships with non-state actor, and minimal monitoring and evaluation on the laid out programs.

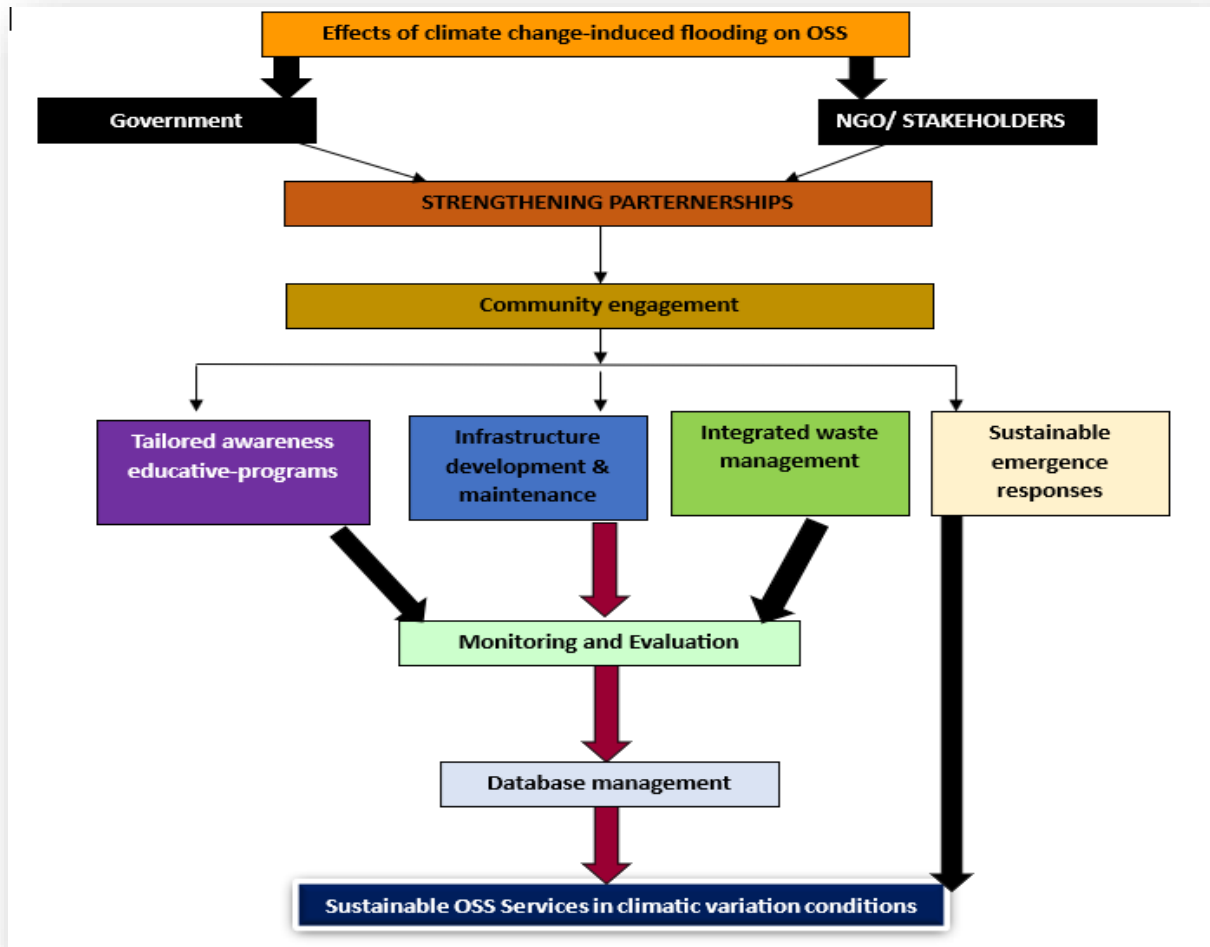


Diagram: proposed sustainability framework aimed at improving onsite sanitation.

4.6 Chapter summary

The chapter began with an overview that set the stage for the detailed examination of the topics that followed. It delved into the demographic characteristics and general views of respondents, exploring gender distribution, educational levels, household income, residence duration, types of sanitation facilities, and the challenges faced in using onsite sanitation facilities. The discussion then shifted to understanding climate change, temperature, and rain pattern variations, particularly focusing on the effects of climate change-induced flooding on onsite sanitation services. Knowledge and awareness of the effects of flooding on onsite sanitation services were investigated. Strategies for addressing onsite sanitation service delivery challenges were outlined, followed by recommendations for enhancing onsite sanitation amid climate change in form of a framework. Each section contributed to a comprehensive understanding of the issues surrounding onsite sanitation in the context of climate change.

CHAPTER FIVE

DISCUSSION

5.0 Introduction

In the quest to comprehend the intricate interplay between flooding and onsite sanitation in Kanyama Compound, this chapter embarks on a comprehensive exploration. As the narrative unfolds, the chapter precisely divides the multi-layered impacts of flooding on various dimensions of sanitation, scrutinizing the influence of demographic characteristics, educational levels, sanitation facilities, household income, and family size. The insights derived from this examination pave the way for a nuanced understanding of the community's awareness regarding the effects of flooding on sanitation and the subsequent development of resilient strategies.

5.1 Demographic characteristics and Flood-Related Effects on Onsite Sanitation

Level of education had a negative and statistically significant effect on the three variables representing the effects of floods incidences. This implies that the household members who have enlightenment in terms of education, the probability of dealing with water contamination in their area, outbreak of diseases, infrastructure damage and overflowing of pit-latrines/septic tank reduces. This means that household heads with a higher level of education are more aware and are able to be informed on how to take care of some effects of floods on onsite sanitations. This is in agreement with the study by Niederberger and Glanville-Wallis, (2019) in Bolivia which concluded that education at all levels of the community is the necessary approach to tackling climatic and water related problems in the 21st century. The improved sanitation facility generated a negative yet statistically significant coefficient on the variables of effects of floods on Onsite sanitations services. This indicates that there is reduction on effects of floods as sanitation facilities gets enhanced. This study's findings correlated positively with the studies examining the Maputo sanitation (MapSan) trial which showed that improving sanitation facilities prevents human fecal contamination in target communities (Holcomb et al. 2020, 2021). Contrary to the findings of Kikuchi, (2023) that improved sanitation or containment type of sanitation may not positively contribute to the prevention of outbreak of diseases in severe- and moderate-flood prone areas.

Household income was found to have a significant negative coefficient indicating that when there is an increase on the income of the household the effects of floods on onsite sanitation reduces. This was in line to the statement by (Loy & Choy, 2015), who said that adequate

economic resources provide people collective security and protection from impending crises. People with less income are more likely to live in hazard-exposed areas and are less able to invest in risk-reducing measures. The lack of access to insurance and social protection means that people in poverty are often forced to use their already limited assets to buffer disaster losses, which drives them into further poverty (UN DESA, 2021).

Family size generated a significant positive coefficient. Implying an increase in all the three variables; contamination of water, infrastructure damage, and overflowing of pit-latrines/septic tanks as the family size for the households increases. This finding is supported by Odigiri et al., (2021), who wrote that in higher population density areas, the greatest potential fecal exposure is related to a combination of direct discharge, ‘uncontained’ septic tanks, and higher groundwater usage—all of which disproportionately affect the poorer households. This finding highlights the need for a combination of decentralized sewerage options supported by local government and well-designed, installed, and maintained on-site sanitation systems if the risk of fecal exposure is to be sufficiently reduced for high-density, low-income households. Furthermore, the cost of emptying services was the primary factor influencing emptying practices, based on occurrence of discussion in the literature. The cost of emptying was described as a barrier to whether households empty their OSS but was not consistently found to be a factor in choosing between mechanical and manual emptying (Balasubramanya et al., 2017b; Harper et al., 2021; Opel and Bashar, 2013; Parkinson and Quader, 2008; Prasad and Ray, 2019). This finding suggests that among households that can afford to empty their OSS, other factors may have greater importance on the emptying method chosen. However, this finding contradicts other literature: two studies looking at emptying in Africa cite the price differential as a major reason for picking between manual and mechanical emptying (Capone et al., 2020; Murungi and van Dijk, 2014). Studies examining the relationship between poverty and emptying practices also had mixed results: only one out of the three studies found a difference in emptying behaviors or willingness-to-pay between wealthier and poorer households (Chandana and Rao, 2021; Frenoux and Tsitsikalis, 2015; Harper et al., 2021, 2020).

5.2 Awareness and Climate-induced floods' effects on onsite sanitation

This study highlights a significant level of awareness and understanding regarding the impact of climate change-induced floods on on-site sanitation among the residents of Kanyama. The theme on climate change knowledge emerged the highest. This indicated how Kanyama residents were conversant with climate change and their subsequent impact on Onsite sanitation

services. This finding is in line with Mondino et al (2020) who said that recognizing people's awareness levels concerning the effects of floods on on-site sanitation is pivotal for informing the risk management authorities. The finding also proved important since vulnerability to floods is linked with a lack of awareness about the natural environment (Hyde Smith et al., 2022). Climate change knowledge theme stands as a back-bone in implementing risk communication strategies (Becheker et al., 2013).

The second highest theme portrayed substantial awareness levels on infrastructure damage and health risks associated with climate change induced floods' effects on Onsite sanitation services. Paradoxically, existing literature has identified the lack of awareness as a significant cause to issues such as overflowing pit-latrines and septic tanks, improper solid waste management, and the outbreak of water-borne diseases (Hyde Smith et al., 2022). However, it is worth noting, as per Mondino et al. (2020), that merely informing households about the effects of floods on on-site sanitation might not be adequate to induce behavioural change. This is the case unearthed in Kanyama, where people are knowledgeable on flooding effects, yet the consequences of floods persist. Additionally, according to Gupta and Joshi, (2023) knowledge alone is not enough to induce change, there should be external parameters to influence households like foul odors, sicknesses, impassable roads and many more for them to take action.

This research discovered that there were awareness disparities on environmental factors affecting onsite sanitation services in Kanyama. Despite adequate awareness from the responses gathered through Questionnaires, a considerable number of households remained oblivious to the necessity of improving their on-site sanitation systems amidst climatic variation effects. The research found out that disparities often stemmed from variations in education levels, where individuals with higher education tended to possess a better understanding of environmental factors and their implications. Additionally, media influence proved significant a factor, some communities experienced awareness gaps due to limited exposure to environmental risks via mainstream media channels. Accordingly, variations in cultural practices and language barriers impacted the communication and reception of environmental information within some communities of Kanyama. Residents coupled with lack of resources to participate in activities that foster environmental awareness, such as attending workshops or engaging in community initiatives. This exacerbated the challenging issue of flood-related effects. This aligns with the findings of Cookey et al. (2020), suggesting that disparities in awareness deter the majority of households from harnessing and continuing in safe practices like proper disposal of solid wastes. To tackle this issue, implementing regulations, policies,

and scheduled emptying for all, can enhance awareness, as proposed by Mehta et al. (2019). Furthermore, tailored advertising campaigns conducted by emptying services can significantly contribute to increasing awareness levels (Gupta and Joshi, 2023).

The researcher also discovered that cultural beliefs deter improvement of onsite sanitation to with stand climate change-induced floods. Contrary to Van Aalst et al., (2008) who said that information on climate-induced floods can be derived from diverse sources such as books, hazard and risk assessments, maps, urban plans, and historical archives to help people on practical measures of handling On-site sanitation services in a flood resilient manner. Beliefs like fear to dispose sanitary pads in bins and also discouraging the use of enclosed sanitation facilities, hearten improper waste disposals, contributing to environmental and public health challenges that necessitate targeted education and awareness initiatives for sustainable behavioral change in line with onsite sanitation services. To curtail information can be disseminated through official sources like public authorities and informal networks such as friends. In line with Mehta et al. (2019), personal research, especially through online searches, has become an increasingly valuable source of information that can be technologically transformed to help alleviate flooding consequences on OSSs. Additionally, formal education, from primary school to university, plays a critical role in imparting knowledge about floods, on-site sanitation services, and natural hazards in general (Aziz 1990).

5.3 Strategies in place to address the effects of flooding

This research has illuminated various strategies and policies implemented by both governmental and non-state actors to mitigate the impacts of flooding on on-site sanitation services. Concerning infrastructure development, the researcher found that the government, with assistance from some non-governmental organizations, was addressing sewer pipe challenges. However, challenges persisted for some residents in being reached by service providers due to the shanty and densely populated nature of the area. Additionally, some lacked the necessary resources to upgrade their on-site sanitation facilities to make them flood resistant. These findings align with Singh and Kumar's (2017) research, emphasizing the importance of implementing and enforcing building and health codes to standardize the construction of on-site sanitation systems (OSSs). The prevalence of poorly constructed OSSs can be addressed through such measures. Furthermore, low-income housing often fails to meet building requirements due to its limited space and high population density (Chiliboyi, Y., 2016). Below are plans and policies by the government to improve onsite sanitations in Kanyama.

5.3.0 Visions and Plans

The vision for Zambia's development, as outlined in the Zambia Vision 2030, encompasses essential goals aimed at providing secure access to safe potable water sources and improved sanitation facilities for the entire population by 2030. Specifically, the vision focuses on improving access to context-specific and environmentally friendly sanitation for all Zambians. This initiative aims to achieve 90 percent access to sanitation for the entire population by 2030 and involves the reconstruction and rehabilitation of sewerage treatment infrastructure in major towns and cities. Notably, this vision emphasizes the promotion of improved sanitation facilities in both urban and rural areas, including informal settlements.

The Eighth National Development Plan (8NDP) for the period 2022-2026 serves as a comprehensive policy document designed to unlock Zambia's potential across all sectors of the economy. This plan addresses the constraints posed by inadequate infrastructure in the sanitation sub-sector and advocates for sustainable sanitation solutions at scale. By emphasizing the need for sustainable sanitation services, the plan aims to foster holistic and inclusive national development, ensuring the well-being of all citizens.

However, this Eighth National Development Plan (8NDP) portrays a significant weakness in that, it emphasises on strengthening the conventional sewerage system, which may hinder achieving sanitation goals, especially in areas without sewer connections. To address this, the

government should promote decentralized sanitation services, incorporating and improving on-site technologies, and allocate funds impartially.

Additionally, the draft lacks mention of establishing new policies and regulations at the household level, which are crucial for effective sanitation management. Introducing stringent regulations would enable monitoring and evaluation from households to the national level, providing a clear understanding of the sanitation status. Furthermore, there is a need for sustainable financing mechanisms in areas such as Kanyama compound, as public-private partnerships alone may not suffice without subsidies to attract private sector involvement. Finally, the lack of collaboration among ministries involved in water supply and sanitation services is a critical weakness. Establishing clear guidelines on responsibilities and fostering collaboration would enhance accountability and move towards achieving national sanitation goals.

5.3.1 Policy and Regulatory Framework

Supporting these overarching visions and plans, the National Water Supply and Sanitation Policy of 2020 plays a pivotal role in accelerating universal access to clean and safe water as well as adequate sanitation in Zambia including Kanyama compound. Aligned with the Vision 2030 and the Sustainable Development Goals (SDGs), this policy serves as a guiding framework. It facilitates the creation of an enabling environment for the effective and sustainable provision of water and sanitation services. The policy outlines specific objectives, such as the development and operation of water supply and sanitation (WSS) infrastructure that promotes improved access, preventive maintenance, appropriate technology usage, and minimal impacts on public health and the environment. Moreover, the policy emphasizes the importance of public awareness, stakeholder participation, and integration of cross-cutting issues such as gender, disability, and social inclusion in all WSS developmental programs, ensuring equity and environmental sustainability.

5.3.2 Subsidized toilets

The study also brought to light the continued implementation of subsidized sanitation services, where residents contribute only a reduced amount (20% of the total cost) for LWSC blue toilets. This strategy aligns with the suggestions of Lerebours et al. (2021), advocating for increased subsidies by policymakers to facilitate the construction or improvement of toilets, ensuring they are easily maintainable and emptiable. Furthermore, incorporating scheduled emptying services, similar to those offered by agencies like the Kanyama Water Trust, can mitigate public

health risks linked to the absence of timely emptying services and extended periods between emptying.

It is imperative for communities and policymakers to recognize the interconnectedness of sanitation, public health, and overall societal well-being (Bunch, M. J. 2016). Adequate sanitation facilities are not only essential for individual health but also for the broader community's resilience against environmental challenges such as flooding. Beyond the immediate focus on upgrading on-site sanitation systems, there is a need for comprehensive awareness campaigns and educational initiatives as part of stakeholder robust interventions. According to Naeem et al., (2016), these efforts can empower residents with the knowledge and understanding necessary to maintain and utilize sanitation facilities effectively. Moreover, fostering community engagement and participation in decision-making processes can lead to sustainable solutions tailored to the unique needs of the area (De Vente et al., 2016). By promoting collaborative efforts between government bodies, non-state actors, and local communities, it's possible to work towards creating safer, healthier, and more resilient living environments for Kanyama residents, even in the face of challenging circumstances like shanty living conditions and limited resources.

5.4 Chapter summary

This chapter began with an overview that set the stage for a deeper discussion of the findings. It first discussed the demographic characteristics and flood-related effects on onsite sanitation, detailing how different populations are impacted by such events. Awareness and the effects of climate-induced floods on onsite sanitation were then analysed, then highlighted the community's understanding and responses to these challenges. The discussion moved on to the strategies in place to address the effects of flooding, including visions and plans, the policy and regulatory framework, and the implementation of subsidized toilets. Each part of the chapter contributed to a thorough breakdown of how climate change induced floods, influenced onsite sanitation and the measures taken to mitigate these impacts.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This research provides a comprehensive analysis of the intricate dynamics between climate change-induced flooding and onsite sanitation services in Kanyama Compound, Lusaka District, Zambia. It reveals that residents are acutely aware of the effects of climate change, particularly the intensified rains and unpredictable weather patterns that severely compromise the integrity of inadequately constructed onsite sanitation facilities such as septic systems and latrines. The study further uncovers diverse community beliefs about the causes of climate change and flooding, highlighting the urgent need for educational initiatives tailored to address specific misconceptions and effectively engage the residents. The proactive measures undertaken by the community, government, and various stakeholders to mitigate these challenges are pivotal. Strategies such as Public-Private Partnerships, Infrastructure Development, Government Initiatives and Policies, Community Engagement and Education, Subsidized Services, and ongoing Data Collection and Improvement have been identified. These initiatives are geared towards enhancing the sanitation infrastructure, refining regulatory frameworks, raising awareness, and providing subsidized services to low-income households. Notably, the adoption of Flood-Resilient Sanitation Facility Designs and improved sewer systems exemplifies a strong commitment to mitigating health risks associated with sanitation-related diseases during flood events.

The findings underscore that addressing the challenges posed by climate change-induced flooding on onsite sanitation requires a holistic and multi-dimensional approach. Continued collaboration among government entities, private organizations, and community-driven efforts is essential to ensure the sustainability of sanitation services in vulnerable urban areas like Kanyama Compound. By fostering a deeper understanding of the community's needs, beliefs, and challenges, tailored interventions can be developed. These interventions will not only promote climate resilience but also enhance community awareness and empower residents to actively participate in safeguarding their sanitation facilities and overall health amid evolving climatic conditions. The commitment to ongoing improvement and relevance of these educational initiatives, as demonstrated through feedback mechanisms, further solidifies the foundation for a healthier environment and improved well-being in Kanyama Compound.

6.2 Recommendations

1. The findings indicated that climate change-induced floods damages infrastructure leading to human waste and lack of toileting privacy. The study recommends, piloting of container-based sanitation for efficiency of Faecal sludge management, climate resilience, and sustainability OSS facilities. This acknowledgment will pave the way for maximizing the efficacy of such practices through the implementation of guidelines for proper collection, transporting and disposal of human waste.
2. The findings unveiled increased experiences of flooding in Kanyama, leading to water contamination. Thus, the study recommends the use of technological interventions, such as household water-treatment or P&G water purification technology as a mitigative measure. The P&G water purification technology stands out as a remarkable innovation with the potential to address water scarcity and improve public health, particularly during flood-water contamination challenges. To maximize the impact of this technology, it is recommended that P&G continues to collaborate with governments, non-governmental organizations (NGOs), and local communities to expand access to the water purification solution. This could involve establishing partnerships for distribution networks, implementing educational programs to raise awareness about the technology, and ensuring affordability for marginalized communities. Moreover, ongoing research and development efforts should be prioritized to enhance the efficiency and scalability of the technology, making it even more accessible and applicable in diverse environmental conditions. By fostering strategic collaborations and continuous improvement, P&G can contribute significantly to global efforts aimed at providing clean and safe drinking water to vulnerable populations.
3. The researcher found that, disparities in community awareness adversely affect on-site sanitation. The researcher, recommends the need for tailored climate change education and awareness campaigns that shift residents' attitudes towards better on-site sanitation practices. These campaigns should be conducted in local languages such as Nyanja, Tonga, lozi or Bemba, incorporating community-friendly language and interactive methods to engage residents effectively. By addressing specific misconceptions and relating climate change and sanitation issues to everyday experiences, these initiatives can bridge the

knowledge gap, enhance awareness, and empower the community to adopt climate-resilient sanitation practices.

4. The findings portrayed the vulnerability of existing sanitation infrastructure to climate change-induced flooding adversities and non-compliance of residents to build septic and toilets to the standards. Therefore, the study recommends the need of improving the structural resilience of sanitation facilities to withstand the effects of flooding and other climate-related events. Additionally, the implementation of proper drainage systems and the elevation of sanitation facilities above flood-prone areas can minimize the risks of contamination and structural damage during floods. Collaborative efforts between government authorities, private sector entities, and non-governmental organizations are essential to fund and execute these infrastructure projects effectively.
5. The findings indicated the presence of various strategies by both state and non-state actors. Thus, there is need for continuous monitoring and evaluation of sanitation interventions to enhance on-site sanitation services in Kanyama Compound. Monitoring interventions may include conducting surveys, community meetings, and feedback sessions to gauge the impact of awareness programs and identify areas that still need attention. Continuous data collection and analysis can inform decision-making processes, allowing for adaptive management and the refinement of interventions based on the evolving needs and challenges faced by the community. Feedback from residents should be actively sought and integrated into planning processes to ensure that sanitation initiatives remain relevant and responsive to the community's requirements.
6. The findings from the demographic survey indicate that the majority of surveyed households have an income ranging from K1000 to K4000. This contrasts with a 2022 report by the Jesuit Centre for Theological Reflection (JCTR), which suggests that a family of five should have an income between K900 and K10,000. Given this context, it is crucial to conduct a thorough research study on the effectiveness of the Constituency Development Fund (CDF) in maintaining on-site sanitation services. This research will be vital in understanding the impact of public funding on community sanitation initiatives. The study should evaluate the efficiency, coverage, and results of the CDF in supporting on-site sanitation infrastructure across constituencies. It will explore the allocation and use of funds specifically designated for sanitation projects, focusing on aspects such as infrastructure enhancement, community education, and the overall accessibility of sanitation services.

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APPENDIX 1: KEY INFORMANT INTERVIEW GUIDE

BACKGROUND CHARACTERISTICS

Office of the respondents Sex of respondent.....

Age of respondent:.....

Time of interview: Start End.....

1. Describe the type of work you do as far as onsite sanitation service delivery system in Kanyama in concerned.
2. What are the current onsite sanitation service delivery practices in Kanyama?
3. What are some of the challenges faced in the onsite sanitation service delivery system in Kanyama?
4. How has climate change impacted the onsite sanitation service delivery system in Kanyama?
5. What measures have been put in place to address the impacts of climate change on onsite sanitation service chain in Kanyama?
6. How effective have these measures been in addressing the impacts of climate change on onsite sanitation service chain in Kanyama?
7. What additional measures do you think can be implemented to improve the resilience of the onsite sanitation service delivery system in Kanyama in the face of climate change?
8. How is the resident's awareness and knowledge of the impacts of climate change on onsite sanitation service chain in Kanyama compound of Lusaka District?
9. In your opinion as a civic leader, what role can the community play in mitigating the impacts of climate change on onsite sanitation service delivery in Kanyama?
10. Based on your experiences, what recommendations would you make to improve onsite sanitation service delivery in Kanyama Compound in the context of climate change?

The End! Thank You!

HOUSEHOLD QUESTIONNAIRE

SECTION 1: DEMOGRAPHIC CHARACTERISTICS

1. ward:
2. Your Sex:
 1. Male ☐
 2. Female ☐
3. Your Age: 1. 15 – 20 Years ☐ 2. 21 – 26 ☐ 3. 27 – 32 ☐
4. 33 – 39 ☐ 5. 39 & above ☐
4. Level of Education? 1. Non ☐ 2. Primary ☐ 3. Secondary ☐ 4. Tertiary ☐
5. Household Income? 1. Below K1000 ☐ 2. K1100 – K2000 ☐ 3. K2100 - K3000 ☐ 4. K3100 and above ☐
6. Marital status? 1. Single ☐ 2. Married ☐ 3. Divorced ☐ 4. Separated ☐ 5. Widowed ☐
7. Family Size? 1. 0 – 3 ☐ 2. 4 – 7 ☐ 3. 8 – 12 ☐ 13 and above ☐
8. For how long have you been staying in Kanyama compound? 1) Below 5 years ☐ 2) 5 – 9 years ☐ 3) 10 – 14 years ☐ 4) 15 years and above ☐

SECTION 2: ONSITE SANITATION FACILITIES:

1. What type of onsite sanitation facilities do you have in your household?
 1. Pit latrine, b) VIP c) composite toilet d) flush to septic tank e) Urine diverting dry toilet f) buckets g) others
2. How many people use these facilities?
 1. 1-3 b) 4 – 5 c) more than 6
3. How often are these facilities emptied?
 1. Weekly b) monthly c) quarterly d) every 6 months e) yearly
4. Have you experienced any challenges with your onsite sanitation facilities? Yes or No if yes, what are the challenges?

SECTION 3: RESIDENT'S AWARENESS AND KNOWLEDGE OF THE IMPACTS OF CLIMATE CHANGE

1. Do you understand by the term climate change? 1) Yes or 2) No
What is it?
2. Have you noticed any changes in rainfall patterns in Kanyama compound over the past few years? 1) Yes or 2) No If yes, please describe.....
3. Have you noticed any changes in temperature patterns in Kanyama compound over the past few years? 1) Yes or 2) No If yes, please describe.....
4. Have you experienced any increased flooding over the past few years? 1) Yes or 2) No If so, how often?.....
5. Have you noticed any changes in the availability and quality of water in Kanyama compound over the past few years? 1) Yes or 2) No If yes, please describe.....
6. Have you noticed any changes in the prevalence of waterborne diseases in Kanyama compound over the past few years? 1) Yes or 2) No If yes, please describe.....

SECTION 4: IMPACT OF CLIMATE CHANGE ON ONSITE SANITATION SERVICE CHAIN

1. What are the existing impacts of climate change on onsite sanitation service chain in Kanyama compound

Please add the number according to the response

1) strongly disagree 2) disagree 3) neither agree nor disagree 4) agree 5) strongly agree (Likert scale)

1. The toilets are accessible to be emptied. []
2. Ground water contamination []
3. Floodwater damages toilets and septic tanks []
4. Floodwater spreads human waste into water supplies []
5. Climate change damages drainage infrastructure and wastewater treatment facilities []

6. Flood water overwhelms waste treatment plants []
 7. Flood water causes pit latrines and septic tanks to overflow []
 8. Blockage, overflow, or backflow in sewers due to too little or too much water []
2. Have you noticed any impact of climate change on the performance of your onsite sanitation facilities? 1) Yes or 2) No If yes, please describe.....
3. Have you had to change the way you use your onsite sanitation facilities due to changes in weather patterns or availability of water? 1) Yes or 2) No If yes, please describe.....
4. Have you had to modify or upgrade your onsite sanitation facilities due to changes in weather patterns or availability of water? 1) Yes or 2) No If yes, please describe.....
5. Have you experienced any challenges in accessing or using onsite sanitation facilities due to changes in weather patterns or availability of water? 1) Yes or 2) No If yes, please describe.....

STRATEGIES TO ADDRESS THE IMPACTS OF CLIMATE CHANGE ON ONSITE SANITATION SERVICE CHAIN

1. Have you implemented any measures to cope with the challenges of onsite sanitation service delivery in the face of climate change? 1) Yes or 2) No If yes please describe these measures.
2. Have you received any support or assistance from the government or other organizations in coping with the challenges of onsite sanitation service delivery in the face of climate change? 1) Yes or 2) No If yes, please describe the support or assistance received.....
3. Do you have coping strategies to address the challenges of onsite sanitation service delivery between wet and dry seasons 1) Yes 2) No , If Yes describe coping strategies
4. Do you think that the government have put in place strategies to address the effects of climate change on onsite sanitation service chain in Kanyama 1) yes 2) No If yes describe what the government has put in place.....

5. Based on your experiences, what recommendations would you make to improve onsite sanitation service delivery in the context of climate change?.....

The End! Thank You!

APPENDIX 2

APPROVAL OF THE STUDY LETTER



THE UNIVERSITY OF ZAMBIA DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road Campus | P.O. Box 32379 | Lusaka10101 | Tel: +260-211-290 258/291
777

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www.unza.zm

APPROVAL OF STUDY

IORG No. 0005376

NASRECREC IRB No. 00006465

18th May, 2023

REF NO. NASREC-2023- APR– 006

Ms. Miyanda Habanyama,
The University of Zambia,
School of Natural Sciences,
P.O. Box 32379,
LUSAKA.

Dear, Ms. Habanyama,

**RE: “ IMPACT OF CLIMATE CHANGE ON ON-SITE SANITATION SERVICE
DELIVERY: A CASE STUDY OF KANYAMA COMPOUND OF LUSAKA DISTRICT
”**

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	ORDINARY REVIEW	APPROVAL NO. NASREC-2023- APR- 006
-------------	-----------------	---------------------------------------

Approval and Expiry Date	Approval Date: 18 th May, 2023	Expiry Date: 17 th May, 2024
Protocol Version and Date	Version - Nil.	17 th May, 2024
Information Sheet, Consent Forms and Dates	English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

CONDITIONS OF APPROVAL

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to NASREC within 5 days.
- All protocol modifications must be approved by NASREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to NASREC within 5 working days.
- All recruitment materials must be approved by NASREC prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. NASREC will only approve a study for a period of 12 months.
- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to NASREC.
- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by NASREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled “late submissions” and will incur a penalty fee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.
- Every 6 (six) months a progress report form supplied by The University of Zambia Natural and Applied Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.
- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO), both NASREC

- and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.
- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.
- Filing a closing report (rather than just letting your approval lapse) is important as it assists NASREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.
- A reprint of this letter shall be done at a fee.
- All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of NASREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,



Dr. Mususu Kaonda

**VICE-CHAIRPERSON
THE UNIVERSITY OF ZAMBIA NATURAL AND APPLIED SCIENCES
RESEARCH ETHICS COMMITTEE - IRB**

cc: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies

APPENDIX 3

Letter of publication



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EAST AFRICAN NATURE & SCIENCE ORGANIZATION

OFFICE OF THE EDITOR-IN-CHIEF

REF: EANSO/EIC/P/04/879970

DATE: 15TH APRIL, 2024

Miyanda Habanyama
University of Zambia
P. O. Box 32379, Lusaka, Zambia.



Dear M. Habanyama,

**RE: PUBLICATION OF YOUR PAPER BY THE AFRICAN JOURNAL OF
CLIMATE CHANGE AND RESOURCE SUSTAINABILITY.**

Your paper titled '*Effects of Climate Change-Induced Flooding on Onsite Sanitation Services: A Case Study of Kanyama, Compound In Lusaka, Zambia*' was successfully published by the African Journal of Climate Change and Resource Sustainability (AJCCRS). The table below shows the metadata assigned to the paper.

Track ID: 5G2V8
Main Author: <i>Miyanda Habanyama</i>
Co-Author(s): <i>Dr. Joel Kabika, PhD & Lucky Mwinga</i>
Title: <i>Effects of Climate Change-Induced Flooding on Onsite Sanitation Services: A Case Study of Kanyama, Compound In Lusaka, Zambia</i>
Received: <i>Monday, 11th March, 2024 at 03:06 PM, EAT.</i>
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Issue: <i>Volume 3, Issue 1, 2024</i>
Pages: <i>98-115</i>
CUE Points: <i>Habanyama: 4, Kabika: 2.67 & Mwinga: 1.33</i>
Article DOI: https://doi.org/10.37284/ajccrs.3.1.1861

Your paper has also been optimized for google scholar and other indexing engines for maximum exposure. You should be able to directly access it through search engines within 2 weeks (by Monday, 29th April, 2024). You must go through the paper just to make sure that no errors were left uncorrected. For more information about your publication, visit <https://tracker.eanso.org> and input the tracking ID 5G2V8 or feel free to contact us any time.

Thank you so much for publishing with us. We really enjoyed working on your paper and look forward to more submissions from you and your colleagues.

Yours Faithfully,

Prof. Jack Simons
EDITOR-IN-CHIEF, AJCCRS

